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Shadows on the Cave Wall: The Cognitive Accuracy of Social Network Perception

David M. Ouellette
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Shadows on the Cave Wall: The Cognitive Accuracy of Social Network Perception

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

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Abstract

SHADOWS ON THE CAVE WALL: THE COGNITIVE ACCURACY OF SOCIAL NETWORK PERCEPTION

By David M. Ouellette, M.S.

A dissertation submitted in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Virginia Commonwealth University.

Virginia Commonwealth University, 2008.

Directors: Donelson R. Forsyth, Professor, Jepson School of Leadership Studies, University of Richmond and Faye Z. Belgrave, Professor, Department of Psychology

How accurately people perceive interpersonal relationships, both among others and with themselves, forms the basis of social inferences about the structure of the social environment and one's place in it. Six hypotheses were tested using the cognitive social structures method from social network analysis with five independent but similar student networks from two universities. Results from all networks were meta-analyzed. Participants gave both their self-reported friendship ratings for every alter in their group and also gave their perceptions of the ratings the other member would give. Perception ratings were correlated to self-report ratings for each participant as a measure of accuracy of social network perception. Participants perceived more structural balance than was present in self-reports in four out of five networks and in the meta-analysis, providing evidence for the balance schema. Attachment anxiety correlated negatively with accuracy for one of the networks but was not statistically significant in the meta-
analysis. Being located in a tightly-knit subgroup reduced overall network accuracy, consistent with the strength of weak ties (SWT) theory, in one network but not in the meta-analysis. In only one network did participants overestimated how central they were, though not significantly in the meta-analysis. Being more central in the social network was unrelated to accuracy, as was the mean social network distance between perceiver and targets. Results provide meta-analytic support for the balance schema and limited support for attachment, SWT, and egocentric bias in social network perception.
Esse est percipi. [To be is to be perceived.]

—George Berkeley, *Treatise Concerning the Principles of Human Knowledge* (1710)

“Et tu, Brute?” were the famous last words of Julius Cesar, who at the height of his power was loved and honored throughout Rome, or so he thought (Shakespeare, 1599/1997). He did not correctly see nascent, secret alliances within the Senate—it was a conspiracy that ended with his closest friend stabbing him in the back. A conspiracy is a task-oriented network with secrecy as one of its paramount concerns, so it is understandable that someone even as politically savvy as Cesar did not see it coming. Perhaps if he were so socially observant as to detect the conspiracy, history would have a different story to tell.

How accurately people can see the social connections of others is not only a concern of politicians and dictators, it is a skill necessary to navigate social life for anyone. Sometimes perceiving just one relationship correctly is all that is needed. Are they friends or lovers? is the question the amorous wonder of the attractive in nightclubs across the world. Do they really like each other or are they just faking? can be heard in any office anywhere. When scaled up to larger networks of individuals, power often takes center stage: Who really runs the company? Whose unofficial approval is
necessary? Who are the players, and who cannot get into the game? Subgroups and their interconnections are especially important in larger groups. The sociopolitical structure of the U. S. Congress can be described as two parties; which chamber, which state, or which district are arguably less important.

An individual’s social relationships are not merely the aggregation of dyads, but dyadic perception is where social perception begins. The presence of higher-order structures, such as triads and cliques, may also affect perceptual accuracy in addition to the placement of perceivers and targets within the larger social space. A sufficiently inclusive analysis necessitates a methodological approach that can comfortably move across these levels. Social network analysis is just such an approach, and it is the organizing methodology behind this dissertation. Therefore, I will explore substantive questions in terms of the accuracy of social network perception.

Social network analysis is a data analysis technique founded on the principle of structuralism, where the pattern of relationships among people itself is presumed to have psychological impact beyond individual differences or the nature of the relationships themselves. The pattern of what are called relational ties, those cognitive, affective, or behavioral bonds linking dyads in some manner such as friendship, form the network’s structure, much like in chemistry, where the structure of bonds among elements forms compounds.

Consider, for example, a company’s formal organizational chart, which is just a graph of the explicit, formal power relation. It most likely shows a classic hierarchical structure: a boss at the top above cascading levels of power distributed among more and
more managers at each level. If this company engages in complex work in a labile environment, the hierarchy itself will impair performance (Cummings & Cross, 2003). The reason was that such non-routine tasks require greater information processing, which requires lateral integration across the organization. If workers want to traverse the hierarchy, perhaps to coordinate with another division, they will have to go up, across, and then down—no small feat in a bureaucracy. Even after controlling for mean level of communication, the hierarchy itself impeded information processing. Ironically, such uncertain environments are also most likely to evoke these highly centralized groups (Argot, Turner, & Fichman, 1989). This is a structural effect beyond any of the qualities of the individuals or even the qualities of the ties themselves—the effect is due to structure alone. Of course, the real power network often differs from the organizational chart, and that network is, in some way, in each person’s underlying perceptions. It is a central assertion of this dissertation that the variance of those perceptions among people is not random but derives from cognitive, affective, and behavioral influences and is even affected by the network structure itself.

The difference between one’s perception of a social network and that network’s real structure represents perceptual accuracy. There are two ways to conceptualize this variance. Of interest to all social scientists is the perspective that the difference between perception and self-reported reality is measurement error, which researchers often seek to minimize. This is a concern especially for anthropologists who often must rely on individual informants to ascertain the structure of larger social groups.
An alternate perspective, the one adopted here, is that the perception-reality variance is itself of substantive interest. Rather than considering this variance to be random measurement error to be forgotten in an error term, perhaps this variance represents systematic functioning of the perceptual apparatus itself. What can account for this variance? Why does it occur? Answers to these questions inform our understanding of one of the most amazing aspects of human society: social cognition and how individuals construct their social perceptions amid social reality (Berger & Luckman, 1966).

The following sections will review the literature on the three broad classes of predictors that can account for accuracy in social network perception: cognitive, affective, and structural. The cognitive dimension suggests two active biases. The balance schema leads people to impose a preconceived view of social structure. The egocentric bias leads people to overestimate how central they are in their own networks. The affective individual difference of attachment anxiety affects the sensitivity of social perception. The structural dimension, where the social environment itself gains primacy, includes the social location of perceivers. Finally, the topology of the network itself impacts how easily social information flows through the network such that free-flowing networks will be easier to perceive. Together, these three dimensions—the cognitive, the affective, and the structural—predict individuals’ accuracy of social network perception.

The organizing principle of this dissertation is a cognitive-affective-structural model of social network perception. The hypotheses derived from this model will be
tested using an advanced social network analysis technique called *cognitive social structures* (CSS), first used by Krackhardt (1987) in a study of the management team of a Silicon Valley company. The essential feature of the CSS design is that each person provides his or her own view of the entire social network, including his or her own immediate ties as in conventional sociometry. These data permit the comparison of the self-reported social network, represented by the traditional sociogram, to each person’s unique perception of that reality. The discrepancy between the two networks yields each person’s perceptual accuracy. Using this method, I can empirically and statistically test the hypotheses presented below.

**Social Perception: Definition and History**

The study of social perception is dominated by person perception, or how accurately one person can perceive the qualities of another (Cronbach, 1955). The question of how accurately one person can perceive another’s social relationships is entirely different, which some authors call *metaperception* (Kenny, Bond, Mohr, & Horn, 1996). Applications include the study of social support, where it is the individual’s perception of how supportive others are that produces effects (Lakey & Cassady, 1990). Additional applications include depression and loneliness, for according to Beck’s depressogenic triad, dysfunctional cognitions and perceptions are the root of the problem (Gotlib & Krasnoperovna, 1998). Applications outside psychology emphasize organizational dynamics, particularly the dynamics of power and reputation (Kilduff & Krackhardt, 1994; Krackhardt, 1990). Within these research programs, the study of the accuracy of social network perception is often ancillary.
Social network perception was not addressed directly until Newcomb (1961) collected data that contained the necessary information—not just who liked whom but also who each person thought each other person liked. In his classic study of 17 men living in a fraternity house rent-free in exchange for study participation, Newcomb’s primary finding was the similarity-attraction effect. However, he also found that, when rank-ordering attraction to other members of the house, most people could estimate someone else’s affiliation preferences with reasonable accuracy (mean accuracy $\rho = .49$ computed from data on Newcomb, 1961, p. 101). Accuracy increased if the perceiver was highly attracted to the sender of the relation, a finding supported by a replication (Curry & Emerson, 1970). Further, accuracy improved for nearly all perceivers with increasing acquaintance to the sender, a finding confirmed by a much later study (Heald, Contractor, Koehly, & Wasserman, 1998).

Interest in the question languished until Krackhardt (1987) responded to a series of studies by Bernard, Killworth, and Sailer (BKS; 1981) showing that informants’ reports of their own behavior seldom corresponded to what they actually did. If people’s reports of their own behavior suffered such error, then using the anthropological practice of using informants would surely entail even more error. Krackhardt’s argument was to highlight the difference between cognitive representations, such as self-reports, and actual behavior with regard to data and theory. For testing cognitive theories, cognitive data of the sort BKS decried would work just fine. What made this paper so important was that he also collected social perception data similar to Newcomb’s (1961) and formulated an analysis technique, which permitted comparison
between the social network each person perceived and the conventional sociometric network formed by each person’s self-reports.

Kenny, Bond, Mohr, and Horn (1996) developed an alternate approach based on analysis of variance decomposition. For every tie, three persons provide their own judgment of the tie: the perceiver, the sender (called judge), and the receiver (called target). ANOVA main effects represent each actor, and there are four interactions for a total of seven terms. The correlation between the perceiver term and the judge term represents accuracy. The results of their analyses of five data sets revealed that perceivers demonstrated substantial accuracy. Kenny et al.’s generalized round robin design is similar to Krackhardt’s (1987) method in that both analyze correlations to assess perceptual accuracy.

What Is Accuracy and How to Measure It

The early studies on accuracy of self-reported communication and social network behavior operationalized accuracy as the difference between what people self-reported and what they actually did as recorded via some other method such as phone or e-mail records (Bernard, Killworth, Kronenfeld, & Sailer, 1984). Shortly after these studies, social scientists wondered that if self-report accuracy of one’s own behavior is so inaccurate, what would be the cognitive accuracy of observing other people’s social behavior? Complicating matters, investigators began asking questions of social relevance that were not as objectively verifiable as contact frequency, such as subjective feelings of friendship. This approach took the measurement of accuracy off the gold standard of independent behavioral observation, creating the need for a method, data
structure, and analytic technique that could compare social perception accuracy against some standard.

In an effort to avert confusion, I will elucidate the difference between accuracy and perceptual congruence (also called consensus). Accuracy, much like in target shooting, is how closely an estimate gets to a target. Perceptual congruence is the degree of agreement between two people without regard for whether their perceptions are accurate (Turban & Jones, 1988). As Kenny (1991) pointed out, congruence and accuracy are different, yet the two can be related. Specifically, highly accurate perceivers will also have high perceptual congruence, for they are all converging on the same target. However, they are two different issues.

To illustrate, Heald, Contractor, Koehly, and Wasserman (1998) used a CSS design in their analysis of the predictors of perceptual congruence, not accuracy. Essentially, each participant’s perception of the network was compared to every other participant’s for similarity in perceiving the network ties. Congruence for each of the \( n(n-1)/2 \) possible pairs was computed as the number of ties where both perceivers agree. The resulting congruence matrix contained numbers measuring the amount agreement. Importantly, the investigators made no effort to verify participants’ perceptions with either the actual senders or the actual receivers of the ties being judged. It was possible that two participants could be highly congruent but also wrong about any particular tie, and this is the crux of perceptual congruence. The consensus network shred between pairs of perceivers could be quite different from one pair to next, as well as different from what the actual senders of those ties self-report.
By comparison, the present study assesses how closely each perceiver can estimate the self-report network, the conventional sociometric graph (Moreno, 1934). For any particular tie in question, all perceivers attempt to hit the same target, which is what the sender of the relation self-reports. Given that all perceivers are attempting the same thing, to what extent they succeed is perceptual accuracy against the self-report standard. Use of the term *accuracy* in this manner is widely accepted practice (Albright, Forest, & Reiseter, 2001; Austin, 2003; Bondonio, 1998; Casciaro, 1998; Casciaro, Carley, & Krackhardt, 1999; Freeman, Romney, & Freeman, 1987; Johnson & Orbach, 2002; Kenny, Bond, Mohn, & Horn, 1996; Kenny & DePaulo, 1993; Krackhardt, 1990).

There is debate about the use of the term *accuracy* but in a different context. The debate centers on studies of person perception where the target person did not self-report. If the target did self-report, then it is called *self-peer accuracy* (Kenny, 1991). Cronbach’s (1955) famous critique of these difference scores was not that self-peer discrepancy is a bad measure of accuracy “as is sometimes mistakenly thought,” but rather the sources of accuracy should be studied in addition to simply whether or not people are accurate (Kenny, 1994, p. 117). When the self-report is not available, some form of consensus is used as a proxy, which Kenny called *peer-peer accuracy*, and indeed the adequacy of using an average for what should be a self-report is highly debatable (Fiske, 1993; Kumbasar, Romney, & Batchelder, 1994; Romney, Weller, & Batchelder, 1986).

Cognitive Social Structures
While Bernard et al. (1984) found self-reports to be highly inaccurate, Krackhardt (1987) argued that behavioral indicators are not the unquestioned standard of reality. The theoretical basis of inquiry should determine whether behavioral or cognitive measures are definitive. Using behavior as an indicator of a cognitive construct, rather than measuring it directly, introduces a layer of indirection that possibly reduces construct validity or introduces measurement error. For example, using contact frequency as an indicator of friendship includes sources of error not present in self-reported friendship, such as visiting more or less often than one would like due to the vicissitudes of work, family, and so on. Cognitive theories are ascendant in social psychology; thus, cognitive measures of social structure are more appropriate for the operationalization of their constructs. Krackhardt (1987) provided five such measures he collectively called cognitive social structures (CSS). Symbolized $R_{i,j,k}$, where $i$ is the sender of a relation $R$, $j$ is the receiver, and $k$ is the perceiver. In CSS studies, the perceiver is an actor in the network as opposed to an outside observer. This form of social network die is called directed, with a distinction between sender and receiver of the tie, and it is conventionally but not necessarily defined as binary, indicating only whether the relational tie exists, not its value or tie strength. In conventional social network data matrixes, the row is the sender, the column is the receiver, and in a CSS matrix, the layer or table is the perceiver. For example $R_{2,4,6} = 1$ if on a helping relation Actor 6 perceives that Actor 2 gives help to Actor 4, otherwise $R_{2,4,6} = 0$. The resulting three-dimensional data matrix would have a 1 in the cell located at row 2, column 4, layer 6.
For a social network of $N$ actors and $R$ relations among them, CSS data forms a $R(N \times N - I \times N)$ matrix. Not only is this a voluminous amount of data to ask research participants to report, but it presents the question of how to analyze network data in three dimensions. One possibility is to compare two data structures of the same form but representing different relations, such as a friendship relation to an advice relation within the same network. Note that, because these are from the same network, these two relations are likely not independent, violating a central assumption of the General Linear Model (Cohen, Cohen, West, & Aiken, 2003). A common solution is to use Quadratic Assignment Procedure regression, which calculates standard errors from an empirical comparison distribution derived by repeated random permutation of the data matrix, essentially a nonparametric sampling distribution (Krackhardt, 1988). Though this solves the nonindependence problem, analyzing a three-dimensional matrix is an unusual challenge. One approach, particularly suited to the analysis of social perception, is to reduce the data to two dimensions or aggregations. Krackhardt’s (1987) aggregations are called slices, locally aggregated structures (LAS), and consensus structures (CS).

A slice from the three-dimensional data structure is where the perceiver is held constant, a single layer from the CSS matrix. Recall that in the CSS data matrix, rows list the senders of the ties, columns list the receivers, and each layer or slice is the perceiver of those ties. Therefore, a slice is a square matrix of ties sent and received, and it contains data on the entire network solely from one perceiver’s perspective. For example, Heider’s (1958) balance theory is restricted to whether someone, called ego,
perceives a pattern of balanced ties among one’s friends, called *alte®rs*. Whether the friends agree with ego’s perception is largely irrelevant to the theory, for it is the perception of balance or imbalance that affects strain. This form of egocentric network data is also easier to collect, though it may be a scientifically costly expedient if social reality beyond one person’s comprehension is at all important to the theoretical question. Slice data are by definition filtered through the perceptions of a single actor, which may be affected by unique biases or the social situation that informant occupies. Hence, the derived data may have limited external validity.

For example, Stokes (1985) used slice data (before the term was invented) to test the hypothesis that personal networks of lonely people have a lower density of ties among their friends. Each participant completed a slice matrix of their 20 closest friends, indicating who was a friend of whom. In CSS terms, the senders and receivers of the friendship relation were all friends of ego (by ego’s self-report), but the perceiver of these 180 possible undirected ties was ego. None of the senders or receivers participated in Stokes’s study, so these data showed only how participants perceived their friendship networks. Indeed, lonely participants (aka, ego or the perceiver *k*) reported less dense personal networks than nonlonely participants. Unfortunately, Stokes’s interpretation exceeded the data by claiming lonely people really do have less dense friendship networks. Ouellette’s (2004) whole network analysis of loneliness included alters’ reports of those same friendships, rather than just relying on ego’s perception. The relationship between loneliness and density disappeared. Ouellette concluded that lonely people think their friendship networks are less dense even though
they are not, providing suggestive evidence of a perceptual bias among lonely people akin to the dysfunctional cognitions in depression (Gotlib, & Krasnoperova, 1998).

Ouellette’s (2004) data was in the form of another of Krackhardt’s (1987) cognitive social structures: row-dominated locally aggregated structure (RLAS), $R_{i,j,i}$, where the friendship relation from $i$ to $j$ is from $i$’s report, as in traditional sociometry. The corollary column-dominated LAS (CLAS), $R_{i,j,j}$, would be $j$’s report that $i$ considers himself $j$’s friend, especially appropriate for social support research. Both forms of LAS can be combined using either of two rules, the intersection rule $\{R_{i,j,i} \cap R_{i,j,j}\}$ or the union rule $\{R_{i,j,i} U R_{i,j,j}\}$. The intersection rule produces a symmetric matrix where both sender and receiver agree on the directed relation (note this is not reciprocity, which is $\{\text{ego} R_{i,j,i} \cap \text{alter} R_{i,j,i}\}$, where sender, receivers, and perceiver are all different. The union rule relaxes the criterion such that a tie is recorded if either or both members of the dyad report the tie. This form of data is most appropriate when the two actors involved are the best or theoretically most important judges of the relation, as in friendship.

The final aggregation is the consensus structure, where the relation between $i$ and $j$ is judged from all perceivers $k$. This vector of judgments of this one relation from all network actors is reduced to a scalar value by using a threshold function, which establishes some minimum proportion of agreement among the perceivers that the tie exists. The resulting consensus network would be appropriate for the study of prevailing norms or phenomenon that are widely circulated. Krackhardt (1987) argued that the threshold function is a valid and simpler approximation of Romney, Weller, and
Batchelder’s (1986) technique for weighting each participant’s observation according to how “competent” they are.

