DO POWERFUL CHILDREN HAVE MORE ACCURATE NETWORK PERCEPTION? THE ROLE OF INDIVIDUAL STATUS AND NETWORK CENTRALITY IN PREDICTING ACCURACY IN SOCIAL NETWORK PERCEPTION

By

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(Under the Direction of A. Michele Lease)

ABSTRACT

The current study examined individual-level status (i.e., influence, leadership, popularity, social preference) and network-level centrality (i.e., degree, eigenvector, and betweenness centrality) relatedness to children's network perception accuracy. Participants included 400 3rd, 4th, and 5th grade students nested in 8 grade-level units from three rural schools. Participants named groups of students who "hang out together, just doing a lot together." The collected data were used to construct the social network of each grade unit, obtain individual network perception accuracy values, and measure children's degree, betweenness, and eigenvector centrality values. Participants also nominated peers who were most popular, those who they liked and disliked, and peers who were influencers and leaders. Results indicated leadership, social preference, popularity, and degree centrality were positive predictors of network perception accuracy. Although gender differences were observed in network accuracy, no interaction effects were observed between the predictor variables and network perception accuracy. Furthermore, degree centrality predicted accuracy above and beyond individual-level status variables, suggesting knowledge of the network structure might be more dependent upon being connected to more individuals beyond possessing individual characteristics indicative of social status.

INDEX WORDS: Interpersonal Accuracy, Social Verticality, Power, Status, Social Preference, Popularity, Leadership, Degree Centrality, Network Perception Accuracy

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CHAPTER 1

INTRODUCTION

Socialization is the process by which children adapt to and internalize various social norms and rules. There are two major models that explain children's socialization process: deterministic and constructivist models (Corsaro, 1997; Kuczynski & Mol, 2015). The deterministic model claims that children play a passive role in their socialization process and that children are appropriated by the society's norms and values. The deterministic model, which was largely popular in the 60s and 70s, argues that society's systematic pattern of order and balance as well as stable pattern of conflicts and inequalities integrate children into society (Corsaro, 1997; Goslin, 1969; Kuczynski & Mol, 2015). Such patterns teach children to internalize society's norms and values. This view, however, received much criticism as scholars argued it underestimates the contributions that all members of the society, including children, added to the social norms and values (Corsaro, 1997; Kuczynski & Mol, 2015).

From this criticism arose the constructivist model, which posits that children function as active agents who dynamically construct the social world and their place in it (Corsaro, 1997; Vygotsky, 1978; Wadsworth, 1996). For example, one of the major constructivist theorists, Jean Piaget, argued that from birth people actively observe, organize, interpret, and organize information gathered from the environment to form "mental structures" of their physical and social worlds (Corsaro, 1997). Vygotsky (1978) further developed Piaget's theory, stating children's active participation in acquiring social knowledge and skills functions in extending and maintaining future cultural systems.

Though the constructivist model drove much of socialization research in the early years, Corsaro (1992) addressed a major limitation of constructivism. Corsaro argued constructivism "does not consider seriously how interpersonal relations reflect cultural systems, or how children, through their participation in communicative events, become part of these interpersonal relations and cultural patterns and reproduce them collectively" (pg. 161). Corsaro criticized the constructivists' strict adherence to an "individualistic doctrine that regards social development solely as the child's private internalization of adult skills and knowledge" (pg. 18). Instead, he noted socialization should be understood as a social and collective process, wherein children reproduce peer cultures and contribute to the pre-existing adult culture as they develop their social skills within the boundaries of the peer network. Thus, to break-away from the "individualistic doctrine" of traditional constructivism literature, Corsaro named this approach an "interpretive reproduction" view of development (Corsaro, 1997). Such an approach, however, requires researchers to examine the transactional nature of socialization and its influence on development. This type of research has been slow to be conducted based on the field's methodological limitations (Hanish & Rodkin, 2007).

Social Network Analysis (SNA) is one methodology allowing researchers to examine the relational aspects of socialization, such as an individual's position within a network, presence or lack of social connections, and the structural patterns and relationships within a group. SNA is both a theoretical framework and a methodology attempting to describe and explore social ties and relationship patterns between individuals that exist within a designated network (Scott, 2017) and the consequences for the individuals embedded in that social structure (Freeman, 2004). Network analysts seek to uncover various kinds of relationship and structural network patterns existing within a social environment, determine the conditions under which those patterns arise, and discover their consequences in ways that are not possible with traditional statistical analyses (Freeman, 2004; Hanish & Rodkin, 2007). For example, Hanish and Rodkin (2007) explained SNA makes it possible to examine how large and dense children's peer networks are, how children are positioned within their networks, the structural configurations of children's social groups, and the composition of individual children's social networks to understand socialization in a more dynamic fashion.

Network science originally began with Moreno's attempt to understand how interaction patterns of children from kindergarten through high school influence individual behavior (Hanish & Rodkin, 2007). Bronfenbrenner, who recognized the importance of Moreno's research, invested in this idea and began to explore how the methodology could be utilized to answer "dynamic questions about individuals in society" (Hanish & Rodkin, 2007, p. 2). Eventually, such efforts gave birth to Ecological Systems Theory (EST), a widely adopted theory that emphasizes the importance of considering "the entire ecological system in which growth occurs" (Bronfenbrenner, 1994; Neal & Neal, 2013).

Despite network science's origin in developmental psychology and its potential to answer dynamic questions related to socialization, SNA eventually disappeared from the child development research literature for several reasons. First, developmental psychologists had to dedicate much of their efforts trying to disentangle the complex nature of children's social environment. According to Rubin, Bukowski, and Parker (2009), it took 25 years' worth of research to conceptualize and articulate the multiple levels of analyses and perspectives that comprise the peer system and to understand the hierarchy of social complexity included processes at the individual, interaction, relationship, and group levels. Consequently, the methodological questions related to applying SNA in developmental psychology, such as how to identify or define a group, how to collect network data (e.g., self-report or peer-report), how to deal with violation of theoretical and statistical independency among the "nodes" in the network, and how to decide what determines a tie, were largely left unanswered (Hanish & Rodkin, 2007). Without answering such methodological concerns, it was impractical to apply SNA in exploring socialization. Additionally, many developmental scientists believed examining children's interaction patterns at the network-level would not add much information once dyadic information (i.e., friendships) was examined using traditional statistical methodologies (Cairns, Xie, & Leung, 2007). As a result, developmental scientists continued to focus on exploring dyadic relationships to understand social interaction patterns and to rely on traditional statistical methodologies. In fact, network science became so neglected that Bronfenbrenner's EST, which is rooted in SNA perspective, is readily referenced without a single mention of SNA-related concepts (Hanish & Rodkin, 2007).