To address the issue of accuracy of social network perception, each individual’s perception must be compared against some defensible “reality” network. The slice contains an individual’s perceptions, and there is only one other aggregation that most closely matches social reality—the RLAS. Because each perceiver is identifying who likes whom, the perceiver is actually attempting to ascertain the feelings only in the sender of the relation, and the RLAS is constructed solely of each sender’s self-reports of whom they like. The thoughts of the receiver of the relation, as in the CLAS, the intersection, or the union, are irrelevant to how the sender feels, as is some mass of the network as in the CS. Therefore, the slice operationalizes individual perception, and the RLAS operationalizes social network reality. The comparison of the two yields accuracy.

Accuracy is how closely someone’s estimate gets to a target. The slice is each participant’s estimate, and the RLAS is the target. A distance metric operationalizes accuracy in the same way similarity data are analyzed in multidimensional scaling (Borg & Groenen, 2005). Conceptually, accuracy is a question of how similar a participant’s estimate is to a standard. Though there are several from which to choose, the correlation coefficient is most common. It has the three essential features of a distance metric: (a) that the distance cannot be negative, (b) it is symmetric, and (c) that the distance from an object to itself is zero (Wasserman & Faust, 1994).

Three Classes of Predictors
There are three general classes of predictors of accuracy: individual differences, network position, and network topology. The mechanism of all their action is information flow through the network and the extent the individual engages that social environment. Future research can locate additional variables by considering the social network as a communication and influence medium through which social information flows. Potential variables include any individual difference that increases social awareness, such as being motivated to increase one’s accuracy, which the sociometer model suggests should happen to those who experience lowered self-esteem (Leary, Tambor, Terdal, & Downs, 1995). Other potential variables include how well the structure of the network flows information and how efficient local structure affects the individuals in those regions. Because perception ultimately involves both encoding and processing, cognitive mechanisms can bias, particularly when available social information is ambiguous (Green & Sedikides, 2001). Quality and quantity of social information, its encoding, and its processing are the critical points in the system of social network perception.

Actor Attributes

Attachment anxiety. The self-enhancement effect can be construed as placing one’s self in a slightly better light than what one considers the average person, thereby protecting self-esteem. However, not everyone sees the self through such rose-colored glasses. Some people consider themselves to be unworthy of love and caring from others, called attachment anxiety, and this negative self-bias also produces biased social perception.
Bowlby’s (1969, 1973) attachment theory postulates two, orthogonal dimensions, anxiety and avoidance, which derive from respective internal working models. These models are formed through social experience with caregivers in infancy. Though they continue to be modified throughout the lifespan by significant interpersonal relationships, they often become moderately stable by adulthood (Fraley, 2002; Waters, Merrick, Treboux, Crowell, & Albersheim, 2000). The internal working model of self assesses to what extent one’s self is worthy of love and caring, corresponding to the anxiety dimension. The internal working model of other assesses to what extent others are dependable and trustworthy providers of love and affection, corresponding to the avoidance dimension.

A revision to the traditional interpretation of the attachment dimensions forms the basis of its inclusion in this dissertation. The control-systems model of attachment reinterprets anxiety as a social monitoring system and avoidance as a behavioral system (Fraley & Shaver, 2000). High attachment anxiety underlies a tendency toward social vigilance, particularly to cues of abandonment or rejection. This is analogous to a child keeping a watchful eye on the caregiver (i.e., attachment figure). Attachment avoidance, however, guides behavior such that highly avoidant people will inhibit emotional expression and proximity seeking. Thus the control-systems model suggests social perception should be related to attachment anxiety, given its role in social appraisal.

An attachment relationship, as between caregiver and child, is a microcosm of the individual's connection to the wider social universe. Those given to high attachment anxiety are preoccupied with such connection, at once needing its provisions while
fearing its loss. When extended beyond kith and kin, the anxious preoccupation can be considered a driven need to belong to human groups (Baumeister & Leary, 1995) and to obtain love and security in those groups (Rom & Mikulincer, 2003, Study 2). However, the caprices of group life mean that even the most devoted member may find themselves the outcast, and for those who focus on this risk, defense of their membership status requires the development of skills unique to staying in good stead. The best way to solve a problem is to avoid it, and if rejection or abandonment is the problem, then avoiding requires seeing it coming. Therefore, those with a high need to belong should be more accurate in their social perceptions.

Pickett, Gardner, and Knowles (2004) theorized a social monitoring system (SMS) as a counterpart to the sociometer (Leary, Tambor, Terdal, & Downs, 1995). Whereas the sociometer theory claims self-esteem is an indicator of one’s social status, the SMS processes social information with the goal of obtaining inclusion. Participants with a high need to belong were more accurate in perceiving vocal tone and facial expression identification, similar to later findings from participants with few friends (Gardner, Pickett, Jefferis, & Knowles, 2005).

Attachment anxiety shares substantial similarities with the SMS and the sociometer. However, attachment research finds diametrical results, where anxious people were less accurate in perceiving their romantic partner’s feelings, not more (Tucker & Anders, 1999). In one of the first studies to empirically test the appraisal-monitoring interpretation of attachment anxiety, anxious participants perceived greater romantic relationship conflict than non-anxious participants in a two-week diary study,
and the perceived conflict was even more than their partners perceived (Campbell, Simpson, Boldry, & Kashy, 2005). Eliminating the possibility that anxiously attached people are correctly perceiving the high conflict in their relationships, videotaped discussions of a relationship conflict showed anxiously attached participants were more distressed regardless of how supportive their partners behaved. These results suggest attachment anxiety may actually reduce the accuracy of social perceptions, at least in the context of romantic relationships.

A possible reconciliation of these contradictory findings is that daily events have a greater effect on anxious people’s estimates of current and future relationship functioning (Campbell, Simpson, Boldry, & Kashy, 2005). Where securely attached individuals are by definition more sure of their relationships, highly anxious individuals’ beliefs are more tenuous, and they respond with greater attention to the vicissitudes of daily life and a keen eye to abandonment cues. In this sense, perhaps anxious people do pay more attention, as the sociometer and SMS lab findings suggest, yet in the real world, hypervigilance is rewarded with error.

One source of perception error is the amount of evidence upon which judgments are made. For a classmate and potential romantic partner, Zhang and Hazan (2002) asked participants to estimate the number of behavioral instances they would require before either confirming or disconfirming 24 trait judgments. Highly anxious participants required the least behavioral evidence for both confirming and disconfirming interpersonal traits, implying attachment anxiety was associated with quick and possibly unstable social perceptions.
Further evidence for a mercurial perceptual style, a lab experiment showed participants a movie of a face morphing either from neutral to an emotional expression or the reverse and to identify the point where the expression completely appeared or disappeared, respectively (Fraley, Niedenthal, Marks, Brumbaugh, & Vicary, 2006). Anxious participants perceived the appearance and disappearance earlier, and that hypervigilance was associated with errors in perceiving the emotions themselves, regardless of which emotion. To test whether jumping to conclusions was the cause of the error, participants did not stop the movies, but instead watched given amounts, and then made their judgments. Here anxious participants were more accurate than other participants, suggesting that their errors were due to their “hair-trigger” style of social perception, and that when amount of information is held constant, anxious people are indeed more accurate.

However, attachment anxiety often implies greater self-focus, diverting perception resources away from partners (Schachner, Shaver, & Mikulincer, 2005), and negative affect. Those with high social anxiety, when put in a tense situation and given the opportunity to turn their attention toward internal or toward external potential threat cues, focused internally (Pineles & Mineka, 2005). Self-focus is not only related to anxiety but can also be caused by depression (Salovey, 1992). However, more recent investigations have shown that mere mood arousal, regardless of valence as Salovey argued, is not enough to generate self-focus. Green, Sedikides, Saltzberg, Wood, and Forzano (2003) experimentally induced a happy mood, which reduced self-focus, and an induced sad mood increased it. These findings suggest that negative affect causes
attention to turn inward and become narrowed, which in turn reduces the likelihood of perceiving external social information. That reduced access to social information is the theorized mechanism that reduces social perception accuracy.

The attention effects of anxiety and depression are consistent with Fredrickson’s (1998, 2001) broaden-and-build theory, which posits that positive affect broadens the range of possible thoughts and actions people use, so called thought-action repertoires, by increasing approach behaviors, activity, and engagement with the environment. In contrast, negative affect narrows thought-action repertoires. Experimental evidence supports the broaden hypothesis that positive emotions broaden attention, at least with respect to visual perception of global or local elements (Fredrickson & Branigan, 2005), similar to the mechanism that Casciaro, Carley, and Krackhardt (1999) theorized by which positive affectivity produced social network perceptual accuracy. Specifically, they argued that positive affectivity increases global attention at the expense of local attention, resulting in greater accuracy of the global friendship social network but reduced accuracy of the advice local network.

In support of the theory that engagement with the social environment improves accuracy, Casciaro (1998) investigated the individual difference variables of need for achievement and need for affiliation. The principle was that people with a high need for achievement would be particularly sensitive to social information at work, as it is an important element to one’s own achievement potential. Need for affiliation, similar to positive affectivity, represents a person’s social orientation. Those high in the need for affiliation pay attention to social information as a way to facilitate their relationships.
Results showed that both variables predicted cognitive accuracy as measured by the correlation between each perceiver’s slice and the union LAS.

*Cognitive balance schema.* Barlett’s (1932) use of the term *schema* pertains to how people organize information cognitively and use it to interact with the world. Baldwin (1992) argued for the existence of cognitive representations of social relations, *relational schemas*, which are most likely to be activated in ambiguous situations. Several researchers have adapted the schema concept to the perception of social networks, particularly in an ambiguous context.

The most important schema germane to social network perception is the *balance schema* (De Soto, 1960). The balance schema is the tendency to perceive relatively ambiguous social triads as balanced in the Heiderian sense (1958). Heider argued that if a person $P$ likes some other person $O$, then a cognitively balanced state emerges in $P$ if both agree in their attitudes toward some other entity $X$, such as another person. The other balanced state for $P$ is when $O$ likes $X$ but $P$ dislikes them both. Note that cognitive balance is a psychological mechanism in individuals. Cartwright and Harary (1956) extended the concept to graphs of relations among groups of actors, called *structural balance*. *Transitivity* is the graph theoretic concept underlying structural balance where $i \rightarrow j$, $j \rightarrow k$, and $i \rightarrow k$. While traditional balance research focused on positive and negative ties, one of its more modern incarnation is with ties that are either present or absent (Holland & Leinhardt, 1971). The balanced triad and what Granovetter (1973) called the *forbidden triad*, which is imbalanced, are depicted in
Figure 1. The absence of a tie between B and C is highly unlikely, an observation made by Newcomb (1961, p.165) who found that as time went on in his 15-week study, he observed increasing numbers of balanced triads of close friends.

What Heider (1958) and Granovetter (1973) theorized, and Newcomb (1961) observed, Janicik and Larrick (2005) experimentally produced. They used De Soto’s (1960) paired-associates task, which involves flashcards displaying one directed tie from a four-actor network, 12 dyads in all. The participant would guess if that dyad was really present or absent in the network, and the participant would check the answer on the back. After going through all 12 flashcards, they would be shuffled, and the process
would be repeated until the participant was able to get all 12 cards correct twice in a row. How many trials to get to this level of learning was the dependent variable.

Consistent with De Soto’s results, Janicik and Larrick found across all five studies that learning a balanced network took about one-third as many trials as an unbalanced network, even in Study 4, in which participants were explicitly trained to detect unbalanced networks.

Implicit in Janicik and Larrick’s (2005) work was that the participant was not a member of the network being observed, a rarity in social network field studies. Koehly and Pattison (2005) reanalyzed Krackhardt’s (1987) hi-tech managers data set and found evidence for the balance schema, but only when the perceiver was not in the triad. In general, participants perceived both reciprocity and transitivity more than the actual tie partners did. This effect is consistent with schema theory, which postulates that schemas have their greatest effect in situations of limited or ambiguous information, such as observations at a social distance (aka graph theoretic distance or the number of relational ties that have to be crossed to connect two actors).

With the relative ease of learning balanced networks well established in the lab (De Soto, 1960; Janacik & Larrick, 2005) and in the field (Koehly & Pattison, 2005), the next two questions are what mechanism produces this effect and does it match social reality. Freeman (1992a) replicated De Soto’s experiment but recorded the type of errors participants made during the learning task. His results showed that people consistently inserted the “missing” tie that would make an intransitive triad transitive, consistent with the balance schema. This is consistent with Butts’s (2003) finding that,
while people may be reasonably accurate in reporting ties that are actually present, they are quite inaccurate (99% false negatives) in reporting ties that are absent.

To elucidate the cognitive process concerning the third tie, Gawronski, Walther, and Blank (2005) experimentally tested the tendency for people to create balance at an important and ambiguous point in social network organization: when ego has met one source person, learned of that person’s attitude toward a target, but ego has not yet met that target person. If ego liked the source person, and the source person liked the target, then it is in this situation that ego expressed the greatest liking for the target. If ego disliked the source, who in turn disliked the target, ego express great liking for the target, consistent with “the enemy of my enemy is my friend” thinking. In the two situations where there was one positive tie and one negative tie, whether between ego and source or between source and target, ego expressed the least liking for the target, maintaining balance. If the third tie from ego to the target were strongly positive, the unbalanced forbidden triad would result. This demonstrated that Freeman’s (1992a) cognitive process actually occurs in a more mundane setting.

The question of whether this is a legitimate simplification of reality or a gross misrepresentation is more complicated. Freeman (1992b) reanalyzed seven classic interaction frequency social networks to determine their degree of transitivity. If balance is defined as all three ties of the same strength, then he concluded that there was so little transitivity in real informal networks that such a strong theory of balance is untenable. However, Granovetter’s (1973) strength of weak ties theory fit Freeman’s data fairly well. Specifically, there is some tie strength that serves as the minimum
strength for two ties and serves as the maximum for the third, the weak tie. Freeman was able to empirically demarcate strong and weak ties by moving his cutoff stepwise down until just before the third tie disappeared. Placing the cutoff at this tie strength, he was able to recover ethnographic social groups reported in the four informal networks.

Given that strong balance, where all three ties are equally strong, is rare, a balance schema that imputes that missing tie at that strength would be a misrepresentation of reality. But Granovetter’s form of balance, which allows the third tie to be weak, matches informal social networks well. If the imputed third tie Freeman (1992a) observed were allowed to be weak, then such a balance schema would recover many real social subgroups with limited information, arguably the primary function of this schema. Though schemas are cognitive shortcuts, this evidence suggests the balance schema may not miss the target by much.

A particularly complex issue regarding the balance schema is where it has its greatest impact. Krackhardt and Kilduff (1999) meta-analyzed four CSS data sets to compare two balance schema models. The traditional approach, called the *emotional tension model*, is based on Heider’s (1958) claim that the perception of unbalanced regions in the network produces a “disharmony” (p. 204) or tension, and that the closer to ego the unbalanced region is, the greater the tension. It is this tension, greatest at close social distances, that motivates ego to perceive balance. A newer approach, called the *cognitive miser model*, argues that heuristics are used to manage information overload. As group size and distance from ego increase arithmetically, the number of ties to manage increases exponentially. Therefore, there is too much social information
to manage at greater graph theoretic distances, so that is where the balance schema is most likely to be activated. The two models are not mutually exclusive. In fact, a composite model fit the data best, where the biased perception of balance, while controlling for actual balance, was greatest both close and far.

Krackhardt and Kilduff (1999) reconciled their results with Kumbasar, Romney, and Batchelder’s (1994) finding that the perception of balance was greatest when the perceiver was a member of the triad. Though the two analytic methods were different, the key feature was that Kumbasar et al. only compared the balance in ego’s neighborhood (only those alters who were directly connected to ego) to the remainder of the network. Dichotomizing distance prevented the detection of the curvilinear relationship Krackhardt and Kilduff found.

In sum, two field studies found balance schema effects at a close distance (Krackhardt & Kilduff, 1999; Kumbasar, et al., 1994). Seven lab experiments (De Soto, 1960; Freeman, 1992a; Janicik & Larrick, 2005) and one field study (Koehly & Pattison, 2005) found balance schema effects when the perceiver was not part of the triad. Regardless of distance, the balance schema appears to cause perceivers to either insert missing ties or cognitively encode bias about the third actor, producing cognitive balance. However, the tendency to perceive balanced triads is not the only cognitive bias. Next is a summary of how people tend to see themselves as the center of their social worlds.

_Egocentric cognitive bias._ Schemas are not the only source of potentially biased social perception. In addition to the balance schema, and the reciprocity schema it
implies, there is evidence for an egocentric centrality bias. Kumbasar, Romney, and Batchelder (1994) approached the challenge of analyzing three-way data differently than Krackhardt. They used correspondence analysis, a descriptive, exploratory technique similar to factor analysis. Their results showed individuals perceived themselves to be much more central within their own cognitive representation of the network compared to how central they were in others’ cognitive representations or in the mean consensus representation.

A more recent analysis of the ego centrality bias found similar results. Johnson and Orbach (2002) investigated a political network with no clear formal network boundary. The sample of 44 was instead defined as the most commonly nominated actors by five “key actors.”

While Johnson and Orbach (2002) did not report effect size (or the relevant standard deviations for this test), it appears the ego centrality bias was substantial given that about two-thirds of the sample over-estimated their centrality. Further, there was a strong relationship between actor centrality in the real network and accuracy such that central actors were more accurate. Not surprisingly, the ego centrality over-estimation bias was found most among the least accurate actors. Given that the least accurate actors only over-estimated their centrality, and the least accurate were the high-status legislators, the authors suggest that insufficient social information leads people to rely on status. Perhaps surprising is that centrality and status did not go together. In fact, the legislators had the lowest centrality, though the appropriate statistical test was not reported.
More common among social network studies is the hypothesis that network position, regardless of who is in that position, will predict accuracy. The underlying principle is that some network positions afford a better view of the social world and expose the occupants of those positions to greater social information. In this line of research, network analysts favor one of their most successful constructs: centrality.

Inspired by Newcomb’s (1961) finding that social interaction improves social perception accuracy, Bondonio (1998) tested hypotheses predicated on the likelihood of information sharing due to network position. To test these accuracy hypotheses, Bondonio compared each perceiver’s own perception of the network to the actual network. Specifically, the most accurate perceivers were those with the highest degree centrality, which is nothing more than the number of alters to whom ego is directly tied, where ego is the focal actor and alters are those directly tied to ego. Degree is often considered a measure of local activity because it ignores the rest of the network. Additionally, a perceiver’s accuracy improved if the perceiver and the sender were both central. The rationale being that, in addition to central perceivers having a better view, a central sender is a high-profile target.

Casciaro’s (1998) findings echoed Bondonio’s (1998) regarding degree centrality and accuracy, but recall that centrality is often used as an operationalization for being well connected or socially powerful. Her analysis also found that those higher in the organization’s formal power hierarchy were actually less accurate in their social perceptions. This finding was later supported in Johnson and Orback’s (2002) analysis
of a political network, where the legislators, the group with the greatest formal power, were also the least accurate. These findings were at odds with Krackhardt’s (1990) older finding that those people rated by others as having greater reputational power were also the most accurate perceivers. The question was ripe for an experiment, which Simpson and Borch (2005) did using a social exchange paradigm. They found that those in weak positions had greater social perception accuracy, particularly at larger social distances, for weaker actors need to compensate for their peripheral positions by paying closer attention to both close and far ties. Interestingly, a series of experiments demonstrated that power reduces perspective taking, which reduces the accuracy in correctly perceiving another person’s perceptions, cognitions, or affect (Galinsky, Magee, Inesi, & Gruenfeld, 2006). Whether power reduces accuracy or weakness increases it cannot be determined from Simpson and Borch’s experiment because those were only two groups and no control group. Galinsky et al.’s Experiment 3, which did have a control group, showed that power actually reduced accuracy in decoding emotional nonverbal behavior.