As developmental psychologists almost exclusively studied socialization at the individual and dyadic level, network scientists, specifically extreme structuralists, focused upon answering technical questions related to SNA, such as the types of structures (e.g., "star" patterns) that might exist in a network and their meaning, without considering attributes of individuals (i.e., personality, age, gender, etc.) (Kilduff & Tsai, 2003). Kilduff and Tsai (2003) refer to the division between SNA research design (i.e., macro domain) and traditional statistical research design focused on the individual (i.e., micro domain) as the "micro/macro divide." With network researchers' focus on technical issues (Kilduff & Tsai, 2003) and developmental psychologists' lack of attention to and, at times, even disregard for the importance of network analysis in understanding children's socialization (Hanish & Rodkin, 2007), the application of network analysis continued to be delayed in the discipline of child development.

Despite the micro/macro divide, there have been psychologists who have tried to “bridge” the gap between structuralist and individualistic research orientations and re-introduce SNA into the field of developmental psychology (Ahn, Rodkin, & Gest, 2013; Cappella, Neal, & Sahu, 2012; Furman & Buhrmester, 1985; Gifford-Smith & Brownell, 2003; Lee et al., 2017; Neal, Neal, & Cappella, 2016). One specific area of research in which scholars have incorporated SNA concepts within the developmental psychology field is *cognitive network theory*. Cognitive network theory is an area of study examining individuals’ perceptions of social networks, how such perceptions influence social network formation, and the reciprocal influence of networks on cognition (Kilduff & Tsai, 2003). Krackhardt (1990) argued that people who create a more accurate mental map of their social network might gain advantages in organizations. Krackhardt found that knowing who to seek advice from in an organization was a significant predictor of how powerful the individual was perceived to be by others. Freeman, Romney, and Freeman (1987) stated the ability to discern social groups and boundaries evolves over time as individuals gain experience in social groups; however, gaining experience in their social groups based on a distorted view of network information can lead to negative developmental outcomes.

Various measures of centrality, in particular, have been of great interest to network analysts and psychologists for understanding how network information can provide added information beyond individual-level variables. Centrality is a representation of an individual’s degree of “importance” within a network based on their positioning in the network (Wasserman & Faust, 1994). For example, *degree centrality* is a measure of prestige, which is measured by the number of ties an individual has with other members in his or her network. Consequently, an individual with the greatest number of direct ties with other members of their network will have the highest degree centrality value (Wasserman & Faust, 1994). *Eigenvector centrality* is a variation of degree centrality that counts the number of ties an individual has (similar to degree centrality) but also accounts for the weight of each person by their eigenvalues, or social worthiness, as defined by the experimenter (Borgatti, Everett, & Johnson, 2013). In other words, individuals who are connected to other powerful friends, as defined by their eigenvalue, will have a higher eigenvector centrality value compared to those whose ties are with less central members of the network. *Betweenness centrality* is yet another variation of prestige or power where individuals high in betweenness centrality values are positioned in between two different groups or clusters of individuals within their network; those high on betweenness centrality serve as "gatekeepers" and have control over interactions or flow of information between the two subgroups (Wasserman & Faust, 1994). Betweenness centrality is calculated by counting the number of times an individual lies in between the shortest path connecting two other individuals within the network (Borgatti, Everett, & Freeman, 2002).

One benefit of SNA is that it allows researchers to examine the socialization process at the individual level (or "node" level in network terminology), dyadic level, and the network level (Borgatti, Everett, & Johnson, 2013), giving new light to socialization research in a way that Corsaro deemed it to be necessary. Because application of SNA in the child development literature is relatively new, there remain numerous questions to be explored. As mentioned by Hanish and Rodkin (2007), researchers hesitate to utilize SNA because there are technical questions that remain unanswered, such as how to best define the presence of a relationship, how to identify a cohesive group, and theoretical questions, such as how children perceive others' relationships and to what degree they are accurately using this information to navigate their social worlds. Furthermore, because SNA is a conceptual framework and not merely an analytical approach, posing questions, collecting data, and interpreting networked relationships requires specialized training not always readily available to researchers.

The goal of the current paper was to add to the socialization literature by 1) exploring how individuals perceive their network structure, 2) examining individual differences in network perception accuracy, 3) identifying variables at the individual- and network-level that contribute to these individual differences, and ultimately 4) bridging “the micro/macro divide” by including both individual-based and network-based variables in research methodology. By exploring these questions, the often-implicit assumption that individuals do not vary significantly in their perception of the network structure or that this variance lacks significance is examined. That is, networks are often assessed by aggregating perceptions of networks across individuals. Examining individual difference in accuracy, or deviation from the aggregate perception, is a simple yet fundamental question necessary in bridging SNA models to developmental psychology literature.

CHAPTER 2

LITERATURE REVIEW

The social world is a complex web of relationships between multiple individuals. People constantly make judgments about the self, others, the social structure, and their positions within the social structure. These judgments, collectively referred to as “interpersonal perception,” impact how individuals make various social decisions (Hall, Schmid Mast, & Latu, 2015). Several studies have reported adults and adolescents whose interpersonal perception is inaccurate experience less favorable workplace outcomes (Byron et al., 2007; Farmer, Hall, Petrin, Hamm, & Dadisman, 2010), poor relationship quality, and psychological maladjustment (Hall, Andrzejewski, & Yopchick, 2009; Schmid Mast & Hall, 2018). Distorted interpersonal perception also has an impact on children and their development. According to Piaget (1965) children who understand their social environment might be better equipped to engage in socially adaptive behaviors and experience less interpersonal conflict. Cillessen and Bellmore (1999) also reported that children’s interpersonal accuracy predicts social-emotional adaptation.