Though relatively limited, the existing research on the predictors of how accurately people can perceive a social network has been fruitful. Local network activity, in the form of degree centrality, consistently predicts accuracy. The motivational dimension of need for affiliation is associated with accuracy, as well as the affective element of positive affectivity. All three are consistent with the theory that those who engage their social environments derive more accurate mental representations of others’ relationships.
But what about the environment they are engaging? The cabal to kill Cesar, the 19 hijackers of September 11, the conspiracy to fix prices in the heavy electrical equipment industry—these are all networks that were particularly difficult to detect. Attempts to make these networks less perceptible included changes in the structure of the networks themselves, suggesting that some network structures are more difficult to perceive than others. The next issue I address is one of network topology and how it affects actors’ accuracy.

**Network Topology and Information Flow**

Most models argue that accuracy operates on the mechanism of social information flow. While some predictors include individual differences and network position of the perceiver and target, some network topologies are more efficient at information flow and diffusion, as can be seen in small-world networks, where distant network actors can be reached in relatively few steps (Watts, 1999). Because information flow and social interaction is a consensus-promoting mechanism (Dean & Brass, 1985; Heald, Contractor, Koehly, & Wasserman, 1998), those networks with high information flow should have more members in agreement, due to the efficient communication. The greater agreement among actors suggests such efficient networks are more easily perceived. Therefore, some network topologies should be easier to perceive than others.

The simplest network feature that affects how information flows is simply the graph theoretic *distance* it must travel, the first subject reviewed in this section. While this can be considered for the whole-network, which would be its *diameter,* or the
longest path connecting any two nodes, it can also be considered for each pair of perceivers and senders. Distance is independent of the structural position of where the dyads are located. The research on distance’s negative effect on accuracy consistently shows what might be called a “social myopia,” for people’s awareness does not extend far from themselves in terms of graph distance (Singh, 2005).

But there is a theoretical reason why information tends to be highly localized, and that will be discussed next. Tie strength affects how far information flows as well as how fast. Finally, an especially astute study found evidence that information flow efficiency is the direct result of specific features of network topology. The significance of this finding for cognitive accuracy research is that those network topologies that facilitate information flow should be more readily perceived.

**Distance to sender: Horizon of observability.** Distance in a social network is the number of ties that must be crossed in order to connect two nodes. If two actors are friends, their distance from each other is 1. A friend of a friend is at a graph distance of 2. There are often multiple paths connecting pairs of actors, but distance is always computed with the shortest path available. Whether the geodesic path is most likely to be used to actually connect actors is a substantive question centering on the nature of the theorized flow process (Borgatti, 2005).

The claim that information does not travel far was first demonstrated by Friedkin’s (1983) investigation of the awareness of a person’s job performance. Studying six networks of scientific researchers at two research institutions in three disciplines, Friedkin found that the “horizon of observability” extended to a graph-
theoretic distance of two—a friend of a friend. This means that researchers who were more than two links removed were unlikely to be aware of each other’s work. Supporting with this finding is Kossinets and Watts’s (2006) analysis of 14 million e-mails in a university over a year, which found that people who were separated by a graph distance of three were about 30 times less likely to form a tie than those separated by a distance of two. This observation is further evidence for how information naturally travels in a restricted flow through real social networks.

If awareness of others drops away with increasing distance, as well as the probability of ever making a connection, then distance should have a strongly negative impact on the accuracy of network perception. Bondonio (1998) found that the greater the distance between a perceiver and the actual sender of a relational tie, the less accurate the perceiver was for all that sender’s ties. Very graciously, Simpson and Borch provided a special analysis of distance on perceptual accuracy and found that, as distance increased, accuracy substantially decreased (B. Simpson, personal communication, July 14, 2006).

_Tie strength._ Perhaps one of the most famous papers in social network analysis is on how network structure affects information flow. Granovetter’s (1973) classic paper, “The Strength of Weak Ties,” explained an intuitive principle with scientific and mathematical rigor. Put simply, a person’s strongest, closest, most important relations are strong ties, such as between best friends. Distant, infrequent, unimportant, passing acquaintances are weak ties. Drawing from Heider’s (1958) balance theory, Granovetter deduced that groups of strongly tied people will not only spend much of their time
together, they will also share a great deal of information—the same information. That is, because groups of close friends tend to have substantial overlap in their social networks, they are exposed to the same information coming from other people. Therefore, any piece of information one friend has will quickly find its way to the other friends. The reason is because close friends occupy similar positions in the information flow network. This redundancy of information among strongly tied persons results in strictly localized information flow.

The important corollary to the information redundancy of strong ties is the insight that weak ties make connections to parts of the network (and sources of information) the focal individual most likely does not otherwise have. Thus weak ties are conduits of unique information. The classic finding concerns how people find new jobs. While close friends are most committed to helping in a job search, they are often the least useful. The reason is that job information known by a friend will probably also be known by the job seeker, which can be attributed to the great overlap between the two friends’ information networks. Granovetter (1974, 1983) found that most people found their jobs through weak acquaintances.

Job availability information is seldom under severe restriction, and even when it is, word will get out eventually. Contrast this unrestrained information flow to the situation where information flow is tightly controlled. Lee published a classic work of sociology in 1969 where she detailed how pregnant women located abortion providers. At the time, abortion was illegal. Doctors could not advertise they performed the illicit service, and pregnant women could not openly solicit it. Despite these curbs to
information flow, these women did locate “abortionists.” Acquaintances met during the search successfully led to an abortionist more often than close girl friends, the most commonly attempted source. This real-world finding supports Granovetter’s assertion that information flows rapidly within a localized ambit of close friends but does not travel far without the aid of weak ties.

*Information flow efficiency.* A more structuralist approach to information flow would be concerned with how patterns of interconnection among people affect flow independently of the individuals themselves. However, this requires some measure of flow efficiency. Yamaguchi (1994) mathematically derived a measure of information flow inefficiency as the mean first passage time for a piece of information to flow from every actor to every other actor in the network.

With a clear dependent measure, Yamaguchi (1994) tested structural predictors of flow efficiency. Not surprisingly, the strongest predictor is a traditional network measure called *diameter*. Every possible pair of nodes in a connected network can be reached via potentially many paths. For any pair, the shortest path connecting them is called the *geodesic path*. For all the pairs in a network, the longest geodesic path is the diameter of the network. A network with a large diameter requires information to traverse many links to get completely across. Yamaguchi found that large network diameter reduced flow efficiency, clearly related to the distance effect.

Density is another key topological feature germane to information flow. Global density is simply the number of total network ties given as a proportion of the maximum possible. The greater the density of ties, the more routes through which
information can flow, and Yamaguchi (1994) did find that greater density increased efficiency, but the effect was small. A nonintuitive finding was that local density reduced efficiency. Local density is an attribute of each node, where the standard density calculation is performed only on those nodes and ties incident to ego. Building on Granovetter’s (1973) classic paper that showed how high local density results in localization of information flow, Yamaguchi found that, while controlling for global density, local density exerted a strong, inhibiting effect on information flow efficiency.

For a real covert network example, Krebs (2002) studied the social network connecting the 19 hijackers from the September 11 attacks. He observed surprisingly low global density and large diameter, suggesting a tradeoff between communication efficiency and maintaining secrecy. These two observations of a real covert network show that reducing the information flow efficiency is an effective method of reducing a network’s perceptibility. Baker and Faulkner (1993) argue from data on a price-fixing conspiracy in the heavy electrical equipment industry that needs for secrecy outweigh needs for efficiency.

From these studies, the structure of the network itself can affect how well information flows and, therefore, also the perceptibility of the network. When distances are far, whether between perceiver and sender or for the entire network’s diameter, accuracy suffers—a phenomenon covert networks employ to conceal themselves. But a network structured in a clustered manner shunts social information into dense cul-de-sacs of close friends with little chance of traveling far. When social information becomes so parochial, the flow efficiency of the network degrades, making accurate
perceptions of the network’s structure difficult. Importantly, this is not an effect of any individual difference of even any particular location within the network. Some network structures are revealing, others concealing.

Conceptualization

This dissertation conceptualizes the accuracy of social network perception as lying at the nexus of the cognitive, the affective, and the structural. This integrative approach recognizes individuals as agentic participants in their social worlds without neglecting the impact of the environment itself. Inspired by Lewin’s (1951) field theory of group dynamics, and his formula $B = f(P, E)$, the person factors are the cognitive and affective biases, and the environment is represented by the structural parameters that define its form. Some people, by virtue of their individual differences, will be more or less accurate in perceiving social relationships. Yet as with the conspiracy against Cesar, some social situations are inherently more or less difficult to perceive. Though conspiracy is a special case, there are more mundane structural parameters that can make the social world transparent or opaque.

The larger theoretical context is couched in terms of social information processing theory (SIP; Crick & Dodge, 1994). The first two stages are the focus of this dissertation: encoding of social cues and their interpretation and mental representation. For completeness, the remaining stages, though not a part of this dissertation, are goal selection, response construction, response decision, and behavioral enactment. SIP provides a social-cognitive process model of behavior.
I propose a CSS design study to test the capacity of these variables to predict how accurately people perceive the structure of their own social networks. Due to the substantial participant burden inherent in collecting three-way data from a large network, instead I want to collect data from at least five smaller networks. Actors will give both their own sociometric choices and their perceptions of the choices of all other network members. Each actor’s slice will be correlated to each respective network’s RLAS, yielding an actor accuracy scores, which will be used as the criterion variable. The bivariate relationship between each hypothesized predictor and the criterion will be tested with QAP correlation, a statistical necessity due to dependence in the data. Next, I will briefly enumerate each hypothesis and its rationale.

Attachment anxiety is the appraisal-monitoring system with a hair-trigger sensitivity. Highly anxious people fear abandonment and rejection more so than others. This fear motivates attention to their social surroundings, and though anxious people do pay more attention, their haste in making social inferences leads to error. **Hypothesis 1:** Attachment anxiety will correlate negatively with accuracy.

Engagement operates at the encoding stage of social information processing (Crick & Dodge, 1994), but it does not determine what perceivers will do with the information once they have it. The cognitive dimension posits that the individual is not merely a passive recipient of social information but rather an active constructor of reality. At the interpretation and mental representation phase in SIP, two well known cognitive biases form the basis of the cognitive analysis.
First, the cognitive balance schema fills in missing information according to the rule of thumb that, given three people where two dyads are positively tied friends, the third dyad is also probably friendly. The mechanism behind this active bias is the tendency to insert the missing third relationship, which should yield a social unit that functions smoother. *Hypothesis 2: Participants will perceive greater cognitive balance, in the form of network transitivity, than there is present in the real network.*

Second, egocentric thinking has been reliably shown to lead people to incorrectly overestimate their own intelligence (Beauregard & Dunning, 1998) and the prevalence of their own beliefs (Krueger & Clement, 1994) among other effects. In social network perception, egocentric cognitions lead people to overestimate how central they are in their own networks. *Hypothesis 3: People will perceive themselves to be more central than they really are.* Together, these two cognitive effects demonstrate that, even if people do obtain sufficient and high-quality social information, its processing can be biased. This is important because it highlights perceptual errors as being systematic not random.

Moving to the environmental factors as represented by network structure, there are fortuitous positions within a social network that afford greater access to social information because more of it must flow through these central locations. While it is possible that socially observant people are the ones who gravitate to central positions, much like those low in neuroticism do (Klein, Lim, Saltz, & Mayer, 2004), it is also possible that being in a position of such social access confers perceptual accuracy. *Hypothesis 4: Actors high in centrality will be more accurate than peripheral actors.*
Network topology affects how easily information flows. The simplest element of flow is how far it must travel. The greater the graph distance between a perceiver and the sender of the relation, the less accurate the perceiver becomes. This is based on the observation that social information tends to remain local. *Hypothesis 5: Accuracy will decline with increasing distance between perceiver and sender.*

A more advanced approach to network flow is that some network structures flow information more efficiently. A non-intuitive finding is a trade-off between local and global flow efficiency. When there are numerous and redundant local connections, as with a tightly-knit group of friends, information will travel quickly but within that proscribed ambit. People can only maintain so many relationships, and if someone’s social world is so circumscribed, everyone in the group will likely be sharing already-common information, for they have limited access to the wider social world because they are so focused on their small group. People who occupy such close groups probably have a clear understanding of relationships within the group but also have substantially less accuracy of more distant parts of the larger network. *Hypothesis 6: Actors who have high local density will be less accurate than actors with lower local density.*

The overarching cognitive-affective model of social network perception being tested in this dissertation integrates actor attributes and network structure in the first two stages of social information processing. Individuals and what suits them to accurate social perception are placed within a larger social environment, which is itself analyzed for both the accuracy of its positions and the efficiency with which social information
can flow. The larger principle is that those who engage their social environments will become more accurate in their perceptions, not discounting perceptual biases. However, where people are in their networks and how perceptible those networks are both impact accuracy and are largely beyond individual control. Accuracy demands a motivated person with a good vantage in an efficient social system.
Method

Participants

Forty men and women from the three undergraduate task groups at one university and two graduate task groups at another nearby university participated. Networks 1-3 were undergraduate student groups focused on campus activities. Network 1 was a student events programming board composed of 10 full-time undergraduates elected to terms of one academic year. They produce cultural events for the student body, such as concerts, comedy performances, movies, and dances. Network 2 was the student newspaper editorial staff, comprising the editors for news, opinion, features, and sports. Most members occupy their positions for one academic year. The group was sampled at the end of the spring semester after a major staff turnover. Network 3 was a student government organization for a liberal arts school within the university that promotes interaction among faculty, students, and staff as well as with the wider university. Networks 4 and 5 were subdivisions within a graduate student professional training organization. The two groups represent separate but related majors and provided services to the university and city community while also training the students for their future careers in mental health. Given sampling was done at the end of the spring semester, a substantial proportion of members were unreachable, particularly in Network 5. The overall mean age was 22.48 years (SD = 3.48; see Table 1). The total sample was 40 with 19 nonparticipants.
Table 1

Descriptive Statistics for the Five Network Samples

<table>
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<th>Network</th>
<th>Age M</th>
<th>Age SD</th>
<th>n Males</th>
<th>n Females</th>
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<td>2</td>
<td>7</td>
<td>9</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>26.10</td>
<td>1.10</td>
<td>1</td>
<td>9</td>
<td>10</td>
<td>6</td>
</tr>
<tr>
<td>5</td>
<td>27.60</td>
<td>2.30</td>
<td>4</td>
<td>1</td>
<td>5</td>
<td>4</td>
</tr>
</tbody>
</table>

Racially, there were 36 white participants, 4 Asian participants, and one white participant who also identified as Hispanic. There were no black or native Americans.

Organizational tenure varied considerably (see Table 2). Network 2 and Network 3 were just turning over at the end of the spring semester, so these networks were composed of mostly new members, but there were a few members of longer standing. Both Network 4 and Network 5 had at least completed their first year, but some in Network 4 had been there as long as four years.

Table 2

Tenure Descriptive Statistics for Each Network in Days

<table>
<thead>
<tr>
<th>Net</th>
<th>Tenure Min</th>
<th>Tenure Max</th>
<th>Tenure M</th>
<th>Tenure SD</th>
<th>Tenure Mdn</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>120</td>
<td>1095</td>
<td>476.43</td>
<td>365.99</td>
<td>485</td>
</tr>
<tr>
<td>2</td>
<td>30</td>
<td>635</td>
<td>197.67</td>
<td>227.09</td>
<td>81</td>
</tr>
<tr>
<td>3</td>
<td>51</td>
<td>455</td>
<td>150.11</td>
<td>165.10</td>
<td>60</td>
</tr>
<tr>
<td>4</td>
<td>365</td>
<td>1,460</td>
<td>817.60</td>
<td>379.37</td>
<td>730</td>
</tr>
<tr>
<td>5</td>
<td>354</td>
<td>665</td>
<td>432.20</td>
<td>132.05</td>
<td>365</td>
</tr>
</tbody>
</table>
Measures

Participants provided responses to two types of measures, the individual difference variable of attachment anxiety and the participants’ social network, in addition to demographic information.

Attachment. Attachment was measured using the Experiences in Close Relationships-Revised (see Appendix D for the ECR-R; Fraley, Waller, & Brennan, 2000). The ECR-R measures the two attachment constructs of anxiety and avoidance with 18-items each on 7-point rating scales anchored by 1 = disagree strongly and 7 = agree strongly. Sibley and Liu (2004) showed both subscales have strong internal consistency reliability, avoidance $\alpha = .93$ and anxiety $\alpha = .95$, and approximately 86% shared test-retest variance with a six-week interval. As a demonstration of validity, the ECR-R predicted anxiety and avoidance in diary interactions with romantic partners, friends, and family (Sibley, Fischer, & Liu, 2005).

Social network. Two traditional social network relations were measured: friendship and admiration. The exact wording of the items was determined by a pretest exploratory factor analysis (EFA) of a series of items that measured the same two constructs (see Appendix A). For the two constructs, the item with the greatest loading on the factor was used for the item text. A guideline for the appropriate EFA sample size is a 10:1 ratio of subjects to items (Costello & Osborne, 2005). The pretest sample of 91 university undergraduate students (no gender or age obtained) was adequate for one six-item factor (ratio 15:1) and one four-item factor (ratio 23:1). Participants were instructed to think of someone from their personal social network they have known for
at least one year, to write in that person's first name, and to rate that person on a 9-point scale anchored by 1 = very little or not at all and 9 = very much or a great deal.

Principal components analysis was used to extract the factors (PCA; Park, Dailey, & Lemus, 2002), and the oblique rotation of direct oblimin was selected because it attempts to locate one high loading item while minimizing the remainder—exactly the purpose of this analysis to find the single best item. The PCA results of the six-item friendship relation showed one clear factor with an eigenvalue of 3.55 that accounted for 59.17% of item variance explained by the factor. However, there was a potential second factor with an eigenvalue of 1.36 that accounted for an additional 22.60% of variance. The rotated structure matrix (see Table 3) showed the first four items loaded onto one factor, and the “time” and “talk” items loaded on another, suggesting these two behavioral items tapped an alternate construct. This is not surprising given that behavioral network indicators are often constrained by the limitations of daily life, such as not having the ability to talk to close friends who may live far away, a situation common in residential college samples such as this one (Freeman, 1992b). The item “How much do you consider X to be a personal friend?” had the greatest loading of .91, and it was selected for the friendship relation.
The PCA for the four-item influence relation extracted one factor with an eigenvalue of 2.52 that accounted for 62.90% of the variance in the items (see Table 4). Because only one factor was extracted, rotation was not possible. The component matrix revealed the item “How much do you admire X?” had the greatest loading, .87, so it was selected for the influence relation.