Accurate interpersonal perception or “interpersonal accuracy,” as coined by Hall and colleagues (2015), appears to have a pervasive impact on developmental outcomes, and researchers have explored different variables contributing to the variability in interpersonal accuracy. A group of variables of particular interest is “social verticality” (Hall et al., 2015). In 2015, Hall, Schmid Mast, and Latu published a meta-analysis summarizing the results of studies with adolescent and adult samples exploring the relationship between social verticality and interpersonal accuracy. The terminology and conceptual definition of social verticality, as used by

Hall and colleagues, builds on Schubert's (2005) introduction of the term to describe the vertical dimensions of social interactions, such as power, status, hierarchy, and dominance. When talking about power, people often use metaphors such as “rising to power,” or “looking down on underlings,” which reference social status in a vertical dimension. Consistent with such metaphors, Schubert (2005) found when participants in an experiment were asked to identify the social status of individuals within a set of visual stimuli, the participants’ responses were faster when high status words were placed higher in the perceptual field in contrast to when high status words were located at a lower position within the perceptual field.

One reason why researchers have examined social verticality is because there are theories suggesting the relationship between social verticality and interpersonal accuracy could either be positive or negative and that the causal relationship between the two could point in either direction (Hall et al., 2015). To illustrate, Krackhardt (1990) hypothesized individuals occupying higher positions in workplace hierarchies might pay close attention to how individuals interact with one another, by the virtue of their positions, and thereby demonstrate better interpersonal accuracy. In contrast, Fiske and Taylor (2013) proposed individuals with higher power might demonstrate lower interpersonal accuracy, as they might depend more on automatic (heuristic-based) social cognition, whereas individuals with lower power might depend more on controlled cognition to compensate for their lower social status. According to Fiske and Taylor’s hypothesis, individuals with lower status are conceivably more motivated to climb up the social ladder and thus should pay more attention to their social environment than those with higher social status.

Hall and colleagues’ (2015) meta-analysis concluded studies examining the relationship between social verticality and interpersonal accuracy report two contradicting results. The studies in the meta-analysis, which included 67 independent studies with a total of 15,505 participants above age 13, were divided into two categories: studies using a testing paradigm and those using an in vivo paradigm. The testing paradigm included studies in which the examiner uses a standard set of stimuli (i.e., video clips of interpersonal information) to assess the accuracy of participants' responses. The in vivo paradigm included studies involving participants engaging in a live interaction with another individual and making judgments about the other person. The majority of the studies included in this meta-analysis operationally defined interpersonal accuracy either as the ability to accurately judge others' emotions or the ability to accurately recall conversations. Overall, studies examining verticality and accuracy in testing paradigm studies concluded there generally is a positive relationship between interpersonal accuracy and verticality. However, studies involving live interaction generally concluded a negative relationship between social verticality and interpersonal accuracy. Hall and colleagues concluded the contradicting results could be due to the difference in research design and how interpersonal accuracy was operationalized (Hall et al., 2015).

Traditionally, the research on interpersonal accuracy has focused on accurate perception of individual characteristics (i.e., personality traits, attitudes, and emotional states, social status, recall of interaction experience, etc.), as demonstrated in the meta-analysis by Hall and colleagues (2015). There is a particular type of interpersonal accuracy, however, that has received relatively less attention but is particularly important when trying to examine how people navigate their social worlds: Accurate perception of social network structures (hereinafter referred to as *network perception accuracy*). There is not a universal terminology for this skill: It has been referred to as cognitive accuracy of network information (Krackhardt, 1987, 1990), accuracy in social network perception (Casciaro, 1998), accurate perception of relationships (Neal et al., 2016), accuracy in interpersonal perception (Kenny & Albright, 1987; Cappella et al., 2012), and perception accuracy

(Lee et al., 2017). However, there has been a dearth of research on network perception accuracy likely due, at least in part, to the general neglect of research on social networks among developmentalists (Hanish & Rodkin, 2007).

When Jacob Moreno (1953) first developed sociometry, the origin of modern-day social network analysis, it was to understand the role of interaction patterns in children's behavior; despite its roots in developmental psychology, SNA eventually all but disappeared from the developmental psychology discipline mainly due to methodological barriers (Hanish & Rodkin, 2007). Until recently, developmental psychologists have largely assumed that relational information could be accounted for by studying interactions at the dyadic level, using traditional statistical methodology, and thus neglected to recognize the need to apply SNA methods and further develop it to fit the needs of the discipline. As a result, there remains a large number of unanswered questions and unexplored territories in applying SNA to developmental psychology, and network perception accuracy is no exception (Hanish & Rodkin, 2007).

Understanding network perception accuracy adds theoretical, methodological, and empirical value to understanding children's social behavior (Cappella et al., 2012; Neal et al., 2016). First, examining network perception accuracy is theoretically important because an individual's perception of the network structure might be more strongly associated with social behavior than the actual structure of the network (Krackhardt, 1987). Second, it is methodologically important because the current stochastic actor-based model of SNA, a model examining how both individual attributes and social network variables predict the possibility of establishing future relationships and is increasingly used in peer influence research, is built on an assumption that all individuals in the network can change their relationships based on accurate knowledge of interpersonal perception, including network perception (Snijders, van de Bunt, &

Steglich, 2010). Finally, understanding network perception accuracy is empirically important, as such a skill might be important for children to navigate their social environment in an efficient and effective way.

According to Simpson and Borch (2005), there are two major hypotheses explaining the relationship between perception and verticality. The first hypothesis argues “dependence begets perception” (pg. 280), which posits individuals lower in power status (i.e., hierarchical level, expert knowledge, higher SES, feeling powerful, etc.) demonstrate better network perception accuracy. For example, Casciaro (1998) found that in a sample of 25 university students, those occupying lower hierarchical position in the organization demonstrated better accuracy in perception of both friendship and advice network structures than did those higher hierarchical position within the organization. Furthering that work, Simpson, Markovsky, and Steketee (2011) conducted an experimental study with 97 college students and demonstrated participants who were primed with lower-power status were more accurate in network perception than individuals primed with high-power status. The authors linked these findings to Fiske and Taylor's (2013) hypothesis explaining those lower in power status are more motivated and more dependent on high-power individuals to make the best of their disadvantaged position within the network.