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Component 1</th>
<th>Component 2</th>
<th>Component 1</th>
<th>Component 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friend</td>
<td>.91</td>
<td>.20</td>
<td>.96</td>
<td>-.13</td>
</tr>
<tr>
<td>Close</td>
<td>.88</td>
<td>.46</td>
<td>.90</td>
<td>-.07</td>
</tr>
<tr>
<td>Like</td>
<td>.87</td>
<td>.24</td>
<td>.82</td>
<td>.18</td>
</tr>
<tr>
<td>Confide</td>
<td>.82</td>
<td>.41</td>
<td>.77</td>
<td>.14</td>
</tr>
<tr>
<td>Time</td>
<td>.25</td>
<td>.95</td>
<td>-.08</td>
<td>.98</td>
</tr>
<tr>
<td>Talk</td>
<td>.45</td>
<td>.94</td>
<td>.15</td>
<td>.89</td>
</tr>
</tbody>
</table>

The social network, both for the friendship relation and the influence relation, were rated on a 9-point scale. For the friendship relation, the items were of the following form: “How much do you consider X to be a personal friend?” and “How much does X consider Y to be a personal friend?” For the influence relation, the items

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Component 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Admire</td>
<td>.87</td>
</tr>
<tr>
<td>Respect</td>
<td>.78</td>
</tr>
<tr>
<td>Advice</td>
<td>.76</td>
</tr>
<tr>
<td>Influence</td>
<td>.76</td>
</tr>
</tbody>
</table>
were, “How much do you admire X?” and “How much does X admire Y?” There was also be an option to indicate the absence of a tie for both self-reporters and perceivers. The web application for the data collection web site replaced X and Y with the names of members of the network (see Appendix D). For each relation, all participants responded to \( n(n - 1) \) items. All of the items regarding one relation were asked together followed by all the items of the other relation.

**Procedure**

Once consent was obtained, participants were contacted directly via e-mail with a special link that authenticated and authorized them to enter the data collection web site (see Appendix C), which was not accessible to the public. Participants filled out the ECR-R and proceeded to the network questionnaires. Following Coromina and Coenders (2006) recommendation to order items by question rather than by alter, the first group of items was the egocentric friendship network: “How much do you like Alice? How much do you like Bob?” This was followed by the same relation from the sociocentric view: “How much do you think Alice likes Bob? How much do you think Alice likes Charlie?” This produced the full slice for each participant. The process was repeated with the influence relation. Once all the questionnaires were completed, the participants were thanked at the end.

For the participants in the 10-person Network 4, there were the 36 items from the ECR-R, 90 items for the friendship relation, and 90 more items for the influence relation, totaling 216 items. This took them 32 min to 47 min to complete, and they were instructed to complete the questionnaires in a single sitting. Because the survey is
online, they were free to do it anywhere; however, they were instructed not to discuss any of the items with anyone and to answer the items alone.

**Missing Data**

The database has two tables: the “subject” table contains all attributes of the participants, and the “tie” table contains attributes of the ties (see Appendix A). Because this database was used to send invitation e-mails, it contains the list of all potential participants. With data collection complete, 12 participants who did not participate (i.e., did not log in to the data collection web site) were deleted to facilitate creation of the data files for analysis in Ucinet and SPSS. Further, four participants logged in but did not provide any network data. They looked at the questionnaires and then decided not to participate, so they were deleted as well.

The next step was to extract the network data. Overall, there were 40 participants in each relation. However, some participants did not provide complete data. Some skipped only a few items, while others skipped entire slices. Despite this, even partial data are useful provided they satisfy the nodal inclusion criteria, defined by individual tie properties, called a *line-generated subgraph* (Wasserman & Faust, 1994). Note the substantive criterion variable of this investigation is the correlation as a measure of metric distance between self-reported sent ties of a given relation, $R_{i,j,i}$, and the perception of those sent ties, $R_{i,j,k}$ where $k \neq i$. For a particular tie to be included, it must both be self-reported by its sender, and it must be perceived by someone else, otherwise the criterion measure cannot be computed.
There were 424 self-reported ties for the friendship relation and 421 for the admiration relation, both with the same 40 distinct actors. Table 5 shows the networks range in size from 5 to 10, and the number of self-reported ties for each self-reporter ranges from 8 to 15. Each network’s total number of target ties, $R_{i,j,i}$, ranges from 40 to 150, which form the list of targets each actor attempted to perceive, less their own self-reports. For example, each of the seven actors in Network 1 provided nine self-report friendship ties. Their task was to also provide perception data on all the remaining 54 self-report target ties (63 total self-reports minus that perceiver’s own 9 self-reports), which is discussed below. Therefore, the first DV criterion of self-reports has no missing data for the friendship relation.

Table 5

<table>
<thead>
<tr>
<th>Network</th>
<th>$n$ Distinct senders</th>
<th>$n$ Self-reported ties/sender $R_{i,j,i}$</th>
<th>Total $n$ target ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>9</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>9</td>
<td>81</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>15</td>
<td>150</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>8</td>
<td>40</td>
</tr>
</tbody>
</table>

However, there are three missing data points in the admiration relation. In Table 6, Network 4 had two actors who did not answer all the self-report items. Actor 68 (listed as S68 in the table) omitted two self-reports where the receivers were Actor 67 and Actor 75, and Actor 65 omitted the one self-report where the receiver was Actor 69.
Therefore, the first DV criterion of self-reports shows three missing data points out of 424 for the admiration relation.

Table 6

<table>
<thead>
<tr>
<th>Net</th>
<th>n Distinct senders</th>
<th>n Self-reported ties/sender $R_{i,i}$</th>
<th>Total n target ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>9</td>
<td>63</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>10</td>
<td>90</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>9</td>
<td>81</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>15 but $S_{68} = 13$, $S_{65} = 14$</td>
<td>147</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>8</td>
<td>40</td>
</tr>
</tbody>
</table>

The second criterion for the DV is that a candidate tie must also have some actors perceive it, which by definition means they cannot be self-reports. For the friendship relation, which has 4,749 perceived ties, Table 7 shows all networks have some missing data, totaling 17 missing perception ties.

Table 7

<table>
<thead>
<tr>
<th>Net</th>
<th>n Distinct perceivers</th>
<th>n Perceived ties/perceiver $R_{i,j}$</th>
<th>Total n perceived ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>81 but $S_{36} = 80$</td>
<td>566</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>100 but $S_{55} = 98$</td>
<td>898</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>81 but $Ss$ 43 and 50 = 80</td>
<td>727</td>
</tr>
<tr>
<td>4</td>
<td>10</td>
<td>225 but $S_{65} = 218$, $S_{66} = 223$, $Ss$ 62 and $76 = 224$.</td>
<td>2239</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>64 but $S_{78} = 63$</td>
<td>319</td>
</tr>
</tbody>
</table>

For the admiration relation, which has 3,801 perceived ties, Table 8 shows a problem: Two Network 4 participants did not provide any perception data. In Network 4, Actor 65 and Actor 69 are missing 201 ties, approximately half the perception data.
they should have given. However, Network 1 and Network 5 have no missing perception data. Collectively, there are 211 missing perception ties in the admiration relation.

Table 8  
Perception Tie Counts for Each Network for the Admiration Relation

<table>
<thead>
<tr>
<th>Net</th>
<th>n Distinct perceivers</th>
<th>n Perceived ties/perceiver $R_{i,j,k}$</th>
<th>Total n perceived ties</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>7</td>
<td>72</td>
<td>504</td>
</tr>
<tr>
<td>2</td>
<td>9</td>
<td>90 but $S_{55} = 86, S_{57} = 89$</td>
<td>805</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>72 but $S_{43} = 71$</td>
<td>647</td>
</tr>
<tr>
<td>4</td>
<td>8</td>
<td>210 but $S_{65} = 118, S_{69} = 101, S_{76} = 207, S_{70} = 209$</td>
<td>1565</td>
</tr>
<tr>
<td>5</td>
<td>5</td>
<td>56</td>
<td>280</td>
</tr>
</tbody>
</table>

With 845 total self-reports for both relations, all networks had some varying number of corresponding perceiver reports. However, because not every actor self-reported every possible tie and because perception data was asked for all potential senders—including those who did not ultimately participate—there were 18 senders for whom participants gave perception data yet did not have a matching self-report. Of the 4,749 friendship perception ties, 1,505 did not have a matching self-report to verify against for accuracy, yielding 3,244. Of the 3,801 admiration ties, 1,097 did not have a matching self-report to verify against for accuracy, yielding 2,704. Note these 2,602 perception data without matching sender data cannot be used in this accuracy analysis; however, they could be used in a perceptual congruence analysis because no one tie is more important than the others.
The final data set is the union of these two sets, 845 self-reports and 5,948 perceptions across all organizations and relations. Therefore, there are 6,793 total tie reports that satisfy both DV inclusion criteria, where each tie has both a self-report and at least one perception report. Table 9 shows the numbers of ties for each relation for each organization. To reiterate, there were 424 total unique friendship ties and 421 total unique admiration ties. This is not the count of specific tie reports, whether self-report or perception, but rather are the counts of the structural relations $R_{ij}$ from sender $i$ to receiver $j$.

Table 9

<table>
<thead>
<tr>
<th>Network</th>
<th>Friendship ties</th>
<th>Admiration ties</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>440</td>
<td>441</td>
<td>881</td>
</tr>
<tr>
<td>2</td>
<td>808</td>
<td>715</td>
<td>1523</td>
</tr>
<tr>
<td>3</td>
<td>727</td>
<td>647</td>
<td>1374</td>
</tr>
<tr>
<td>4</td>
<td>1494</td>
<td>1154</td>
<td>2648</td>
</tr>
<tr>
<td>5</td>
<td>199</td>
<td>168</td>
<td>367</td>
</tr>
</tbody>
</table>
Results

The six hypotheses being tested involve the computation of the following network variables, performed with Ucinet (Borgatti, Everett, & Freeman, 2002): accuracy, slice and RLAS transitivity and betweenness centrality, and RLAS egocentric out-directed density (see Table 10). Recall each actor’s slice represents that participant’s perception of the entire network, and the RLAS is synonymous with traditional network data where each sent tie is self-reported by the sender and, therefore, represents social reality. Accuracy is the correlation between each actor’s slice matrix and the respective RLAS matrix, where a high correlation means the actor’s perceptions of what senders would say is close to what those senders actually did say in the RLAS. Transitivity is the percentage of all possible ordered triads in the network that are transitive, and the slice mean of 82.75 is similar to the 79 from similarly egocentric data from the General Social Survey (Louch, 2000). Betweenness is the specific measure of centrality because the social network information flow theory posits that those who have access to ample social information flowing through the network will be more accurate. Betweenness measures to what extent an actor lies between all pairs of other actors, implying actors high in betweenness are switchboards of information flow and have greater access to social information on which to base their perceptions. Unfortunately, the counseling RLAS has no variance in betweenness, making it a constant, along with RLAS egocentric density.
Table 10
Means (Standard Deviations in Parentheses) of Computed Network Variables for the Friendship Relation

<table>
<thead>
<tr>
<th>Net</th>
<th>Accuracy</th>
<th>Slice transitivity</th>
<th>RLAS transitivity(^a)</th>
<th>Slice betweenness</th>
<th>RLAS betweenness</th>
<th>RLAS egocentric density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.35 (0.12)</td>
<td>86.51 (6.34)</td>
<td>80.95</td>
<td>2.44 (3.19)</td>
<td>3.43 (4.13)</td>
<td>46.16 (30.87)</td>
</tr>
<tr>
<td>2</td>
<td>.55 (0.10)</td>
<td>82.31 (5.68)</td>
<td>77.01</td>
<td>1.13 (2.66)</td>
<td>0.56 (0.26)</td>
<td>77.03 (4.52)</td>
</tr>
<tr>
<td>3</td>
<td>.49 (0.13)</td>
<td>85.64 (3.41)</td>
<td>85.07</td>
<td>0.36 (0.51)</td>
<td>2.78 (3.29)</td>
<td>61.40 (6.51)</td>
</tr>
<tr>
<td>4</td>
<td>.60 (0.07)</td>
<td>81.80 (3.99)</td>
<td>76.59</td>
<td>3.46 (10.30)</td>
<td>1.00 (0.80)</td>
<td>55.95 (5.89)</td>
</tr>
<tr>
<td>5</td>
<td>.71 (0.07)</td>
<td>74.99 (5.63)</td>
<td>70.71</td>
<td>0.22 (0.22)</td>
<td>0 (0)</td>
<td>50 (0)</td>
</tr>
<tr>
<td>Total</td>
<td>.53 (0.15)</td>
<td>82.75 (5.88)</td>
<td>77.01 (5.36)</td>
<td>1.66 (5.41)</td>
<td>1.60 (2.57)</td>
<td>59.46 (16.91)</td>
</tr>
</tbody>
</table>

\(^a\)This is a single computed value for the entire network, not a mean, so there is no standard deviation.

Due to the violation of the independence assumption of the General Linear Model, all hypotheses were tested with bootstrapped standard errors, resampled 10,000 times, which is more than the 1,000 resamples conventional in the network literature (Banks & Carley, 1994) and far more than the recommended minimums (Andrews & Buchinsky, 2001; Carpenter & Bithell, 2000; Efron & Tibshirani, 1993). This is to ensure the construction of a well-formed sampling distribution from which to compute the standard error of the estimate and the confidence interval. The inferential statistics used here are confidence intervals.
Recall that Hypothesis 1 argued that those who are high in attachment anxiety, an individual difference variable, would be less accurate in their social perceptions, likely due to hasty judgments resulting from their hypervigilance. Only three of the five networks showed the hypothesized negative correlation (see Table 11). The only significant correlation (two-tailed) was in Network 4. The Network 5 estimate is in the hypothesized direction, but the CI spanned the full range, which is not surprising given the small sample size. Network 3 was also strongly negative, though nonsignificant. Networks 1 and 2 had positive signs but also had small magnitude.

Table 11

<table>
<thead>
<tr>
<th>Network</th>
<th>$r$</th>
<th>$SE$</th>
<th>2.5%</th>
<th>5%</th>
<th>95%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.21</td>
<td>.39</td>
<td>-.71</td>
<td>-.52</td>
<td>.85</td>
<td>.98</td>
</tr>
<tr>
<td>2</td>
<td>.10</td>
<td>.40</td>
<td>-.86</td>
<td>-.66</td>
<td>.62</td>
<td>.71</td>
</tr>
<tr>
<td>3</td>
<td>-.34</td>
<td>.31</td>
<td>-.77</td>
<td>-.72</td>
<td>.26</td>
<td>.41</td>
</tr>
<tr>
<td>4</td>
<td>-.60*</td>
<td>.23</td>
<td>-.89</td>
<td>-.86</td>
<td>-.16</td>
<td>-.01</td>
</tr>
<tr>
<td>5</td>
<td>-.70</td>
<td>.48</td>
<td>-1.00</td>
<td>-1.00</td>
<td>.81</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*two-tailed significant.

In addition to the individual difference variable of attachment anxiety, two hypotheses test cognitive biases in social perception. Hypothesis 2 predicted that participants would overestimate the amount of network transitivity based on the activation of the balance schema. The analysis is a one-sample $t$-test between each actor’s perceived transitivity from their respective slices and the transitivity in the RLAS. The one-tailed test of Hypothesis 2 is that mean slice transitivity is greater than
RLAS transitivity. Note each network only has one RLAS transitivity statistic. Though the mean of each network’s slices was calculated in the usual manner, the \( t \)-statistics were bootstrapped, as well as the standard errors and confidence limits around the slice mean. Observe from Table 12 that in all networks, the mean slice transitivity is numerically greater than the respective RLAS transitivity; therefore, they are all at least in the hypothesized direction. For the more stringent two-tailed test, the 2.5% confidence limit must be greater than the RLAS transitivity value, which is true for all networks except Network 3. A significant two-tailed test implies a significant one-tailed test as well, yet Network 3 does not achieve one-tailed significance (5% confidence limit) either.

Table 12
\[\begin{array}{cccccccc}
\hline
\text{Network} & \text{t(df)} & \text{RLAS} & \text{M}_{\text{slice}} & \text{SE}_{\text{slice}} & \text{2.5\%} & \text{5\%} & \text{95\%} & \text{97.5\%} \\
\hline
1 & 2.32(6)* & 80.95 & 86.51 & 2.21 & 82.48 & 83.03 & 90.33 & 91.17 \\
2 & 2.80(8)* & 77.01 & 82.31 & 1.79 & 78.94 & 79.44 & 85.32 & 85.94 \\
3 & 0.50 (8) & 85.07 & 85.64 & 1.06 & 84.22 & 84.31 & 87.79 & 88.00 \\
4 & 4.14(9)* & 76.59 & 81.80 & 1.19 & 79.67 & 79.97 & 83.87 & 84.35 \\
5 & 1.70(4)* & 70.71 & 74.99 & 2.25 & 71.29 & 71.57 & 79.27 & 79.98 \\
\hline
\end{array}\]

*two-tailed significant.

Another cognitive bias in social perception is due to the self-enhancement effect, where people tend to overestimate themselves in some socially desirable way (Leary, 2007), and in individualistic cultures such as in the U.S., one way to see one’s self as being especially central in the social network (Sedikides, Gaertner, & Toguchi). The
test of this hypothesis is a paired samples $t$-test, where the difference between the actors’ slice betweenness centrality and the RLAS betweenness centrality will be greater than zero. The estimate of the mean difference was bootstrapped along with the SEs and confidence limits.

Table 13
Hypothesis 3 Paired-Samples $t$-test, Means (Standard Deviations), Standard Errors, and Confidence Limits for Difference Between Slice and RLAS Centrality

<table>
<thead>
<tr>
<th>Net</th>
<th>$t$ (df)</th>
<th>$M_{slice}$</th>
<th>$M_{RLAS}$</th>
<th>$M_{diff}$</th>
<th>$SE_{diff}$</th>
<th>2.5%</th>
<th>5%</th>
<th>95%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-0.40(6)</td>
<td>2.44 (3.19)</td>
<td>3.43 (4.13)</td>
<td>-0.99</td>
<td>2.26</td>
<td>-5.35</td>
<td>-4.74</td>
<td>2.77</td>
<td>3.43</td>
</tr>
<tr>
<td>2</td>
<td>0.62(8)</td>
<td>1.13 (2.66)</td>
<td>0.56 (0.26)</td>
<td>0.57</td>
<td>0.86</td>
<td>-0.55</td>
<td>-0.51</td>
<td>2.31</td>
<td>2.48</td>
</tr>
<tr>
<td>3</td>
<td>-2.36(8)</td>
<td>0.36 (0.51)</td>
<td>2.78 (3.29)</td>
<td>-2.42</td>
<td>0.97</td>
<td>-4.54</td>
<td>-4.16</td>
<td>-0.67</td>
<td>-0.78</td>
</tr>
<tr>
<td>4</td>
<td>0.74(9)</td>
<td>3.46 (10.30)</td>
<td>1.00 (0.80)</td>
<td>2.46</td>
<td>3.12</td>
<td>-1.25</td>
<td>-1.13</td>
<td>8.98</td>
<td>9.27</td>
</tr>
<tr>
<td>5</td>
<td>2.23(4)*</td>
<td>0.22 (0.22)</td>
<td>0 (0)</td>
<td>0.22</td>
<td>0.09</td>
<td>0.05</td>
<td>0.07</td>
<td>0.37</td>
<td>0.38</td>
</tr>
</tbody>
</table>

*two-tailed significant.