The second hypothesis regarding the relationship between network perception accuracy and social verticality is that “power begets perception” (Simpson & Borch, 2005, pg. 279) or that individuals higher in power and status demonstrate better network perception accuracy. In 2018, Marineau, Labianca, Brass, Borgatti, and Vecchi examined the relation between individuals’ formal and informal power and their network perception accuracy in a network of 48 adults, including 12 managers, belonging to a manufacturing company’s technical call center. They measured company workers’ network perception accuracy and collected measures of both formal (i.e., hierarchical position such as manager) and informal (i.e., peer-ratings of influence) power and employee outcomes (i.e., promoted, transferred, exited, or remained). The researchers found powerful individuals are more accurate about the whole network structure and about the incoming negative affective ties than were those who are less powerful. In other words, individuals who occupy a more powerful social position are more accurate about who dislikes whom and which individuals would nominate them as a friend or a foe.

Likewise, in the children's literature, Neal, Cappella, and colleagues found a generally positive relationship between social verticality constructs and network perception accuracy. First, Cappella et al. (2012), found in a sample of 418 second- to fourth-grade children from 33 different classrooms, children with higher degree centrality demonstrated higher accuracy in network perception. Degree centrality, measured by the number of direct connections an individual has with other members in the network, is often used as proxy for power and prestige within the SNA literature. In another study, Neal and colleagues (2016) examined 420 children in 33 second through fourth grade classrooms and found those who were nominated by peers as popular demonstrated higher accuracy in network perception. Lee and colleagues (2017) found similar results in a study of 1,481 seventh- and tenth-grade Chinese students from 346 networks, in which students who were popular and demonstrated high degree centrality reported more accurate perceptions of their personal affiliation-based group and peers' affiliation-based group networks compared to their less popular and less central counterparts. Such findings in the child and adolescent literature are consistent with the "power begets perception" hypothesis, suggesting children who are higher in social verticality generally demonstrate better network perception accuracy.

One finding in Lee and colleagues' (Lee et al., 2017) study contradicting the general findings supporting the "power begets perception" hypothesis is that betweenness centrality was a negative predictor of network perception accuracy. Betweenness centrality is another indicator of power, because individuals high in this type of centrality are viewed as controlling the "flow" of information and/or material goods between two groups or clusters within a network (Scott, 2017). According to Lee and colleagues (2017), when degree centrality values were controlled for, the "gatekeepers" of the network, or children with high *betweenness* centrality, demonstrated *poorer* network perception accuracy than their peers. Individuals high in betweenness might demonstrate low network perception accuracy because they are connected to individuals from differing parts of the network who provide conflicting information regarding who belongs to which group.

In summary, unlike the adult literature, in which there are two different camps with different positions regarding the relationship between network perception accuracy and social verticality, there appears to be strong evidence within the children and adolescents' literature that power and network perception accuracy generally demonstrate a positive relationship. The current findings, however, are limited as research has included only a few variables related to social verticality, namely popularity, degree centrality, and betweenness centrality. These variables are merely partial representations of the social verticality construct. Furthermore, there is a need to dissect the relationship between social verticality and network perception to better understand what it is about "power" that leads to better network perception. Insight into this question might help explain the developmental trajectory of the verticality-perception relationship suggesting a change from a generally positively related relationship reported in the children's literature to two contradicting hypotheses in the adult literature.

Current Study

The goal of the current study was to examine the predictability of individual-level status and network-level centrality in explaining network perception variability. To summarize, social verticality refers to the vertical dimension of social interaction, such as power, status, and hierarchy (Hall et al., 2015), and previous findings have reported conflicting results on the relationship between social verticality and network perception accuracy in the adult literature (Hall et al., 2015; Jayagopi, Ba, Odobez, & Gatica-Perez, 2008; Krackhardt, 1990). While a positive relationship between verticality and network perception accuracy has been shown in a few studies within the children's literature, the only social verticality constructs that have been examined are popularity, degree centrality, and betweenness centrality (Cappella et al., 2012; Lee et al., 2017).

Popularity, degree centrality, and betweenness centrality are often viewed as proxies of power within the children's literature; however, the route to which each of these three variables confers power, and thereby increases an individual's network perception accuracy, could feasibly vary. Popularity is a multi-dimensional, individual-level status variable associated with different behaviors, including peer-nominated social aggression and athleticism, and peer-valued characteristics, such as attractiveness and trendiness (Kornbluh & Neal, 2014; Lease, Kennedy, & Axelrod, 2002; Lease, Musgrove, & Axelrod, 2002). A similar but distinctly different individual-level status variable is social preference. Social preference is an indicator of children's social acceptance in the peer group and is associated with prosocial characteristics, such as cooperation, sociability, and kindness, compared with popularity that is more strongly associated with power, dominance, influence, and social visibility (Peters, Cillessen, Riksen-Walraven, & Haselager, 2010; Sandstrom & Cillessen, 2006). Distinct from individual-level status variables (i.e., popularity and social preference), degree and betweenness centrality are network-level variables that associate power with having the most number of direct ties with others in the network or being the individual connecting two large groups of people; in such cases, the individual has power due to access to a wealth of social resources, information, and knowledge (Scott, 2017; Wasserman & Faust, 1994).

Considering such differences between individual-level status and network-level centrality verticality constructs, the current study adds to the literature by examining a) social preference as a possible individual-level predictor of network accuracy, b) which aspects of popularity might help explain popularity's relation to network perception accuracy, c) which types of centrality best predict accuracy, and d) the joint contribution of individual- and network-level verticality. First, consistent with prior results with children, popularity is expected to positively predict children's network perception accuracy *(Hypothesis 1a)*. However, the current literature does not address which aspect of popularity leads to better network perception accuracy. Consequently, individual-level social verticality constructs closely related to popularity, namely leadership and influence, are expected to positively predict network accuracy and to help explain the relationship between popularity and accuracy (*Hypothesis 1b*). Another moderately associated, yet distinct, individual-level social verticality variable that might help explain network perception variability is social preference, or likeability. Given that children who are socially accepted, well-liked by peers tend to be socially competent and skilled (Rubin, Bukowski, & Bowker, 2015), social preference is hypothesized to be another positive predictor of network accuracy explaining more variance in network perception accuracy *(Hypothesis 1c)*.