Network 5’s RLAS betweenness had no variance, which artificially made the statistical test significant. For this hypothesis, the slice minus the RLAS was predicted to be greater than zero, given in the $M_{diff}$ column in Table 13. The Network 1 and Network 3 differences are negative rather than positive. The Network 2 mean difference was nonsignificant. The Network 4 mean difference was in the hypothesized direction, yet the confidence intervals are too large (viz., include zero) to reject the null hypothesis, likely due to the substantial difference in variance in the two variables’
means. Overall, there is no support for Hypothesis 3, that participants overestimate their centrality as a form of self-enhancement.

Despite the lack of evidence for bias in perceiving one’s own centrality, one’s structural position within the network could theoretically affect accuracy. If social information flows through the network, then actors situated in high-traffic areas of the social system have greater access to that information. If actors have more information on which to base their social inferences, then that may facilitate accuracy. Hypothesis 4 is that those actors high in betweenness centrality will also be high in perceptual accuracy. Though three correlations are positive, as hypothesized, and Network 3 is nearly one-tailed significant, all are nonsignificant due to high standard errors (see Table 14). Therefore, no networks support Hypothesis 4.

Table 14

<table>
<thead>
<tr>
<th>Net</th>
<th>$r$</th>
<th>$SE$</th>
<th>2.5%</th>
<th>5%</th>
<th>95%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>.45</td>
<td>.43</td>
<td>-.48</td>
<td>-.35</td>
<td>.96</td>
<td>.99</td>
</tr>
<tr>
<td>2</td>
<td>-.17</td>
<td>.44</td>
<td>-.82</td>
<td>-.74</td>
<td>.69</td>
<td>.77</td>
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<tr>
<td>3</td>
<td>.30</td>
<td>.24</td>
<td>-.14</td>
<td>-.04</td>
<td>.77</td>
<td>.83</td>
</tr>
<tr>
<td>4</td>
<td>.23</td>
<td>.33</td>
<td>-.44</td>
<td>-.33</td>
<td>.73</td>
<td>.79</td>
</tr>
</tbody>
</table>

Note. Due to the lack of betweenness variance in Network 5, no correlation can be computed.

Betweenness is only one operationalization for the amount of information flowing across an actor’s position. Another perspective is that information has a flow decay predictable by its distance from its source. Therefore, Hypothesis 5 argues that
the farther in social space a perceiver is from all the other targets, the less accurate they would be.

Table 15
*Hypothesis 5 Correlations, Standard Errors, and Confidence Limits for Mean Distance and Accuracy*

<table>
<thead>
<tr>
<th>Network</th>
<th>r</th>
<th>SE</th>
<th>2.5%</th>
<th>5%</th>
<th>95%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-.56</td>
<td>.45</td>
<td>-.96</td>
<td>-.94</td>
<td>.61</td>
<td>.74</td>
</tr>
<tr>
<td>2</td>
<td>.01</td>
<td>.38</td>
<td>-.76</td>
<td>-.63</td>
<td>.67</td>
<td>.82</td>
</tr>
<tr>
<td>3</td>
<td>.55*</td>
<td>.19</td>
<td>.18</td>
<td>.30</td>
<td>.91</td>
<td>.94</td>
</tr>
<tr>
<td>4</td>
<td>-.23</td>
<td>.27</td>
<td>-.74</td>
<td>-.67</td>
<td>.23</td>
<td>.36</td>
</tr>
<tr>
<td>5</td>
<td>-.16</td>
<td>.56</td>
<td>-1.00</td>
<td>-1.00</td>
<td>.97</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*two-tailed significant.

The only significant correlation is in the opposite direction of the hypothesis (see Table 16). Despite that, three are in the hypothesized negative direction, one is very close to zero. Given this, there is no support for Hypothesis 5 that as mean distance in the RLAS increases, accuracy decreases.

The conformation of the social structure through which information flows moderates flow efficiency. Based on one of the most famous insights in social network analysis, the strength of weak ties theory (Granovetter, 1973), information flows rapidly through a network region of dense ties. Yet networks composed of pockets of high local density often suffer a surprising transmission efficiency inhibition due to that very same high local density. Granovetter suggested that people who maintain dense, local networks do so at the expense of wider connectivity, predicated on the assumption that people can only maintain so many ties. Actors can concentrate their ties locally or
globally, necessarily trading off one for the other due to one’s limits of sociability. With this in mind, Hypothesis 6 claimed that those actors with high egocentric density (local and directed outwardly from ego) would be less accurate in perceiving the entire network compared to those with lower egocentric density.

Table 16

<table>
<thead>
<tr>
<th>Network</th>
<th>r</th>
<th>SE</th>
<th>2.5%</th>
<th>5%</th>
<th>95%</th>
<th>97.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-.50*</td>
<td>.26</td>
<td>-.91</td>
<td>-.87</td>
<td>-.06</td>
<td>.11</td>
</tr>
<tr>
<td>2</td>
<td>.35</td>
<td>.47</td>
<td>-.80</td>
<td>-.71</td>
<td>.78</td>
<td>.83</td>
</tr>
<tr>
<td>3</td>
<td>-.47</td>
<td>.36</td>
<td>-.92</td>
<td>-.86</td>
<td>.26</td>
<td>.36</td>
</tr>
<tr>
<td>4</td>
<td>.10</td>
<td>.23</td>
<td>-.31</td>
<td>-.21</td>
<td>.53</td>
<td>.62</td>
</tr>
</tbody>
</table>

*one-tailed significant.

Note. Due to the lack of RLAS out-directed density variance in the counseling network, no correlation can be computed.

Only the Network 1 correlation was significant in the hypothesized direction and only with a one-tailed test (see Table 16). Network 4’s correlation was small, and the Network 1 correlation was in the wrong direction. The Network 3 correlation was in the hypothesized direction and of similar magnitude to Network 1 but nonsignificant. These results offer limited support for Hypothesis 6, where high local density is associated with reduced accuracy.

Meta-Analysis

Due to the small sample sizes of the networks, the hypothesis tests are all severely underpowered. Sampling error is a study artifact that can be corrected via
meta-analysis cumulation. Each hypothesis had five full replications, and to correct sampling error in this manner is the simplest form of meta-analysis.

This analysis uses a random effects model (Hunter & Schmidt, 2004). Because meta-analysis uses effect sizes, each hypothesis effect needs to be converted into a common metric, and the correlation coefficient was chosen, and the $t$ statistics were converted to $r$'s with this formula: $r = \frac{t}{\sqrt{t^2 + N - 2}}$ (Hunter & Schmidt, 2004, Eq. 7.8).

<table>
<thead>
<tr>
<th>Hypothesis</th>
<th>Weighted $r_M$</th>
<th>$N$</th>
<th>2.5%</th>
<th>97.5%</th>
<th>Sampling Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>-.26</td>
<td>40</td>
<td>-.56</td>
<td>.05</td>
<td>100.00</td>
</tr>
<tr>
<td>2</td>
<td>.63*</td>
<td>40</td>
<td>.41</td>
<td>.84</td>
<td>91.16</td>
</tr>
<tr>
<td>3</td>
<td>.03</td>
<td>40</td>
<td>-.37</td>
<td>.43</td>
<td>67.96</td>
</tr>
<tr>
<td>4</td>
<td>.19</td>
<td>35</td>
<td>-.03</td>
<td>.41</td>
<td>100</td>
</tr>
<tr>
<td>5</td>
<td>-.05</td>
<td>40</td>
<td>-.37</td>
<td>.28</td>
<td>100</td>
</tr>
<tr>
<td>6</td>
<td>-.10</td>
<td>35</td>
<td>-.46</td>
<td>.25</td>
<td>96.67</td>
</tr>
</tbody>
</table>

*two-tailed significant.

The meta-analysis uses the mean correlation as effect size and weights it by sample size, both of which are given for each hypothesis with the 95% confidence interval in Table 17. Of the six hypotheses, only Hypothesis 2 was significant, where perceived slice transitivity was significantly greater than actual RLAS transitivity. Two additional hypotheses approach statistical significance. Hypothesis 1, that attachment anxiety would negatively correlate with accuracy, was nearly significant. Additionally, Hypothesis 4, which posited a positive correlation between centrality and accuracy, was also nearly significant. The lack of statistical significance for Hypothesis 4 is not
surprising given that even the meta-analysis was based on a sample of only 35 due to the lack of variance in the counseling network.

The very small sample sizes imply large sampling error (see Table 17). One goal of meta-analysis is to assist researchers in determining if unstable or contradictory effect size estimates are due to sampling error or the presence of moderators. Hunter and Schmit (2004) suggest that if sampling error can account for more than 75% of the variance in observed effect size estimates, then moderators are unlikely. The meta-analysis for Hypothesis 3, that slice transitivity would be greater than RLAS transitivity, cannot account for enough variance to eliminate the possibility of moderators, yet this test is also known to have a high Type I error rate (Sagie & Koslowsky, 1993).
Discussion

The purpose of this dissertation is to assess predictors of individuals’ ability to perceive others’ social sentiments. Social cognition informed hypotheses about schemas, biases, and attachment. Structuralism formed the basis of the social network information flow theory of social perception. Collectively, this investigation attempted to synthesize findings about individuals and groups into a model of how people see the world and their place in it.

The results only offer limited support for the social network information flow theory of social perception. The small sample sizes and limited variance greatly limited statistical power. Despite this, meta-analytic results support the conclusion that perceived transitivity was greater than transitivity based on self-reports, providing evidence for the balance schema. Participants perceived more transitivity, or structural balance, than was self-reported in four of out the five networks, with the remaining network trending in the hypothesized direction. Theoretically, schemas are activated under conditions of limited information, where people rely on heuristic assumptions instead (Baldwin, 1992). In this case, the rule of thumb is that if two people like each other, and one of them also likes a third, then the other will probably also like that third, yielding Heiderian balance (1958). The rationale is that it is a socially awkward situation if that last tie were missing or negative, and the schema assumes people are motivated to avoid it.
These results are consistent with Koehly and Pattison’s (2005) reanalysis of Krackhardt’s (1987) classic CSS data set and Kumbasar et al.’s (1994) balance schema evidence at close social distance. A meta-analysis of four CSS studies, similar to the present dissertation, also found evidence of the balance schema but only at close and far, not intermediate, social distances (Krackhardt & Kilduff, 1999). The present results are consistent with the close distance findings of Krackhardt and Kilduff, but no comparison can be made to intermediate and far social distances due to the small size of the networks in this dissertation. The present results contribute further evidence to the theory that people perceive greater structural balance than really exists in their social networks. Schemas organize information, and this is evidence that balance is an organizing principle for people and the relationships as well.

Attachment anxiety was inversely related to perceptual accuracy in three out of six networks, with moderate to strong effect sizes, yet only one achieved statistical significance and only at the two-tailed level at that. This is consistent with the hypothesis that greater attachment anxiety is associated with reduced accuracy in social perception. The results are similar to the finding from a diary study that anxiously attached people perceived more conflict in their romantic relationships than their partners (Campbell, Simpson, Boldry, & Kashy, 2005) and also less support than assessed by independent raters (Collins & Feeney, 2004). Similarly, anxious people in a dating relationship were less accurate in perceiving their partners self-reports of love (Tucker & Anders, 1999). The theoretical explanation for this finding is that, though anxiously attached people or otherwise people high in the need to belong, may be more
sensitive to social information in controlled experiments (Pickett, Gardner, & Knowles, 2004), their cursory judgments come with more error. In a movie-morph paradigm, where a face transformed from an emotional expression to neutral and vice versa, participants were asked to stop the movie at the point of emotional expression onset or offset (Fraley, Niedenthal, Marks, Brumbaugh, & Vicary, 2006). Anxiously attached people perceived both earlier than other people, resulting in more perception errors. But when experimenters had anxious participants watch the movie for the same length of time as others, attachment anxiety was associated with greater accuracy, not less.

These results suggest a resolution to the paradox of less accuracy in real relationships but greater accuracy in experiments on decoding accuracy of vocal tone and facial expression (Pickett, Gardner, & Knowles, 2004). Perceptual accuracy could have been an artifact of the control of the experimental situations. In the uncontrolled real world, attachment anxiety’s hypervigilance could lead people turn their attention inward, focusing on their own unmet needs (Schachner, Shaver, & Mikulincer, 2005). When attachment anxiety’s hypervigilance is paired with the finding that such individuals also rely on less evidence for social inferences (Zhang & Hazan, 2002), the social inferences of anxious people may in turn be more tied to variation in daily events and thereby be more unstable as well.

The findings here contribute to the literature on attachment anxiety and accuracy of social perception in two ways. First, the targets were friends or acquaintances rather than romantic partners common in attachment research, suggesting the theoretical mechanism has influence beyond these closest of relationships. Second, these results
pertain to how well one perceives social ties among others as well as the self, not merely sentiments directed at the self. When errors propagate further into the network, anxious people may perceive themselves amid a labile, precarious social network, which could represent a greater risk of rejection than there really exists. In such a potentially threatening social context, the attachment system could be in a chronic state of activation, which could in turn lead to social anxiety disorder (Vertue, 2003).

However, if people with high attachment anxiety could be therapeutically trained to make more cautious social observations based on more evidence than they normally would, they would perceive their social networks as more stable and supportive.

Only one network showed significant evidence of participants perceiving they have greater centrality relative to self-reports from the entire network, yet there was no variance in centrality based on self-reports, making it a questionable result. Two other networks trend in the hypothesized direction, but the remaining two networks trend in the opposite direction. The meta-analytic results are inconclusive. Two studies report this self-enhancement bias in perceiving one’s self as more central than others. Kumbasar, Romney, and Batchelder’s (1994) finding was based on a larger network of 25 actors and used correspondence analysis and defined the center as the centroid, two important methodological differences that could account for the differences in results. Johnson and Orbach’s (2002) analysis was of an even larger network of 44 actors, but perhaps even more important, they analyzed a political network composed of legislators, lobbyists, and the like. They found that more marginal actors over-estimated their centrality, yet this network was defined by people aspiring to social power. The
present results are consistent with other findings that people do not overestimate their own social status for fear of its social opprobrium and negative consequences for belongingness (Anderson, Ames, & Gosling, 2008; Anderson, Srivastava, Beer, Spararo, & Chatman, 2006). Perhaps those so driven be to in social control are most susceptible to self-enhancement, as Joubert (1998) found, suggesting Johnson and Orbach’s results may be limited to this unique quality of their sample.

Consider that centrality is not necessarily equivalent to status, depending on the relation that defines the network, yet some authors suggest enough similarity exists to permit synonymous usage (Bonacich & Lloyd, 2004). If a status characteristic is some attribute that gives rise to inequalities, then network centrality could be tantamount to status (Berger, Rosenholtz, & Zelditch, 1980). Given that centrality is in the eyes of others and implicitly ranks people, then it is a fair operationalization of even the most traditional conceptualizations of status, which are also defined by other people (Goldhamer & Shils, 1939). However, the distinction here is that, rather than people erring in estimating their social rank directly, as in the status research, the error absent here is the individual’s cognitive perception of the social network does not place them more at the center than in the network defined by the aggregate self-reports of all actors. This null effect should not be interpreted due to the limited betweenness variance.

An essential tenet of the information flow theory of social perception is that network structure moderates accuracy due to its effects on access to social information. People high in centrality should be more accurate given their advantageous position, yet the present results do not support this conclusion. Though three out of four correlations
are in the hypothesized direction and of moderate magnitude, with another marginally negative and the fifth without variance, meta-analysis suggests there is too much sampling error to make an inference at the 95% confidence level, though it is close.

Both Bondonio (1998) and Casciaro (1998) found the relationship between centrality and accuracy but using indegree, or the number of ties directed toward ego, instead of betweenness as the centrality index. Indegree is an index of local prominence or how many alters choose ego as a friend, an explicit indicator of inward flow, whereas betweenness consider the entire graph. Given Friedkin’s (1983) horizon of observability, that if social information flow does affect perceptual accuracy, perhaps only local flows are relevant, similar to the circumscribed effects of brokerage (Burt, 2007). Testing this hypothesis with a larger network may produce different results because actors high in betweenness have a relatively shorter distance to others.

Another feature of the network information flow theory is that social information does not flow far, based on Friedkin’s (1983) early findings. Three networks trend in the hypothesize direction, one strongly, but the others are either zero or strongly in the wrong direction. The present analysis used mean distance between perceiver and targets as the predictor of overall accuracy. It is possible this method obscured the relationship between individual distances and accuracy; however, observation would be nested within individuals, necessitating multilevel modeling (Snijders & Bosker, 1999). Somewhat similarly, Bondonio’s (1998) distance finding was computed using a perceiver’s accuracy at estimating all of one target actor’s ties, resulting in $n - 1$ distances and accuracy scores. Also given the small size of the
networks analyzed here, perhaps there was insufficient variance in distance to analyze. Kossinets and Watts (2006) found ties were unlikely to be formed at a distance of three, too great a distance for these small networks.

Based on the strength-of-weak-ties theory (Granovetter, 1973), greater local density should be associated with reduced accuracy overall, owing to the parochial nature of such structure, yet only one network significantly supported this conclusion, with one other of similarly strong yet nonsignificant magnitude. These results are consistent with Yamaguchi’s (1994) simulation model of information flow efficiency, and with Burt’s (1992) concept of structural holes. In networks of high local density, information flows easily within these dense pockets but seldom travels beyond owing to ties missing between the dense subgraph and other regions of the wider graph, the so-called structural holes. Burt (2005) found bridging such a structural hole offers competitive advantages due to access to the opportunity to broker between the groups. Implicit in brokerage is that the two groups’ high internal density comes at the cost of external connection. The results for Network 1 do strongly support this postulate, as does Network 3, though not significantly.

An alternative interpretation for this result is that people with certain psychological traits germane to social perception tend to have higher local density. Confounding the relationship between network structure and accuracy is that particular network structures are more common among people with particular personalities. For example, people socially located inside dense subgraphs tended to espouse stronger in-group social identities and to be more conformist (Burt, Jannotta, & Mahoney, 1998;
Kalish & Robins, 2006). The relationship between social categorization and the out-group homogeneity effect suggests an individual difference explanation for why people in tightly-knit subgroups are less accurate (Park & Rothbart, 1982).

Perhaps the most hobbling limitation of the present investigation is the small sample sizes. This was a necessary trade-off with using the CSS design, where as network size increases linearly, participant burden increases as nearly its cube. This arduous form of comprehensive data is necessary to investigate differences between perceptions and self-reports. Using meta-analysis to combine the samples offers the potential to correct for the substantial sampling error, yet, more would have been better. One advantage to this approach is that if more networks are sampled in the future, they can be added to the meta-analysis. Though the present meta-analytic results only support the balance schema hypothesis, perhaps with additional data, the other hypotheses can be tested with adequate statistical power.

Another strength is the use of attachment anxiety as a predictor of accuracy, though with limited support. This is a contribution to the attachment literature by testing relatively new theorizing about the functions of the attachment dimensions and doing so outside of the usual purview of romantic relationships. These results suggest that attachment’s social implications extend beyond mothers and lovers.

Operationalizing centrality as betweenness rather than degree was a useful variation in testing the effects of structural position on perception. An interpretation is that perhaps self-referential cognitive phenomena, such as the egocentric centrality bias or centrality as expansive vantage, do not extend far into the network. This would add
consonance to the research on social distance. However, schemas could still be relevant at greater distances as a means of filling in the gaps of social knowledge.

Finally, empirically testing the effects of local density on perception has never been done before in this manner and supports simulation findings. Moreover, this forms a unique test of not one but three related theories: the strength of weak ties, structural holes, and the small world. All are synthesized by the idea that a hub-structured network, as in small worlds, admits structural holes, which confer advantage on those who broker them, often with weak ties across densely connected subgroups. The assumption tested by this investigation is that high local density would be purchased at the expense of limited accuracy of the larger social system.

The greatest opportunity for future work lies in handling the difference between perception and self-report. Edwards (1993, 2001) has advanced an incisive criticism of the use of various forms of difference score, including correlation, in the analysis of congruence or similarity. Not only may they reduce reliability, they also impose assumptions that should be hypotheses, discard information from the original data, and have uncertain interpretation. The solution is to quite simply not use them. Instead, where congruence is the predictor, use the original variables in polynomial regression (Edwards, 2002). Where congruence is the criterion, the originals are similarly used in multivariate regression (Edwards, 1995). All forms of similarity, accuracy, congruence, and fit research would benefit from this analysis strategy.

A last recommendation is for the larger methodological direction of social science. Many social theories, including my network information flow theory of social
perception tested here, argue that individuals are not independent of each other. This reciprocal influence is the very subject of social disciplines. We have since moved beyond main effects models to more sophisticated models of variable interaction, yet seldom do we test models of interpersonal interaction. To overcome this, the next phase in methodological development will see the rise of agent-based modeling (ABM; Miller & Page, 2007; Smith, 2007).

One of the greatest obstacles to scientific inference with social networks is the difficulty of performing true experiments. If network structure is theorized to cause some outcome, then an experiment would require the manipulation of the social network. Unfortunately, networks are notoriously difficult to control in the field, and appropriate networks are difficult to create in the laboratory. Further, network structure is not the real cause of social effects in flow models—the real cause is whatever is flowing, and the network moderates its effect. Yet network structure is simply assumed to be a fair proxy for whatever is flowing, so flow theories are typically tested without direct measurement, much less manipulation, of the causal mechanism. ABM actually models the generative process that gives rise to the statistical relationships, with the added advantages of virtually unlimited sample size, control, and iteration—the dynamic quality often lacking in even the most innovative laboratory experiments. A prospect for the future would be to model information flowing through a social network, and compare the model results to empirical data.

The implications of this investigation are that social perception is related, not only to individual differences in cognition, personality, and affect, but also to the social
system itself. The central tenet of the network hypotheses is that social information regarding others’ interpersonal sentiments actually flows from one person to the next via structured relational ties. One person’s perceptions are related to others’ perceptions. What one sees or does not see is not solely the product of the nature of that individual. Instead, both position in the social network and the nature of the social system itself also impinge on individual perceptions. Though people were quite accurate, there was enough error in participants’ apprehension of social structure to permit analysis and wonder. How is it that these small groups of people, who regularly met each other face-to-face, could have such divergent views of the same social world? Differences in perception are due to differences elsewhere. Though it is taken as given that people are different, there is more to a person than what makes an individual. The social environment forms and is formed by those who people it. Attention to this reciprocal relationship between the individual and larger society, each defining and redefining the other, is what these findings compel.

But the social network should not be reified; a map is not the road it depicts. Yet to the extent that the map guides our travels, it is real enough to become a subject of study as its own entity. But whose map should we trust? As social mapmakers, we ask the road builders themselves. Each person builds their own social environment, making this a self-organized system. As new connections are made, others fall into disuse, making this a dynamic system. But we must depart from the metaphor at the most marvelous point: The structure of relational ties affects the structure of other relational ties, making this a complex system. This insight, researched here as Heider’s balance
theory, means one tie depends on two others. Imbalance is only one dynamical force, the motive behind self-organization. The roads to others that people build depend on how they survey the landscape, itself derived from the vision of the individual, the point of view, and the perceptibility of the subject itself. It is a roiling landscape viewed by a wanderer of limited sight. I wonder what people see.

In sum, social network studies are so rooted in the structuralist paradigm that the theories ignore what makes individuals unique. Psychological studies emphasize what is within the individual that they can forget no man is an island. Each has its vision but also its blindness. This dissertation integrates individual differences with social structure and crosses disciplinary lines between psychology and sociology, taking the best each has to offer, and synthesizes them into a model where society comprises real individuals and where individuals compose a real society.
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Appendix A

Please think of a person who is part of your "social network" who you have known for at least 1 year. Please think of that person now, and then rate them on the following scales. It is important that you think of a specific individual as you complete the scales, so please write their first name below:

X is named: ________________________________

Please rate person X on a scale from 1 to 9, where 1 means "very little" or "not at all" and 9 means "a great deal" or "very much." Circle the appropriate number.

How much do you like X?

<table>
<thead>
<tr>
<th>1</th>
<th>2</th>
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<td>Very little</td>
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<td>Very much</td>
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How close are you to X?

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<tr>
<td>Very little</td>
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<td>Very much</td>
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</table>

How much do you confide in X?

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<td>Very much</td>
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How much do you consider X to be a personal friend?

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<td>Very much</td>
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</table>
How much time do you spend with X?

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<td>Very little</td>
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<td>Very much</td>
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How much do you talk to X?

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<tr>
<td>Very little</td>
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<td>Very much</td>
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</table>

How much do you respect X?

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<td>Very little</td>
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</table>

How much do you influence X?

<table>
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<td>Very little</td>
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<td>Very much</td>
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</tbody>
</table>

How much do you go to X for advice?

<table>
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<th>6</th>
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<td>Very little</td>
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<td>Very much</td>
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</tbody>
</table>

How much do you admire X?

<table>
<thead>
<tr>
<th>1</th>
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<th>3</th>
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<th>5</th>
<th>6</th>
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<tbody>
<tr>
<td>Very little</td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
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<td>Very much</td>
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</table>

Thank you for your participation.
Appendix B

Data collection began by entering name, group, and e-mail data into the MySQL database, which used the following schema. It is normalized into two tables because there are two entities, subjects and ties. Each entity has its attributes recorded as columns in its respective table. For example, age is an attribute of the participant, so it is a column in the subject table. Ties are separate entities and should properly be stored in a separate table, where the relation, sender, receiver, perceiver, and tie strength value are all attributes of the ties, not of the participants. The two tables have a defined one-to-many relationship, where one subject may have many ties. The primary key is the column common to both tables that permits their relation, and it is the subject_id column. Below is the Structured Query Language (SQL) code, the language relational databases speak, that fully defines the tables.

```
CREATE TABLE `subject` (  
  `subject_id` int(11) NOT NULL auto_increment,  
  `last_name` varchar(30) default NULL,  
  `first_name` varchar(30) default NULL,  
  `email` varchar(50) default NULL,  
  `organization` varchar(100) default NULL,  
  `age` tinyint(4) default NULL,  
  `sex` tinyint(4) default NULL,  
  `tenure_years` tinyint(4) default NULL,  
  `tenure_months` tinyint(4) default NULL,  
  `tenure_weeks` tinyint(4) default NULL,  
  `tenure_days` tinyint(4) default NULL,  
  `black` tinyint(4) default NULL,  
  `white` tinyint(4) default NULL,  
  `asian` tinyint(4) default NULL,  
  `native` tinyint(4) default NULL,  
  `hispanic` tinyint(4) default NULL,  
  `pa` int(11) default NULL,  
  `na` int(11) default NULL,  
  `panas1` tinyint(4) default NULL,  
  `panas2` tinyint(4) default NULL,  
  `panas3` tinyint(4) default NULL,  
  `panas4` tinyint(4) default NULL,  
  `panas5` tinyint(4) default NULL,  
  `panas6` tinyint(4) default NULL,  
  `panas7` tinyint(4) default NULL,  
  `panas8` tinyint(4) default NULL,  
  `panas9` tinyint(4) default NULL,  
  `panas10` tinyint(4) default NULL,  
  `ecr_avoidance` double default NULL,  
  `ecr_anxiety` double default NULL,  
  `ecrl` tinyint(4) default NULL,  
  `ecr2` tinyint(4) default NULL,  
  `ecr3` tinyint(4) default NULL,
);```
`ecr4` tinyint(4) default NULL,
`ecr5` tinyint(4) default NULL,
`ecr6` tinyint(4) default NULL,
`ecr7` tinyint(4) default NULL,
`ecr8` tinyint(4) default NULL,
`ecr9` tinyint(4) default NULL,
`ecr10` tinyint(4) default NULL,
`ecr11` tinyint(4) default NULL,
`ecr12` tinyint(4) default NULL,
`ecr13` tinyint(4) default NULL,
`ecr14` tinyint(4) default NULL,
`ecr15` tinyint(4) default NULL,
`ecr16` tinyint(4) default NULL,
`ecr17` tinyint(4) default NULL,
`ecr18` tinyint(4) default NULL,
`ecr19` tinyint(4) default NULL,
`ecr20` tinyint(4) default NULL,
`ecr21` tinyint(4) default NULL,
`ecr22` tinyint(4) default NULL,
`ecr23` tinyint(4) default NULL,
`ecr24` tinyint(4) default NULL,
`ecr25` tinyint(4) default NULL,
`ecr26` tinyint(4) default NULL,
`ecr27` tinyint(4) default NULL,
`ecr28` tinyint(4) default NULL,
`ecr29` tinyint(4) default NULL,
`ecr30` tinyint(4) default NULL,
`ecr31` tinyint(4) default NULL,
`ecr32` tinyint(4) default NULL,
`ecr33` tinyint(4) default NULL,
`ecr34` tinyint(4) default NULL,
`ecr35` tinyint(4) default NULL,
`ecr36` tinyint(4) default NULL,
`mtime` timestamp NOT NULL default CURRENT_TIMESTAMP on update CURRENT_TIMESTAMP,
`logged_in` datetime default NULL,
`logged_out` datetime default NULL,
`next_page` varchar(50) default NULL,
PRIMARY KEY (`subject_id`)};

CREATE TABLE `tie` (  
`tie_id` int(11) NOT NULL auto_increment,  
`mtime` timestamp NOT NULL default CURRENT_TIMESTAMP on update CURRENT_TIMESTAMP,  
`relation` tinyint(4) default NULL,  
`sender` int(11) default NULL,  
`receiver` int(11) default NULL,  
`subject_id` int(11) default NULL,  
`strength` tinyint(4) default NULL,  
PRIMARY KEY (`tie_id`)};
Appendix C

An initial e-mail invitation was sent to those who signed consent forms. The PHP code that sent this message is below.

```php
<?php
// For admin use. No session or authentication.
require('db-include.php');
$mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
    printf("Can't connect to MySQL Server. Errorcode: %s
",
        mysqli_connect_error());
    exit;
}

// Get those who have not started or finished.
$stmt = "SELECT subject_id, first_name, last_name, email, organization
      FROM subject
      WHERE next_page IS NULL OR next_page != 'logout.php'";
$result = $mysqli->query($stmt);
$numHits = $result->num_rows;
echo "There were $numHits hits. <br />

// Report what we're sending.
while ($row = $result->fetch_assoc()) {
    echo "<hr />
    First Name: {$row['first_name']} <br />
    Last Name: {$row['last_name']} <br />
    Subject ID: {$row['subject_id']} <br />
    Email: {$row['email']} <br />
    Organization: {$row['organization']} <br />

    $link = 'http://www.davidmouellette.com/login.php?subject_id='
          . $row['subject_id'] . '&invite=' . crypt($row['email']);
    echo "Link: $link
    <br />

    $to = $row['email'];
    $subject = 'Social Network Psychology Study';

    // Here's my message.
    $msg = <<<EOD
    Hello {$row['first_name']} {$row['last_name']},
    Thank you for signing up to participate in the social network study from
    Virginia Commonwealth University and the University of Richmond.
    This e-mail contains a special link to the data collection web site, so
    you can take the online survey you signed up for. It will only take a

    EOD
    
    smtp->send($msg, $to, $subject);
}

exit;
```

// For admin use. No session or authentication.
require('db-include.php');
$mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
    printf("Can't connect to MySQL Server. Errorcode: %s
",
        mysqli_connect_error());
    exit;
}

// Get those who have not started or finished.
$stmt = "SELECT subject_id, first_name, last_name, email, organization
      FROM subject
      WHERE next_page IS NULL OR next_page != 'logout.php'";
$result = $mysqli->query($stmt);
$numHits = $result->num_rows;
echo "There were $numHits hits. <br />

// Report what we're sending.
while ($row = $result->fetch_assoc()) {
    echo "<hr />
    First Name: {$row['first_name']} <br />
    Last Name: {$row['last_name']} <br />
    Subject ID: {$row['subject_id']} <br />
    Email: {$row['email']} <br />
    Organization: {$row['organization']} <br />

    $link = 'http://www.davidmouellette.com/login.php?subject_id='
          . $row['subject_id'] . '&invite=' . crypt($row['email']);
    echo "Link: $link
    <br />

    $to = $row['email'];
    $subject = 'Social Network Psychology Study';

    // Here's my message.
    $msg = <<<EOD
    Hello {$row['first_name']} {$row['last_name']},
    Thank you for signing up to participate in the social network study from
    Virginia Commonwealth University and the University of Richmond.
    This e-mail contains a special link to the data collection web site, so
    you can take the online survey you signed up for. It will only take a
```
short time, and the results will be completely confidential and very helpful.

Please try to complete the survey in a single sitting this week.

IMPORTANT! Please do not click the Back button in your browser at any time.
Proceed forward by clicking the Continue button only. If you click the Back button, you will see an error message. Please reply to this e-mail if you do, and the experimenter will reset the site for you.

To take the survey, just click on the link below between the angle brackets.
Or you can copy the ENTIRE link without the angle brackets and paste it into your Web browser (be sure to include the trailing period if there is one).

<{$link}>

Thank you very much.

David M. Ouellette
Experimenter
EOD;

// Uncomment this section to go live and send.
(hdrs = 'From: experimenter@davidmouellette.com';
  if ( mail($to, $subject, $msg, $hdrs) ) {
    echo "Message sent to " . $row['email'] . "<br />";
  }
} // This goes with the while statement.

// Close connection
mysqli->close();
?>

After two weeks, I sent the following reminder e-mail.

<?php
// For admin use. No session or authentication.
require('db-include.php');
$mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
  printf("Can't connect to MySQL Server. Errorcode: %s\n",
    mysqli_connect_errno());
  exit;
}

// Get those who have not started.
$stmt = "SELECT subject_id, first_name, last_name, email, organization FROM subject";
WHERE next_page IS NULL;
$result = $mysqli->query($stmt);
$numHits = $result->num_rows;
echo "There were $numHits hits. <br />

// Report what we're sending.
while ($row = $result->fetch_assoc()) {
    echo "<hr />
First Name: {$row['first_name']}<br />
Last Name: {$row['last_name']}<br />
Subject ID: {$row['subject_id']}<br />
Email: {$row['email']}<br />
Organization: {$row['organization']}<br />
";

$link = 'http://www.davidmouellette.com/login.php?subject_id=' . $row['subject_id'] . '&invite=' . crypt($row['email']);
echo "Link: $link\n<br/>

$to = $row['email'];
$subject = 'FINAL REMINDER: Social Network Psychology Study';

// Here's my message.
$msg = <<<EOD
Hello {$row['first_name']} {$row['last_name']},

This is the FINAL REMINDER about your participation in the social network study from Virginia Commonwealth University and the University of Richmond. Your participation is very important to this research, and we cannot continue until you complete the brief questionnaire online. This e-mail contains a special link to the data collection web site, so you can take the online survey you signed up for. It will only take about 45 min, and the results will be completely confidential and very helpful.

Please try to complete the survey in a single sitting in the next week.

IMPORTANT! Please do not click the Back button in your browser at any time. Proceed forward by clicking the Continue button only. If you click the Back button, you will see an error message. Please reply to this e-mail if you do, and the experimenter will reset the site for you.

To take the survey, just click on the link below between the angle brackets. Or you can copy the ENTIRE link without the angle brackets and paste
it into your Web browser  (be sure to include the trailing period if there is one).

<$link>

Thank you very much for your participation.

David M. Ouellette
Experimenter
EOD;

// Uncomment this section to go live and send.

    $hdrs = 'From: experimenter@davidmouellette.com';
    if ( mail($to, $subject, $msg, $hdrs) ) {
        echo "Message sent to ". $row['email'] . "<br />";
    }

// Close connection
$mysqli->close();
?>
Appendix D

This appendix contains all the PHP code and HTML used to make the data collection website. When participants click on the link in the invitation e-mail, they were sent to the login.php page, given below, which authenticated and authorized them.

```php
<?php
session_start();
require('db-include.php');

// get the get parameters.
$subject_id = $_GET['subject_id'];
$invite = $_GET['invite'];

// 1. CONNECT
$mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
    printf("Database Connection Failed: %s\n",
        mysqli_connect_error());
    exit();
}

// Construct query.
$sql = "SELECT * FROM subject WHERE subject_id=$subject_id";

// Retrieve the results.
$result = $mysqli->query($sql);

// Get the row.
$row = $result->fetch_assoc();
// magic_quotes_gpc is on at hostgator so stripslashes() is unnecessary.
// Stop Ss trying to redo their answers.
if ( $row['logged_out'] ) {
    exit("You completed this survey on $row['logged_out']. Thank you.");
}

if (crypt($row['email'], $invite) == $invite) {
    // This is the ticket.
    $_SESSION['subject_id'] = $row['subject_id'];
    // These are for the welcome.php page.
    $_SESSION['first_name'] = $row['first_name'];
    $_SESSION['last_name'] = $row['last_name'];
    $_SESSION['organization'] = $row['organization'];

    // Login and redirect to welcome.php
    $timestampQuery = "UPDATE subject SET logged_in=NOW(), "
```

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If authentication failed or if there was any other navigation error, the participant’s web browser would be redirected to this error.html page, which contained a link to e-mail me. That participant would no longer be able to log in again or navigate until I rectified the problem manually.