Next, network-level variables were examined in the prediction of network perception accuracy, namely three separate measures of centrality. First, based on results reported by Cappella et al. (2012) and Lee et al. (2017), children who have more direct interaction-based connections (i.e., *degree centrality*) within the network are expected to demonstrate better network perception accuracy (*Hypothesis 2a*). Those who are better connected likely have more access to information or knowledge about the network structure. Second, the predictiveness of *betweenness* centrality, whose relationship with accuracy is less clear, was examined. Lee et al. (2017) found when degree centrality values were controlled for, the "gatekeepers" of the network, or children with high *betweenness* centrality, demonstrated *poorer* network perception accuracy than their peers. According to the authors, individuals high in betweenness centrality are connected with multiple social cliques and thus might have conflicting ideas about who belongs to which groups (*Hypothesis 2b*). As the relationship between betweenness centrality and network perception accuracy remains unclear, the current study adds to the literature by re-examining this relationship with a different set of data. In addition to the previously examined centrality variables, *eigenvector* centrality, which has yet to be related in the accuracy research, to our knowledge, was examined. *Eigenvector* centrality is the degree to which an individual is connected to other centrally positioned individuals, and given its definition, it is hypothesized to be positively correlated with network perception accuracy. *(Hypothesis 2c).* As a measure of network popularity (Borgatti et al., 2013), it might or might not be distinct from individual-level popularity.

In addition to individual-level social verticality constructs, it is likely an increase in network perception accuracy is a function of how connected a person is with those around him or her. Therefore, network-level social verticality constructs are hypothesized to further predict network perception accuracy above and beyond what individual-level verticality variables predict *(Hypothesis 3).* While individual-level constructs are based on peer-nominations of behavioral characteristics (i.e., leadership and influence) and social status (i.e., popularity, social preference), network-level verticality constructs are derived from who children are connected to and their position within the social network. More connections might lead to more information and knowledge, which might increase children's understanding of their social environment. The final hypothesis is examined using individual- and network-level variables shown to be significant predictors of network accuracy in our analyses examining *Hypotheses 1a-2c*. To each of the models examined, two individual level characteristics, namely (a) gender and (b) being of the racial majority within the network were added. Consistent with past research, females are expected to demonstrate better network perception accuracy than males (Cappella et al., 2012). Furthermore, being of the majority race is expected to increase network perception accuracy. Elementary school children generally form friendships with individuals of the same-race (Shrum, Cheek, & Hunter, 2006), and, by virtue of this trend, individuals belonging to the majority race of the network might have more opportunities to form ties and thereby be exposed to more information than their peers belonging to the minority race.

CHAPTER 3

METHOD

Setting and Participants

Participants for the current study were selected from three rural elementary schools in the southeastern United States. In total, there were 408 children (197 males and 211 females), which included 102 3rd graders, 154 4th graders, and 152 5th graders. The current study included 75% White, 14.2%, Black, 6.9% Hispanic, and 3.2% Biracial students, a representative sample of the school records which indicated 77% of the students were White, 13% were Black, and 9% were other ethnicities. Three students did not report their ethnicity and thus were not included in the current demographic data. The racial/ethnic composition of the schools was predominantly White. Table 1 contains demographic information for the participants.

Table 1
Demographic Information (n = 408)

Variable	N	%
Gender		
Male	197	48.3
Female	211	51.7
Race		
White	306	75.0
Black	58	14.2
Hispanic	28	6.9
Biracial	13	3.2
Grade		
Third	102	25.0
Fourth	154	37.7
Fifth	152	37.3

Based on input from the personnel of participating schools in this study, the researchers determined the most ecologically valid reference group for the study was the grade-level peer network (Cillessen & Marks, 2017). The school personnel indicated students in the participating schools interacted with their entire grade during recess and lunch. Given this information, I used grade-unit as opposed to classroom-unit as the reference group when collecting peer-nomination and network data.

The current study labeled students as *minority* race if they were in a grade unit in which most of their peers were of a differing race, and children were labeled as *majority race* if the majority of their peers were of the same race. Because White was the majority race in all of the grade units, students who identified themselves as White are hereinafter referred to as the *majority race* and all other students were identified as *minority race.* Data collection was completed in two sessions as part of a larger study on children's peer relationships. During the first session, 408 students completed the peer-nomination items. During the 2nd data collection session, 8 students were absent and only 400 self-reported network data were collected from the students. Despite numerous attempts to collect the missing data from the 8 students, the network data could not be collected from these students, reducing our effective sample size from n = 408 to n = 400.

Procedure

Invitation forms to participate in the study were distributed to all parents of the children in the participating grades in each of the three schools. Both parental consent and child assent were required for all children who participated in this study. Only grade level units reaching a minimum consent rate of 75% were invited to participate. The overall average consent rate was 81%, with a range of 75-86% across the 8 grade units.

To assist in survey completion, two researchers were present in the data collection session: one member read all items aloud and a second research member provided individualized assistance. For all nomination measures, participants were provided with a list of participating students. In accordance with Institutional Review Board guidelines, children whose parents did not give consent were not included in the study in any way, meaning their names were excluded from the class roster listing participating children who could be nominated for peer report measures. Prior to measure completion, students were told that their responses were confidential and were provided with an index card to cover their responses. After completing the two 1-hour sessions, all children in participating classrooms were presented with a small gift to thank them for their time and effort.

Measures

Individuals' Network Perception

The current study utilized Cairns and Cairns's (1994) Social Cognitive Mapping (SCM) method to collect network data and measure children's perception of their social networks. Following the typical procedures of this method, participants were asked to think about the kids in their grade who "hang out together, just doing a lot together." They were then asked to list the group of kids "who play, work or hang out together a lot." For each nomination item, 10 blanks were provided for nominations; however, participants were instructed they could provide more than 10 nominations if desired. The use of an essentially unlimited nomination procedure, as opposed to a limited nomination one, allows for a more accurate representation (Cillessen & Marks, 2017). Unlimited nominations have demonstrated better psychometric and distributional properties than limited-nomination procedures (Gommans & Cillessen, 2015). To ensure that only children's perceptions of other students' cliques were being reported on, all self-nominations for this item were removed.

Network Perception Accuracy

To calculate the network perception accuracy measure, the network data collected from individual students were aggregated into a co-nomination matrix, which was then dichotomized into a binary matrix based on the 75th percentile in number of frequency count. In other words, the number of ties reported between two students needed to have exceeded the 75th percentile out of the total number of nominations that all ties received within each grade unit to be considered as a "real tie" between two individuals. This cut-off criterion, rather than a set number of ties, was also utilized to control for variability in classroom size and network density, both of which may influence how well students know which students hang out with whom.

To obtain individuals' network perception accuracy values, students' individual network perception matrix obtained from the SCM data was correlated with the aggregated and dichotomized peer-nomination matrix via QAP correlation analysis available in UCINET 6 software (Borgatti, Everett, & Freeman, 2002). Children's network perception accuracy could thus range from having no overlap with their peer-reported network structure to having complete overlap with peer-reported network structure.

Individual-level Verticality Predictors obtained via Peer-Nominations

To obtain individual-level status verticality constructs, students in the current study were asked to nominate participating peers who fit various behavioral and social characteristics, including social influence ('has a lot of influence or a big effect on how kids act'), leadership ('gets chosen as the leader'), and two aspects of social status, including social preference assessed with 'like-most' and 'like-least nominations' (Coie, Coppotelli, & Dodge, 1982) and perceived popularity assessed by asking children to nominate peers who are 'the most popular at school' (Lease, Kennedy, et al., 2002). Research with upper elementary school children suggests, albeit related, social preference and perceived popularity are associated with meaningfully distinct behavioral characteristics (Lease, Kennedy, et al., 2002; Peters et al., 2010; Sandstrom & Cillessen, 2006). Again, 10 blanks were provided for nominations; however, participants were instructed they could provide more than 10 nominations if desired. Children were allowed to nominate same- and cross-gender peers. Each of the peer-nominated items were standardized to a mean of 0 and a standard deviation of 1 within each grade unit to account for variability in the number of nominators, and thus potential nominations any given individual could receive, across grade units. To create the social preference score, a participant's standardized 'like-least' score was subtracted from the standardized 'like-most' score and then re-standardized (Coie et al., 1982). Table 1 includes the peer nomination items used to measure the individual-level verticality predictors.

Network-level Verticality Predictors obtained via Social Network Analysis

The network-level verticality predictors included in the current study are degree centrality, eigenvector centrality, and betweenness centrality. Each of the network-level verticality predictors were calculated via UCINET 6 using the dichotomized co-nomination matrix obtained from the aggregated SCM data (Borgatti et al., 2002).

CHAPTER 4

RESULTS

Overview of Analysis

Analyses were performed using SPSS software. To address our hypotheses, three distinct analyses were conducted. First, a bivariate correlation analyses was conducted to examine the association between predictor variables and accuracy (*Hypotheses 1a, 1c, and 2a-2c).* This analysis was followed by a series of one-way ANOVAs to examine gender and majority race differences in accuracy and to identify variables that might potentially present interaction effects with those demographic variables. Finally, significant variables identified via correlation analyses were used to run a hierarchical regression analysis to examine the predictability of popularity above and beyond leadership (*Hypothesis 1b*) and the predictability of network-level degree centrality above and beyond significant individual-level status variables (*Hypothesis 3*).

Associations between Individual-level Status, Network-level Centrality, and Accuracy

To identify candidate variables to include in the final hierarchical regression model, bivariate associations among all variables of interest were examined. Means and standard deviation for all study variables and bivariate correlations are reported in Table 2. Results indicated significant bivariate correlations between network perception accuracy and social preference, popularity, leadership, and degree centrality. Among the predictor variables significantly correlated with accuracy, social preference was also significantly correlated with popularity and leadership. Degree centrality was significantly correlated with popularity and leadership. There was also a relatively strong correlation between popularity and leadership. Based on the results of the bivariate correlation analyses, leadership, popularity, and social preference were included as individual-status verticality candidate variables (*Hypothesis 1a, 1c)* and degree centrality as a possible network-level centrality verticality variable (*Hypothesis 2a*) that might uniquely predict network perception accuracy in the final hierarchical regression model examining the contribution of network-level variables beyond the individual-level for predicting network perception accuracy.

Table 2

Bivariate Correlations Between All Study Variables (n = 400)

Variables	M (*SD*)	1	2	3	4	5	6	7
1. Accuracy	0.29 (0.16)							
2. Social preference	0.00 (0.99)	.214**						
3. Popularity	0.00 (0.99)	.271**	.351**					
4. Leadership	0.00 (0.89)	.257**	.459**	.716**				
5. Influence	0.00 (0.89)	.052	.125*	.448**	.396**			
6. Degree	3.61 (2.95)	.295**	.173**	.475**	.328**	.319**		
7. Eigenvector	0.10 (0.31)	.083	.152**	.079	.121*	.050	.312**	
8. Betweenness	16.18 (48.95)	.013	.042	.296**	.254**	.273**	.375**	.112*

Note. * $p < .05$. ** $p < .01$.

Group Differences in the link between Individual-level status and Network-level centrality variables and Network Perception Accuracy: Gender and Majority-Race.

To examine group differences in network perception accuracy, a series of one-way ANOVAs with two demographic variables (i.e., gender and majority race) were conducted. Males and females demonstrated significant differences in network perception accuracy (F(1, 398) = 10.74, $p < .001$), with females reporting significantly higher network perception accuracy (M = 0.31, SD = 0.16) than males (M = .26, SD = 0.16) (Table 3). Network perception accuracy between the two racial category groups (F(1, 398) = 3.35, p = .068) was not significantly different. These results indicate being in the racial majority group does not lead to better network perception accuracy than being in the racial minority of the network (Table 3).

Table 3

ANOVA Comparisons of Network Perception Accuracy based on Gender and Race

Group	*n*	Mean	*SD*	*F-value*
Gender - Male	193	.26	.16	10.73**
Gender - Female	207	.31	.16	
Race - Majority	300	.28	.15	3.35
Race - Minority	100	.31	.17	

Note. *p < .05. **p < .01. ***p < .001.

Given the significant gender difference in network accuracy, a series of regression models were performed with the predictor variables and gender predicting network perception accuracy and the interaction between the two. Results of two-way interactions between gender and leadership (β = .040, t(400) = 0.57, p = .57, R^2 = .08), popularity (β = .031, t(400) = .42, p = .67, R^2 = .09), social preference (β = .046, t(400) = 0.64, p = .52, R^2 = .07), and degree centrality (β = -.022, t(400) = -.23, p = .82, R^2 = .10) revealed gender did not significantly moderate the relationship between verticality measures and network perception accuracy.

In sum there was no main effect of majority race on network perception accuracy. Gender, on the other hand, did demonstrate a significant main effect; however, no interaction effect of gender with the predictor variables was observed. Therefore, interaction terms were not included in the hierarchical regression models.