<html>
<head>
<title>Authentication Error</title>
</head>
<body>
<h1>Authentication Error</h1>
<p>This system cannot authenticate you. Please enter this site by clicking the link you received in your e-mail from the experimenter. Alternatively, you can copy the entire link and paste it into the address bar of your Web browser.</p>
<p>This site requires that "cookies" be enabled in your Web browser. In Microsoft Internet Explorer, click on the Tools menu, then Internet Options, then the Privacy tab. Slide the slider all the way down so it says "Accept All Cookies." Click "OK," and then click the link you were sent again. In Firefox, click the Tools menu, then Options, then Privacy. Check "Accept cookies from sites," then click the link again.</p>
<p>Each link is custom-made for each participant. Do not use anyone else’s, and do not share your link with anyone else.</p>
</body>
</html>
Once authenticated and authorized, each participant’s web browser was redirected to the welcome.php page.

```php
<?php
// Must be first.
session_start();
?>

<html>
<head>
<link rel="stylesheet" type="text/css" href="style.css">
<title>Welcome to the Social Network Perception Study</title>
</head>
<body>
<h1>Welcome to the Social Network Perception Study</h1>
<h2>Hello, <?php echo "{$_SESSION['first_name']}{$_SESSION['last_name']}"; ?></h2>
<p>You are a member of the <strong><?php echo $_SESSION['organization']; ?></strong> group.<br />
<span class="note">If this is not correct, please reply to the experimenter's e-mail explaining what happened, and then <a href="error.html">click here.</a></span></p>
<p>This website contains the questionnaires for the study you signed up to participate in. It should take approximately 45 minutes to complete. We request the following:
</p>
<ul>
<li>Please complete the entire questionnaire in one sitting.</li>
<li>Do not close your web browser while you are doing this study.</li>
<li>Do not discuss the questions or your answers with anyone.</li>
<li>Answer all the questions to the best of your ability, even if you don't know the answer. Just give your best estimate. <em>Do not skip any questions.</em></li>
</ul>
Read the directions at the top of each questionnaire.
After you finish answer all the questions on a page, click the "Continue" button at the bottom to move to the next page.
Do not use your browser's Back button. Proceed forward by clicking the Continue button only.
If you have any problems, reply to the experimenter's e-mail, and we will be glad to help.

Your responses are completely confidential while data collection is ongoing, and afterward, the data will become anonymous. Thank you very much for your participation.

--David M. Ouellette
Experimenter

Click Here to Begin the Study

After reading these instructions, participants began the data collection procedure by first going to the demographics.php page.

Welcome

Please answer the following questions. When you have answered all questions on a page, click the "Continue" button at the bottom. This will take you through the entire survey. If you want to go to a previous page to change an answer, use your browser's Back button, make the change, and click "Continue" again. If you have any questions, reply to the e-mail you received from the experimenter. Thank you for participating.
<input type="hidden" name="form" value="demographics">

<p>What is your sex?<br />
<select name="sex" size="1">
<option></option>
<option value="0">Female</option>
<option value="1">Male</option>
</select></p>

<p>How old are you in years?<br />
<select name="age" size="1">
<option></option>
<option value="16">16</option>
<option value="17">17</option>
<option value="18">18</option>
<option value="19">19</option>
<option value="20">20</option>
<option value="21">21</option>
<option value="22">22</option>
<option value="23">23</option>
<option value="24">24</option>
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<option value="40">40</option>
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<option value="45">45</option>
<option value="46">46</option>
<option value="47">47</option>
<option value="48">48</option>
<option value="49">49</option>
<option value="50">50</option>
<option value="51">51</option>
<option value="52">52</option>
<option value="53">53</option>
<option value="54">54</option>
</select></p>
<p>How long have you been a member of the<br /><?php echo $_SESSION['organization'];?>? <br />Years:</p>
<select name="tenure_years" size="1">
    <option value=""></option>
    <option value="1">1</option>
    <option value="2">2</option>
    <option value="3">3</option>
    <option value="4">4</option>
    <option value="5">5</option>
    <option value="6">6</option>
    <option value="7">7</option>
    <option value="8">8</option>
    <option value="9">9</option>
    <option value="10">10</option>
    <option value="11">11</option>
    <option value="12">12</option>
    <option value="13">13</option>
    <option value="14">14</option>
    <option value="15">15</option>
    <option value="16">16</option>
    <option value="17">17</option>
    <option value="18">18</option>
    <option value="19">19</option>
    <option value="20">20</option>
    <option value="21">21</option>
    <option value="22">22</option>
    <option value="23">23</option>
    <option value="24">24</option>
    <option value="25">25</option>
    <option value="26">26</option>
    <option value="27">27</option>
    <option value="28">28</option>
</select>
<br />

Months:
<select name="tenure_months" size="1">
    <option value=""></option>
    <option value="1">1</option>
    <option value="2">2</option>
    <option value="3">3</option>
    <option value="4">4</option>
    <option value="5">5</option>
    <option value="6">6</option>
    <option value="7">7</option>
    <option value="8">8</option>
    <option value="9">9</option>
    <option value="10">10</option>
    <option value="11">11</option>
</select>
<br />

Weeks:
<select name="tenure_weeks" size="1">
    <option value=""></option>
</select>
<option value="1">1</option>
<option value="2">2</option>
<option value="3">3</option>
<option value="4">4</option>
<option value="5">5</option>
<option value="6">6</option>
<option value="7">7</option>
<option value="8">8</option>
<option value="9">9</option>
<option value="10">10</option>
<option value="11">11</option>
<option value="12">12</option>
<option value="13">13</option>
<option value="14">14</option>
<option value="15">15</option>
<option value="16">16</option>
<option value="17">17</option>
<option value="18">18</option>
<option value="19">19</option>
<option value="20">20</option>
<option value="21">21</option>
<option value="22">22</option>
<option value="23">23</option>
<option value="24">24</option>
<option value="25">25</option>
<option value="26">26</option>
<option value="27">27</option>
<option value="28">28</option>
<option value="29">29</option>
<option value="30">30</option>
<option value="31">31</option>
<option value="32">32</option>
<option value="33">33</option>
<option value="34">34</option>
<option value="35">35</option>
<option value="36">36</option>
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<option value="38">38</option>
<option value="39">39</option>
<option value="40">40</option>
<option value="41">41</option>
<option value="42">42</option>
<option value="43">43</option>
<option value="44">44</option>
<option value="45">45</option>
<option value="46">46</option>
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<option value="48">48</option>
<option value="49">49</option>
<option value="50">50</option>
<option value="51">51</option>
</select>
<br />
Days:
<select name="tenure_days" size="1">
  <option value=""></option>
  <option value="1">1</option>
  <option value="2">2</option>
  <option value="3">3</option>
  <option value="4">4</option>
  <option value="5">5</option>
  <option value="6">6</option>
  <option value="7">7</option>
  <option value="8">8</option>
  <option value="9">9</option>
  <option value="10">10</option>
  <option value="11">11</option>
  <option value="12">12</option>
  <option value="13">13</option>
  <option value="14">14</option>
  <option value="15">15</option>
  <option value="16">16</option>
  <option value="17">17</option>
  <option value="18">18</option>
  <option value="19">19</option>
  <option value="20">20</option>
  <option value="21">21</option>
  <option value="22">22</option>
  <option value="23">23</option>
  <option value="24">24</option>
  <option value="25">25</option>
  <option value="26">26</option>
  <option value="27">27</option>
  <option value="28">28</option>
  <option value="29">29</option>
  <option value="30">30</option>
  <option value="31">31</option>
</select>

What is your race (check all that apply)?
<input type="checkbox" name="black" value="1"> African American
<input type="checkbox" name="white" value="1"> White
<input type="checkbox" name="asian" value="1"> Asian
<input type="checkbox" name="native" value="1"> Native American

Are you Hispanic?
<input type="radio" name="hispanic" value="1"> Yes
<input type="radio" name="hispanic" value="0"> No
Once this form was completed, clicking the “Continue” button submitted the responses to the server, where it was handled by the dissertation.php, which contained all the data handling code. Note that while PHP can support object-oriented programming, its facilities are limited at this time. Therefore, I used a simpler procedural style. The following code constitutes the core of this web application. It is decomposed into a navigation handler, which redirected the participants browser from one form to the next, and a series of data handler functions, which separately validated and scored the data and then sent the data to the database. The db-include.php code is omitted for security reasons; it contains the username and password to the database and was kept outside the document tree of the web server, making it inaccessible to anyone but me and the web application code itself.

```php
<?php
session_start();

require("db-include.php");

$form = $_POST['form'];

// Navigation.
switch ($form) {
    case "demographics":
        $set = scoreDemographics();
        $sql = getUpdate($set);
        store($sql);
        updateNextPage('panas.php');
        header("Location: http://{$_SERVER['SERVER_NAME']}/panas.php");
        break;
    case "panas":
        $set = scorePanas();
        $sql = getUpdate($set);
        store($sql);
        break;
    case "ecr":
        $set = scoreEcr();
        $sql = getUpdate($set);
        store($sql);
        updateNextPage('friendEgoNet.php');
        break;
}
```
header("Location: http://{$_SERVER['SERVER_NAME']}/friendEgoNet.php");

break;
case "friendEgoNet":
    store(scoreNet());
    updateNextPage('friendAlterNet.php');
    header("Location: http://{$_SERVER['SERVER_NAME']}/friendAlterNet.php");
    break;
case "friendAlterNet":
    store(scoreNet());

    // If we have more senders, then go back until they're gone.
    if ( !empty($_SESSION['friendSenders']) ) {
        header("Location: http://{$_SERVER['SERVER_NAME']}/friendAlterNet.php");
    } else {
        updateNextPage('admireEgoNet.php');
        header("Location: http://{$_SERVER['SERVER_NAME']}/admireEgoNet.php");
    }
    break;
case "admireEgoNet":
    store(scoreNet());
    updateNextPage('admireAlterNet.php');
    header("Location: http://{$_SERVER['SERVER_NAME']}/admireAlterNet.php");
    break;
case "admireAlterNet":
    store(scoreNet());

    // If we have more senders, then go back until they're gone.
    if ( !empty($_SESSION['admireSenders']) ) {
        header("Location: http://{$_SERVER['SERVER_NAME']}/admireAlterNet.php");
    } else {
        updateNextPage('logout.php');
        // logged_out updated in logout.php
        header("Location: http://{$_SERVER['SERVER_NAME']}/logout.php");
    }
    break;
default:
    updateNextPage('error.html');
    header("Location: http://{$_SERVER['SERVER_NAME']}/error.html");
function scoreDemographics() {
    $setClause = "";
    foreach ($_POST as $key => $value) {
        // Skip the form name and empty strings
        if ($value == 'demographics' || $value == "") continue;
        // This lets 0 get through correctly.
        if (isset($value)) {
            $setClause .= "$key=$value,;"
        }
    }
    return $setClause;
}

function scorePanas() {
    $panas = $_POST['panas'];

    $paItems = array(1, 12, 17, 3, 9, 14, 10, 16, 5, 19);
    $naItems = array( 2, 4, 6, 13, 8, 11, 15, 18, 7, 20);

    $pa = 0;
    $na = 0;

    foreach ($paItems as $item) {
        if (isset($panas[$item])) {
            $pa += $panas[$item];
        }
    }
    foreach ($naItems as $item) {
        if (isset($panas[$item])) {
            $na += $panas[$item];
        }
    }

    // Begin the SET clause of the UPDATE statement.
    $setClause = "";
    foreach ($panas as $key => $value) {
        if ($value != "") {
            $setClause .= 'panas'.$key.'='. $value . '; '
        }
    }

    // Cat the two dimension scores.
    $setClause .= "pa=$pa, na=$na";

    // Send the SET clause back to caller.
    return $setClause;
}
function scoreEcr() {
    $ecr = $_POST['ecr'];

    // Reverse score items that are actually there.
    $reverseItems = array(18, 22, 3, 7, 15, 17, 19, 21, 23, 25, 29,
                          31, 33, 35);
    foreach ($reverseItems as $item) {
        if (isset($ecr[$item])) {
            $ecr[$item] = 8 - $ecr[$item];
        }
    }

    // Compute avoidance (odd) dimension mean
    $avoidanceSum = 0;
    for ($i = 1; $i < 37; $i += 2) {
        $avoidanceSum += $ecr[$i];
    }
    // This will return a float.
    $avoidance = $avoidanceSum / 18;

    // Compute anxiety (even) dimension mean
    $anxietySum = 0;
    for ($i = 2; $i < 37; $i += 2) {
        $anxietySum += $ecr[$i];
    }
    // Returns float.
    $anxiety = $anxietySum / 18;

    // Begin the SET clause of the UPDATE statement.
    $setClause = "";
    foreach ($ecr as $key => $value) {
        if ($value != "") {
            $setClause .= 'ecr' . $key . '=' . $value . ', 
        }
    }
    // Cat the two dimension scores.
    $setClause .= "ecr_avoidance=$avoidance, ecr_anxiety=$anxiety";

    // Send the SET clause back to caller.
    return $setClause;
}

function scoreNet() {
    // Get the values from the form.
    $values = $_POST['net'];

    $records = 'INSERT INTO tie (relation, sender, receiver, subject_id, strength) VALUES ';
foreach ($values as $value) {
    $records .= "($value),";
}

// Remove trailing comma.
$sql = rtrim($records, ',');
return $sql;
}

function getUpdate($setClause) {
    $sql = "UPDATE subject
           SET $setClause";

    // Remove trailing comma from SET clause.
    $sql = rtrim($sql, ',');
    // Need the leading space.
    $sql .= " WHERE subject_id={$_SESSION['subject_id']}";
    return $sql;
}

// Update navigation field next_page.
function updateNextPage($nextPage) {
    $nextPageSql = "UPDATE subject
                   SET next_page='{$nextPage}' WHERE
                   subject_id={$_SESSION['subject_id']}";
    store($nextPageSql);
}

// Send the stmt to the DB for storage.
function store($stmt) {
    $mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
    if (mysqli_connect_errno()) {
        printf("Can't connect to MySQL Server. Errorcode: %s\n",
               mysqli_connect_error());
        exit;
    }
    $mysqli->query($stmt);
    $mysqli->close();
}

?>

After completing the demographics, participants were presented with the
PANAS, given below in the file panas.php.

<?php
// Must be first.
session_start();
<h1>Positive and Negative Affect Schedule</h1>
<p class="instructions">This scale consists of a number of words that describe different feelings and emotions. Read each item and then mark the appropriate answer. Indicate to what extent you generally feel this way, that is, how you feel on average. Use the following scale to record your answers.</p>
<form method="post" action="dissertation.php">
<input type="hidden" name="form" value="panas">
<p>1. interested</p>
<table border="1">
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
<tr>
<td><input type="radio" name="panas[1]" value="1"></td>
<td><input type="radio" name="panas[1]" value="2"></td>
<td><input type="radio" name="panas[1]" value="3"></td>
<td><input type="radio" name="panas[1]" value="4"></td>
<td><input type="radio" name="panas[1]" value="5"></td>
</tr>
</table>
<p>2. distressed</p>
<table border="1">
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
<tr>
<td><input type="radio" name="panas[2]" value="1"></td>
<td><input type="radio" name="panas[2]" value="2"></td>
</tr>
</table>
</form>
<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>3. excited</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>4. upset</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>5. strong</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>
6. guilty

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[5]&quot; value=&quot;1&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[5]&quot; value=&quot;2&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[5]&quot; value=&quot;3&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[5]&quot; value=&quot;4&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[5]&quot; value=&quot;5&quot;&gt;</td>
</tr>
</tbody>
</table>

7. scared

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[6]&quot; value=&quot;1&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[6]&quot; value=&quot;2&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[6]&quot; value=&quot;3&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[6]&quot; value=&quot;4&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[6]&quot; value=&quot;5&quot;&gt;</td>
</tr>
</tbody>
</table>

8. hostile

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[7]&quot; value=&quot;1&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[7]&quot; value=&quot;2&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[7]&quot; value=&quot;3&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[7]&quot; value=&quot;4&quot;&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[7]&quot; value=&quot;5&quot;&gt;</td>
</tr>
</tbody>
</table>
9. enthusiastic

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[9]&quot; value=&quot;1&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[9]&quot; value=&quot;2&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[9]&quot; value=&quot;3&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[9]&quot; value=&quot;4&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[9]&quot; value=&quot;5&quot;/&gt;</td>
</tr>
</tbody>
</table>

10. proud

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[10]&quot; value=&quot;1&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[10]&quot; value=&quot;2&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[10]&quot; value=&quot;3&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[10]&quot; value=&quot;4&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[10]&quot; value=&quot;5&quot;/&gt;</td>
</tr>
</tbody>
</table>

11. irritable

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[11]&quot; value=&quot;1&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[11]&quot; value=&quot;2&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[11]&quot; value=&quot;3&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[11]&quot; value=&quot;4&quot;/&gt;</td>
<td>&lt;input type=&quot;radio&quot; name=&quot;panas[11]&quot; value=&quot;5&quot;/&gt;</td>
</tr>
<tr>
<td>Very slightly or not at all</td>
<td>A little</td>
<td>Moderately</td>
<td>Quite a bit</td>
<td>Extremely</td>
</tr>
<tr>
<td>---------------------------</td>
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</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

12. alert

13. ashamed

14. inspired
15. nervous

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

16. determined

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

17. attentive

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extremely</td>
<td>Very slightly or not at all</td>
<td>A little</td>
<td>Moderately</td>
</tr>
<tr>
<td>-----------</td>
<td>-----------------------------</td>
<td>---------</td>
<td>------------</td>
</tr>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
</tr>
</tbody>
</table>

18. jittery

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

19. active

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
<th>Quite a bit</th>
<th>Extremely</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>3</td>
<td>4</td>
<td>5</td>
</tr>
</tbody>
</table>

20. afraid

<table>
<thead>
<tr>
<th>Very slightly or not at all</th>
<th>A little</th>
<th>Moderately</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
After the PANAS, participants were presented with the ECR-R, from the file ecr-r.php

```php
<?php
    // Must be first.
    session_start();
?