Predictability of Individual-level Verticality Variables in Network Perception Accuracy

A hierarchical regression analysis was performed to examine if leadership helps to explain the relationship between popularity and network perception accuracy (*Hypothesis 1b)*. Although results of the bivariate correlation analyses revealed popularity and leadership were highly correlated (Table 2), the assumption of no multicollinearity was not violated (maximum variance inflation factor = 2.3, minimum variance inflation factor = 1.0, tolerance statistics > 0.3). Therefore, leadership was included in the final hierarchical regression model. First, gender was entered in Step 1 to control for the gender effect on network perception accuracy. Leadership was then entered in Step 2 and popularity in Step 3 to examine the predictability of popularity above and beyond leadership. Table 4 contains the standardized regression coefficients at entry and in the final model (β_{entry} and β_{final}), R^2, and change R^2 (ΔR^2).

Results of the hierarchical regression model revealed that gender (β_{final} = 0.12, $p < .05$) and popularity (β_{final} = .17, $p < .05$) were uniquely related to network perception accuracy and collectively explained 9.6% of the variance in network perception accuracy ($F(3, 396) = 13.032$, $p = .013$). Although leadership (β_{entry} = .24, $p = .000$) significantly explained 5.6% of the variance ($p = .000$) in network perception accuracy at Step 2 of the model ($F(2, 297) = 17.73$, $p = .000$), it's significance diminished (β_{final} = .11, $p = .086$) when popularity was added into the final model (Table 4). The final model significantly explained 9.6% of the network perception variance ($F(5, 394) = 12.80$, $p = .000$). While leadership helps to explain the relationship between popularity and network perception accuracy, it does not fully account for the relationship and suggests there are other aspects about being popular that predicts network accuracy.

Table 4

Predicting Accuracy from gender and individual-status (popularity & leadership)

Variables	β_{entry}	β_{final}	ΔR^2	R^2
Step 1			0.026***	0.026***
Gender (boys = 0, girls = 1)	0.16***	0.122*		
Step 2			0.056***	0.082***
Leadership	0.24***	0.118		
Step 3			0.014*	0.096*
Popularity	0.17*	0.17*		

Note. *p < .05. **p < .01. ***p < .001.

Predictability of Individual-Status and Network-level centrality in explaining Accuracy

Finally, a hierarchical regression model was performed to examine the predictability of network-level degree centrality above and beyond individual-status variables (e.g., leadership, popularity, and social status) (*Hypothesis 3)*. First, gender was added in Step 1 to control for gender effects. Following that test, all the significant individual-level status variables, namely popularity, leadership, and social preference were added in Step 2. In Step 3 of the model, the only network-level variable added was a significant predictor of network perception accuracy in bivariate correlations, namely degree centrality. Table 5 contains the entry and final standardized regression coefficients (β_{entry} and β_{final}), R^2, and change R^2 (ΔR^2).

Results of the hierarchical regression model at Step 2 revealed gender and individual-level status variables popularity (β_{entry} = .011, p = .05) and social preference (β_{final} = .008, p < .05) significantly explained 10.6% of the variance in network perception accuracy (Step 2: $F(4, 395)$ =

11.724, p = .000). Leadership (β_{final} = .17, p < .05) was not a significant predictor of network perception accuracy when entered simultaneously at Step 2 with popularity and social preference. When degree centrality was added at Step 3, an additional 3.4% of the variance of the network perception accuracy was explained (Step 3: $F(5, 394) = 12.798$, p = .000). In sum, one network-level verticality construct, degree centrality, explained variability in network perception accuracy above and beyond individual-status verticality variables (*Hypothesis 3*).

Beyond gender, it is notable that the only standardized regression coefficients from the final model (β_{final}) to retain significance in predicting unique variance, once all other variables were in the model, were social preference (β_{final} = .109, p < .05) and degree centrality (β_{final} = .208 , p < .001) (Table 5). This might indicate overlap in measures assumed to tap into social power, namely popularity and degree centrality, regardless of whether those measures were assessed as individual-level verticality constructs or as derived from network position.

Table 5

Predicting Accuracy from gender, individual-status and network centrality

Variables	β_{entry}	β_{final}	ΔR^2	R^2
Step 1			0.026***	0.026***
Gender (boys = 0, girls = 1)	0.162***	0.108**		
Step 2			0.080***	0.106***
Leadership	0.013	0.078		
Popularity	0.011*	0.064		
Social Preference	0.008*	0.109*		
Step 3			0.034***	0.140***
Degree Centrality	0.208***	0.208***		

Note. *p <.05. ** p < .01. ***p < .001.

CHAPTER 5

DISCUSSION

The goal of this study was to expand upon the current network perception accuracy literature by using Hall and colleagues' (2015) conceptual definition of social verticality to explore candidate predictors of children's network perception accuracy beyond popularity, degree centrality, and betweenness centrality (Cappella et al., 2012; Lee et al., 2017; Neal et al., 2016). Although popularity, degree centrality, and betweenness centrality are each viewed as proxies of power within the children's literature, the route to which each of these three variables confer power, and thereby increase an individual's network perception accuracy, could feasibly vary.

Examining what accounts for the individual variability in network perception accuracy is empirically important because children's social behaviors might depend upon how accurately they are able to perceive the social structures within their environment, and accurate perception of the network might provide aide in navigating the complex web of social interactions (Neal et al., 2016). It is methodologically important as the stochastic actor-based model of SNA functions under the assumption that all individuals can accurately perceive the network structure of their social environment (Snijders et al., 2010). Finally, answering this questions is theoretically important as findings may or may not support the current "power begets perception" hypothesis of network perception accuracy (Simpson & Borch, 2005).