<html>
<head>
    <title>Experiences in Close Relationships Revised</title>
    <link rel="stylesheet" type="text/css" href="style.css">
</head>
<body>
<h1>Experiences in Close Relationships Revised</h1>
<p class="instructions">The following statements concern how you feel in romantic relationships. We are interested in how you generally experience relationships, not just in what is happening in a current relationship. Respond to each statement by indicating how much you agree or disagree with it. Click the most accurate response.</p>
<form action="dissertation.php" method="post">
</form>
</body>
</html>
```
1. I prefer not to show a partner how I feel deep down.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Radio button]</td>
<td>[Radio button]</td>
<td>[Radio button]</td>
</tr>
</tbody>
</table>

2. I'm afraid that I will lose my partner's love.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Radio button]</td>
<td>[Radio button]</td>
<td>[Radio button]</td>
</tr>
</tbody>
</table>

3. I feel comfortable sharing my private thoughts and feelings with my partner.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[Radio button]</td>
<td>[Radio button]</td>
<td>[Radio button]</td>
</tr>
</tbody>
</table>
4. I often worry that my partner will not want to stay with me.

5. I find it difficult to allow myself to depend on romantic partners.
6. I often worry that my partner doesn't really love me.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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</tr>
</tbody>
</table>

7. I am very comfortable being close to romantic partners.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<tr>
<td>7</td>
<td></td>
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</tr>
</tbody>
</table>

8. I worry that romantic partners won't care about me as much as I care
9. I don't feel comfortable opening up to romantic partners.

10. I often wish that my partner's feelings for me were as strong as my feelings for him/her.
<p>11. I prefer not to be too close to romantic partners.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[10]" value="1"></td>
    <td><input type="radio" name="ecr[10]" value="2"></td>
    <td><input type="radio" name="ecr[10]" value="3"></td>
    <td><input type="radio" name="ecr[10]" value="4"></td>
    <td><input type="radio" name="ecr[10]" value="5"></td>
    <td><input type="radio" name="ecr[10]" value="6"></td>
    <td><input type="radio" name="ecr[10]" value="7"></td>
  </tr>
</table>

<p>12. I worry a lot about my relationships.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[11]" value="1"></td>
    <td><input type="radio" name="ecr[11]" value="2"></td>
    <td><input type="radio" name="ecr[11]" value="3"></td>
    <td><input type="radio" name="ecr[11]" value="4"></td>
    <td><input type="radio" name="ecr[11]" value="5"></td>
    <td><input type="radio" name="ecr[11]" value="6"></td>
    <td><input type="radio" name="ecr[11]" value="7"></td>
  </tr>
</table>
<p>13. I get uncomfortable when a romantic partner wants to be very close.</p>

<p>14. When my partner is out of sight, I worry that he or she might become interested in someone else.</p>

<p>15. I find it relatively easy to get close to my partner.</p>
16. When I show my feelings for romantic partners, I'm afraid they will not feel the same about me.

17. It's not difficult for me to get close to my partner.
<table>
<thead>
<tr>
<th>Agree Strongly</th>
<th>Neutral/Mixed</th>
<th>Disagree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
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<tr>
<td></td>
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</tr>
<tr>
<td>18. I rarely worry about my partner leaving me.</td>
<td></td>
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<tr>
<td></td>
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<td></td>
</tr>
<tr>
<td>19. I usually discuss my problems and concerns with my partner.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
20. My romantic partner makes me doubt myself.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
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<tr>
<td>[ ] 4</td>
<td>[ ] 5</td>
<td>[ ] 6</td>
</tr>
<tr>
<td>[ ] 7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

21. It helps to turn to my romantic partner in times of need.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ] 1</td>
<td>[ ] 2</td>
<td>[ ] 3</td>
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<td>[ ] 4</td>
<td>[ ] 5</td>
<td>[ ] 6</td>
</tr>
<tr>
<td>[ ] 7</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

22. I do not often worry about being abandoned.

<table>
<thead>
<tr>
<th>Disagree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>[ ] 1</td>
</tr>
</tbody>
</table>
23. I tell my partner just about everything.

24. I find that my partner(s) don't want to get as close as I would like.
<table border="1">
<tr>
<th>Disagree Strongly</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Neutral/Mixed</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Agree Strongly</th>
</tr>
<tr>
<td><input type="radio" name="ecr[24]" value="1"/></td>
<td><input type="radio" name="ecr[24]" value="2"/></td>
<td><input type="radio" name="ecr[24]" value="3"/></td>
<td><input type="radio" name="ecr[24]" value="4"/></td>
<td><input type="radio" name="ecr[24]" value="5"/></td>
<td><input type="radio" name="ecr[24]" value="6"/></td>
<td><input type="radio" name="ecr[24]" value="7"/></td>
</tr>
</table>

25. I talk things over with my partner.

<br />

<table border="1">
<tr>
<th>Disagree Strongly</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Neutral/Mixed</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Agree Strongly</th>
</tr>
<tr>
<td><input type="radio" name="ecr[25]" value="1"/></td>
<td><input type="radio" name="ecr[25]" value="2"/></td>
<td><input type="radio" name="ecr[25]" value="3"/></td>
<td><input type="radio" name="ecr[25]" value="4"/></td>
<td><input type="radio" name="ecr[25]" value="5"/></td>
<td><input type="radio" name="ecr[25]" value="6"/></td>
<td><input type="radio" name="ecr[25]" value="7"/></td>
</tr>
</table>

26. Sometimes romantic partners change their feelings about me for no apparent reason.

<br />

<table border="1">
<tr>
<th>Disagree Strongly</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Neutral/Mixed</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Agree Strongly</th>
</tr>
<tr>
<td><input type="radio" name="ecr[26]" value="1"/></td>
<td><input type="radio" name="ecr[26]" value="2"/></td>
<td><input type="radio" name="ecr[26]" value="3"/></td>
<td><input type="radio" name="ecr[26]" value="4"/></td>
<td><input type="radio" name="ecr[26]" value="5"/></td>
<td><input type="radio" name="ecr[26]" value="6"/></td>
<td><input type="radio" name="ecr[26]" value="7"/></td>
</tr>
</table>
27. I am nervous when partners get too close to me.

<table>
<thead>
<tr>
<th></th>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<tr>
<td>7</td>
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</tr>
</tbody>
</table>

28. My desire to be very close sometimes scares people away.

<table>
<thead>
<tr>
<th></th>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
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<td>7</td>
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</tr>
</tbody>
</table>

29. I feel comfortable depending on romantic partners.

<table>
<thead>
<tr>
<th></th>
<th>Disagree Strongly</th>
<th>Neutral/Mixed</th>
<th>Agree Strongly</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
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<td></td>
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<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
<p>30. I'm afraid that once a romantic partner gets to know me, he or she won't like who I really am.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[29]" value="1"></td>
    <td><input type="radio" name="ecr[29]" value="2"></td>
    <td><input type="radio" name="ecr[29]" value="3"></td>
    <td><input type="radio" name="ecr[29]" value="4"></td>
    <td><input type="radio" name="ecr[29]" value="5"></td>
    <td><input type="radio" name="ecr[29]" value="6"></td>
    <td><input type="radio" name="ecr[29]" value="7"></td>
  </tr>
</table>

<p>31. I find it easy to depend on romantic partners.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[30]" value="1"></td>
    <td><input type="radio" name="ecr[30]" value="2"></td>
    <td><input type="radio" name="ecr[30]" value="3"></td>
    <td><input type="radio" name="ecr[30]" value="4"></td>
    <td><input type="radio" name="ecr[30]" value="5"></td>
    <td><input type="radio" name="ecr[30]" value="6"></td>
    <td><input type="radio" name="ecr[30]" value="7"></td>
  </tr>
</table>
32. It makes me mad that I don't get the affection and support I need from my partner.

33. It's easy for me to be affectionate with my partner.

34. I worry that I won't measure up to other people.
<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[34]" value="1"></td>
    <td><input type="radio" name="ecr[34]" value="2"></td>
    <td><input type="radio" name="ecr[34]" value="3"></td>
    <td><input type="radio" name="ecr[34]" value="4"></td>
    <td><input type="radio" name="ecr[34]" value="5"></td>
    <td><input type="radio" name="ecr[34]" value="6"></td>
    <td><input type="radio" name="ecr[34]" value="7"></td>
  </tr>
</table>

<p>35. My partner really understands me and my needs.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[35]" value="1"></td>
    <td><input type="radio" name="ecr[35]" value="2"></td>
    <td><input type="radio" name="ecr[35]" value="3"></td>
    <td><input type="radio" name="ecr[35]" value="4"></td>
    <td><input type="radio" name="ecr[35]" value="5"></td>
    <td><input type="radio" name="ecr[35]" value="6"></td>
    <td><input type="radio" name="ecr[35]" value="7"></td>
  </tr>
</table>

<p>36. My partner only seems to notice me when I'm angry.</p>

<table border="1">
  <tr>
    <th>Disagree Strongly</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Neutral/Mixed</th>
    <th>&nbsp;</th>
    <th>&nbsp;</th>
    <th>Agree Strongly</th>
  </tr>
  <tr>
    <td><input type="radio" name="ecr[36]" value="1"></td>
    <td><input type="radio" name="ecr[36]" value="2"></td>
    <td><input type="radio" name="ecr[36]" value="3"></td>
    <td><input type="radio" name="ecr[36]" value="4"></td>
    <td><input type="radio" name="ecr[36]" value="5"></td>
    <td><input type="radio" name="ecr[36]" value="6"></td>
    <td><input type="radio" name="ecr[36]" value="7"></td>
  </tr>
</table>
After the ECR-R, participants were then presented with the form for self-reporting the friendship relation, friendEgoNet.php.

```php
<?php
session_start();

// This only needs to be done once at first contact with net pages.
require("db-include.php");
$conn = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
    printf("Can't connect to MySQL Server. Errorcode: %s\n",
        mysqli_connect_error());
    exit;
}
// Get full actors list.
$stmt = "SELECT subject_id, first_name, last_name
    FROM subject
    WHERE organization='{$_SESSION['organization']}'";
$result = $conn->query($stmt);

// Put the receiver info from DB into an MD array.
while ($row = $result->fetch_array()) {
    // Fill the MD array one row at a time.
    // This should add rows as needed.
    $dbActors[] = $row;
}

// Load receivers list in the session for use on every page.
$_SESSION['receivers'] = $dbActors;
```
// My local variable
$receivers = $_SESSION['receivers'];

// Copy receivers to both senders session without the subject.
foreach ($receivers as $potentialSender) {
    if ($potentialSender['subject_id'] != $_SESSION['subject_id']) {
        $senders[] = $potentialSender;
    }
}

// Load the session with both types of senders.
$_SESSION['friendSenders'] = $senders;
$_SESSION['admireSenders'] = $senders;

$result->close();
$mysqli->close();

$tableHeader = ' ';
<table border="1">
    <tr>
        <th>Not at all</th>
        <th>&nbsp;</th>
        <th>&nbsp;</th>
        <th>&nbsp;</th>
        <th>&nbsp;</th>
        <th>&nbsp;</th>
        <th>&nbsp;</th>
        <th>Very much</th>
    </tr>
    <tr>...
</table>

<html>
<head>
<title>Self-Report Friendship Network</title>
<link rel="stylesheet" type="text/css" href="style.css">
</head>
<body>
<h1>Your Personal Social Network</h1>
<p class="instructions">As a member of the <?php echo $_SESSION['organization']; ?>, please indicate to what extent you consider each named person from this group a personal friend of yours. Click the most appropriate response using the provided rating scale. Please answer all questions to the best of your ability.</p>
<p><em>Do not use your browser's Back button from now until the end. Proceed</em></p>

forward with the Continue button only.</p>

<form action="dissertation.php" method="post">
<input type="hidden" name="form" value="friendEgoNet">

<?php
// As many items as receivers. $i is item number, but -1 so don't print it.
for ($i = 0; $i < count($receivers); $i++) {
    $receiver = $receivers[$i];

    // Don't ask reflexive item. This is only for egonets.
    if ($_SESSION['subject_id'] == $receiver['subject_id'])
        continue;

    $value = "{{$_SESSION['subject_id']}},{{$receiver['subject_id']}},{{$_SESSION['subject_id']}}","
    $question = "<p>How much do you consider <strong>{$receiver['first_name']} {$receiver['last_name']}</strong> to be a personal friend?</p>
";

    // Values are relation, sender, receiver, perceiver/subject_id, strength.
    // Clear $tableResponses to avoid accumulation.
    $tableResponses = '';
    for ($strength = 0; $strength < 9; $strength++) {
        $tableResponses .= '<td><input type="radio" name="net" value="0,' . $i . '." value="0," . $value . $strength . '."/>
"</td>';  
    }

    $tableResponses .= "\n</tr>\n</table>\n"
;

    print($question);
    print($tableHeader);
    print($tableResponses);
}
?>

<p class="note">
<input type="submit" value="Continue"><br />
</p>

</body>
</html>
Next came the form for collecting perceptions of the friendship relation. Note these were presented as a series of web pages programmatically constructed by the following code in the file friendAlterNet.php, where each sender and all receivers were give one page at a time.

```php
<?php
session_start();

// My local variables
$sender = array_pop($_SESSION['friendSenders']);
$receivers = $_SESSION['receivers'];

$tableHeader = '  
<tr>
  <th>Not at all</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>Very much</th>
</tr>
';

<html>
<head>
<title>Perceived Friendship Network</title>
<link rel="stylesheet" type="text/css" href="style.css">
</head>
<body>
<h1>How You Perceive Other People's Friendship Choices</h1>
<p class="instructions">The following pages ask you to estimate to the best of your ability, <em>even if only an estimate</em>, to what extent each named person from the <?php echo $_SESSION['organization']; ?> would say about their relationship with the other named person. For example, if you believe Alice considers Bob "very much" a personal friend, then you would click the circle under "very much." This is what you believe how Alice feels toward Bob. Click the most appropriate response using the provided rating scale.</p>
<p><em>Please do not skip any questions. Answer all to the best of your ability,</em></p>
</body>
</html>
```
even if you have to make a rough estimate. Also do not use your browser's Back button."
</p>

<form action="dissertation.php" method="post">
<input type="hidden" name="form" value="friendAlterNet">

<?php
// As many items as receivers. $i is item number, but -1 so don't print it.
for ($i = 0; $i < count($receivers); $i++) {
    $receiver = $receivers[$i];

    // Skip reflexive ties.
    if ($sender['subject_id'] == $receiver['subject_id']) continue;

    $value = "{$sender['subject_id']},{$receiver['subject_id']},$_SESSION['subject_id'],";
    $question = "<p>How much do you think <strong>{$sender['first_name']} {$sender['last_name']} </strong>
    considers <strong>{$receiver['first_name']} {$receiver['last_name']}
    </strong> to be a personal friend?</p>";

    // Values are relation, sender, receiver, perceiver/subject_id, strength.
    // Clear $tableResponses to avoid accumulation.
    $tableResponses = '';
    for ($strength = 0; $strength < 9; $strength++) {
        $tableResponses .= '<td><input type="radio" name="net[' . $i . ']' value="0,' . $value . $strength . '"></td>'';
    }
    $tableResponses .= "\n</tr>\n</table>\n"

    print($question);
    print($tableHeader);
    print($tableResponses);
}
?>

<p class="note">
<input type="submit" value="Continue"><br />
</p>
After completing the friendship relation, the same sequence of forms was presented to the participant but for the admiration relation. First was the file admireEgoNet.php.

```php
<?php
session_start();

// My local variables
$sender = array_pop($_SESSION['admireSenders']);
receivers = $_SESSION['receivers'];

$tableHeader = ';
<table border="1">
<tr>
<th>Not at all</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>&nbsp;</th>
<th>Very much</th>
</tr>
<tr>
<td>Very much</td>
</tr>
</table>
';
?>
```

```html
<html>
<head>
<title>Self-Report Admire Network</title>
<link rel="stylesheet" type="text/css" href="style.css">
</head>
<body>
<h1>Your Personal Social Network of Admiration</h1>
<p class="instructions">As a member of the <?php echo $_SESSION['organization']; ?>, please indicate to what extent you <strong>admire</strong> each named person from this group. Click the most accurate response using the provided rating scale. Please answer all questions.</p>
<form action="dissertation.php" method="post">
<input type="hidden" name="form" value="admireEgoNet">
</form>
```
<?php

// As many items as receivers. $i is item number, but -1 so don't print it.
for ($i = 0; $i < count($receivers); $i++) {
    $receiver = $receivers[$i];
    // Don't ask reflexive item. This is only for egonets.
    if ($_SESSION['subject_id'] == $receiver['subject_id'])
        continue;

    $value = "$_SESSION['subject_id'],".$receiver['subject_id'].";"
    $question = "<p>How much do you admire <strong>{$receiver['first_name']} {$receiver['last_name']}</strong>?</p>
    ";

    // Values are relation, sender, receiver, perceiver/subject_id, strength.
    // Clear $tableResponses to avoid accumulation.
    $tableResponses = '';

    for ($strength = 0; $strength < 9; $strength++) {
        $tableResponses .= '<td><input type="radio" name="net[".
        . $i
        . "]" value="1,".
        . $value
        . "]"></td>";
    }
    $tableResponses .= "\n</tr>\n</table>\n";

    print($question);
    print($tableHeader);
    print($tableResponses);
}

<p class="note">
<input type="submit" value="Continue"><br />
</p>

</body>
</html>
After the egocentric items of the admiration relation, the perception items were presented by the file admireAlterNet.php.

```php
<?php
session_start();

// My local variables
$sender = array_pop($_SESSION['admireSenders']);
$receivers = $_SESSION['receivers'];

$tableHeader = ';
<table border="1">
<tr>
  <th>Not at all</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>&nbsp;</th>
  <th>Very much</th>
</tr>
</table>

<html>
<head>
<title>Perceived Admire Network</title>
<link rel="stylesheet" type="text/css" href="style.css">
</head>
<body>
<h1>How You Perceive People Admire Others</h1>
<p class="instructions">The following pages ask you to estimate to the best of your ability, <em>even if only an estimate</em>, how much each named person from the <?php echo $_SESSION['organization']; ?> would say they admire the other named person. For example, if you believe Alice admires Bob "very much," then you would click the circle under "very much." This is what you believe how much Alice admires Bob. Click the most appropriate response using the provided rating scale.</p>
<p><em>Please do not skip any questions. Answer all to the best of your ability, even if you have to make a rough estimate. Also do not use your browser's Back button.</em></p>
```

<form action="dissertation.php" method="post">
<input type="hidden" name="form" value="admireAlterNet">

<?php
// As many items as receivers. $i is item number, but -1 so don't
print it.
for ($i = 0; $i < count($receivers); $i++) {
    $receiver = $receivers[$i];

    // Skip reflexive ties.
    if ($sender['subject_id'] == $receiver['subject_id']) continue;

    $value = "{$sender['subject_id']},{$receiver['subject_id']},{$_SESSION['subject_id']},";
    $question = "<p>How much do you think <strong>{$sender['first_name']} {$sender['last_name']} </strong>
        admires <strong>{$receiver['first_name']} {$receiver['last_name']} </strong></p>";

    // Values are relation, sender, receiver, perceiver/subject_id,
    strength.
    // Clear  $tableResponses to avoid accumulation.
    $tableResponses = '';

    for ($strength = 0; $strength < 9; $strength++) {
        $tableResponses .= '<td><input type="radio" name="net[' . $i . ']' . $value . $strength . '"></td>
        
    }
$tableResponses .= "\n</tr>\n</table>\n"

print($question);
print($tableHeader);
print($tableResponses);
}

<p class="note">
<input type="submit" value="Continue"><br />
</p>
At this point, the participant has completed all the forms, and was redirected to a logout page that gave the participant thanks and my e-mail address if they had any questions. The code in logout.php removed the session from the web server and recorded in the database that data collection was complete, thus prohibiting the user for logging back in, even with using the browser’s Back button.

```php
<?php
session_start();

require("db-include.php");
mysqli = new mysqli('localhost', DB_USER, DB_PASS, DB_NAME);
if (mysqli_connect_errno()) {
    printf("Can't connect to MySQL Server. Errorcode: %s\n",
            mysqli_connect_error());
    exit;
}
$timestampQuery = 'UPDATE subject SET logged_out=NOW()
WHERE subject_id=' . $_SESSION['subject_id'];
mysqli->query($timestampQuery);
mysqli->close();

unset($_SESSION['subject_id']);
session_destroy();
?>
<html>
<head>
    <title>Logout</title>
</head>
<body>
    <h1>Thank You</h1>
    <p>Your participation in this study is complete. Your patience is greatly appreciated. If you have any questions, please contact the experimenter at <a href="mailto:experimenter@davidmouellette.com">experimenter@davidmouellette.com</a>.</p>
    <p>Sincerely, <br />
    David M. Ouellette <br />
    Experimenter <br />
    </p>
</body>
</html>
Vita

David M. Ouellette was born on September 12, 1972, in Washington, DC, and is an American citizen. He graduated from McLean High School, McLean, Virginia, in 1991. He received his Bachelor of Arts in psychology from the University of Virginia in 2001. He received his Master of Science in psychology from Virginia Commonwealth University in 2004. He has taught undergraduate psychology and graduate social work courses at Virginia Commonwealth University, including Research Methods, Social Psychology, Group Dynamics. At the University of Richmond’s Jepson School of Leadership he taught Social Science Research Methods and Group Dynamics.