To better understand the relationship between verticality and network perception accuracy, social verticality constructs into categorized two categories: individual-level status variables and network-level centrality variables. Based on Hall and colleagues' (2015) conception of social verticality, popularity, leadership, influence, and social preference were selected as potential candidate variables within the individual-level verticality category. Popularity is often associated with peer-nominated social aggression and athleticism (Kornbluh & Neal, 2014; Lease, Kennedy, et al., 2002; Lease, Musgrove, et al., 2002), as well as leadership and influence, and is indicative of power and social visibility (Peters et al., 2010; Sandstrom & Cillessen, 2006). In contrast, research consistently has shown that social preference is associated with academic motivation and prosocial characteristics, such as cooperation, sociability, and kindness, and is indicative of social competence (Rubin et al., 2015). Given that these two variables are considered dimensions of elevated social status, these two variables are hypothesized to positively predict network perception accuracy based on the "power begets perception" hypothesis (*Hypotheses 1a and 1c)*. As expected, correlation analyses revealed that each of the two individual-level status variables, namely popularity and social preference, were positively associated with network perception accuracy. Furthermore, leadership and influence were examined as potential individual-level verticality constructs closely associated with popularity that might significantly predict network perception accuracy (*Hypothesis 1b).* Results from the correlational analyses revealed that, of these two, only leadership was significantly associated with network perception accuracy. Furthermore, results of a hierarchical regression indicated that the relation between popularity and network perception accuracy is explained by more than leadership qualities alone (*Hypothesis 1b)*. Leadership did not fully account for the relationship between popularity and accuracy, revealing that there are other variables that need to be examined in understanding the relationship between popularity and accuracy.

Distinct from individual-level status variables (i.e., popularity and social preference), degree, betweenness, and eigenvector centrality were identified as possible network-level verticality predictors of network perception accuracy (*Hypotheses 2a-2c)*. Degree centrality associates power with having the most number of direct ties with others in the network, betweenness centrality with being the individual connecting two large groups of people, and eigenvector centrality with being connected to other influential individuals within the network. In such cases, the importance of centrality is assumed to be due to having access to a wealth of social resources, information, and knowledge (Scott, 2017; Wasserman & Faust, 1994).

First, based on results reported by Cappella et al. (2012) and Lee et al. (2017), children who have more direct interaction-based connections (i.e., *degree centrality*) within the network were hypothesized to demonstrate better network perception accuracy (*Hypothesis 2a*). As expected, those who had a greater number of direct connections with their peers demonstrated better network perception accuracy, perhaps due to having more access to information or knowledge about the network structure.

Next, Lee et al. (2017) found that when degree centrality values were controlled for, the "gatekeepers" of the network, or children with high *betweenness* centrality, demonstrated *poorer* network perception accuracy than their peers. According to the authors, individuals high in betweenness centrality may demonstrate poor network perception accuracy as they are connected with multiple social cliques and thus may have conflicting ideas about who belongs to which groups (*Hypothesis 2b*). Different than the results of Lee et al., (2017), the current study examined simple association between betweenness centrality and accuracy and did not find a significant association between the two variables. While it may be possible that children with high betweenness centrality may receive conflicting information from those around them, this relationship may not be consistent across different kinds of networks.

In addition to the previously examined centrality variables, *eigenvector* centrality, often discussed as a variant of power (Borgatti et al., 2013; Scott, 2017), was examined as another potential network-level verticality predictor, which has yet to be examined in research, to our knowledge, with network perception accuracy. Specifically, *eigenvector* centrality is the degree to which an individual is connected to other centrally positioned individuals, and it was hypothesized that eigenvector centrality would be positively correlated with network perception accuracy *(Hypothesis 2c)*. Contrary to the hypothesis, eigenvector centrality was not significantly associated with network perception accuracy. This result suggests that, in the case of network perception accuracy, it is more important to be connected to numerous other people in the network (i.e., high degree centrality) than to be specifically connected to other powerful people (i.e., eigenvector centrality). In other words, being exposed to more direct connections may provide an individual with more information, thereby increasing their knowledge of the network structure.

Last, increased accuracy in network perception may come from power in the form of increased access to network contacts and information, above and beyond possessing individual-characteristics (i.e., behavioral traits and status) associated with power. As expected, our results indicated that network-level social verticality, namely degree centrality, accounts for variability in network perception accuracy above and beyond individual-level social verticality (i.e., popularity, leadership, and social preference) *(Hypothesis 3).*

In addition to our stated hypotheses, this study found the only individual-level status predictor remaining significant after degree centrality was added into the final regression model was social preference. This finding adds two new perspectives to the current literature. First, while popularity is often viewed as proxy for power, this variable may not be distinct from degree centrality. Furthermore, the significance of social preference as a positive predictor of network perception accuracy suggests that likeability, often a proxy of social competence, contributes to an individual's network perception accuracy along with social status, namely popularity.

In sum, the results regarding accurate network perception provide support for the theoretical presupposition that "power begets perception," at least for school-age children. Furthermore, these findings also add to the literature by suggesting that there may be different pathways by which "power begets perception" is achieved. In 1990, Carley theorized social interaction and knowledge dynamically co-evolve. Carley argued social interaction drives knowledge acquisition, which creates more opportunities for social interaction, a self-sufficing cycle that eventually propels an individual's social development. Shared social position leads to shared knowledge, which leads back to shared social position. The piece left unaddressed in Carley's theory is, which comes first: the position or social competence (i.e., social knowledge)? Though the current study cannot answer this question, it raises another question that is worth exploring: if the relationship between position and knowledge is consistently positive in childhood, what is the cause of the contradicting results in the adult literature? Is there a factor that changes *how* the two dynamically co-evolve between individuals?

Limitations and Future Directions

While the current study adds meaningful information regarding the general relationship between social verticality and network accuracy, there are a few limitations that are worth addressing. One of the strengths of SNA is that structural characteristics of whole networks can be examined, such as density of connections, cohesiveness, and other structural characteristics evident in whole networks. However, the current study did not examine such network structures and characteristics, which might directly relate to network perception accuracy. For instance, in a network segmented into isolated cliques and communities, network centrality measures might predict accuracy differently than in highly interconnected networks. These types of whole network studies would conceivably require a much larger sample size of networks, whereas our study included only eight networks (i.e., 8 grade level units). Adding this information might better explain unexplained variance in children's network perception accuracy. For instance, such whole characteristics might help to explain why male students are less accurate than their female counterparts, as females may engage in more information-sharing behavior than males or interact in a more tightly-knit networks than their male counterparts (Cappella et al., 2012).

Despite this limitation, this study adds to the literature on network perception accuracy and social verticality by incorporating SNA concepts into the research design, exploring the relationship between predictor variables that potentially explain *how* individuals come to perceive network information, and encouraging future use of SNA in the developmental psychology literature. Future research on network perception accuracy should explore the causal relationship between social verticality and network perception accuracy and include network-level variables to examine how various environmental context (i.e., network size, density, cohesion) influences this relationship.

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