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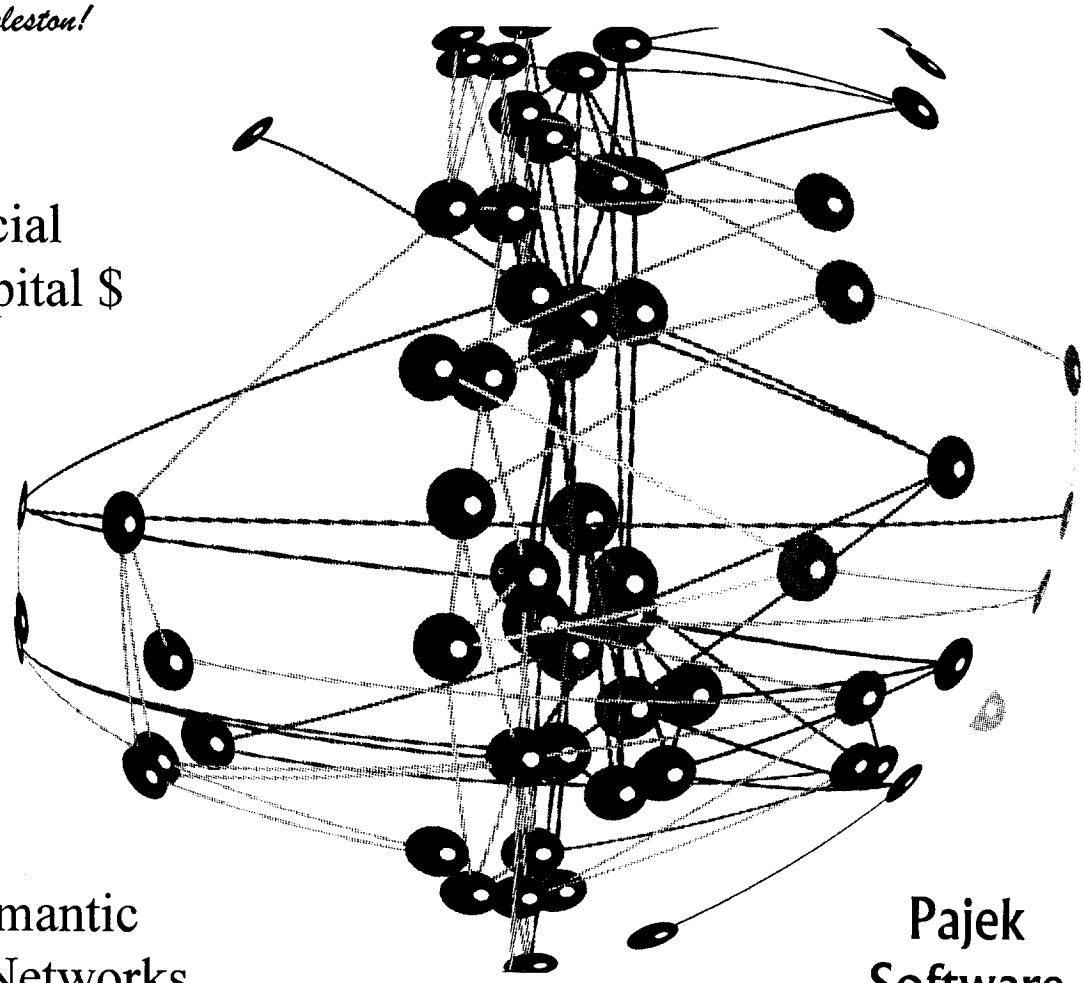

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What Constitutes Semantic Network Analysis? A Comparison of Research and Methodologies[1]

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INTRODUCTION

What is semantic network analysis? Semantic network analysis is the use of network analytic techniques on paired associations based on shared meaning as opposed to paired associations of behavioral or perceived communication links. In the follow up of Monge and Eisenberg's (1987) review of the organizational network analysis literature, Monge and Contractor (in press) categorized a variety of research articles as semantic network analyses (e.g., Contractor, Eisenberg, & Monge, 1994; Contractor & Grant, 1996; Danowski, 1982; Jang & Barnett, 1994; Krackhardt & Kilduff, 1990; Lievrouw, Rogers, Lowe, & Nadel, 1987; Rice & Danowski, 1993; & Stohl, 1993). Common to these research projects are the use of network analysis techniques to analyze respondents' communication about or perceptions of their organization. However, these projects use different in that the methods to construct "semantic networks." They varied from the use of 7-point scales to measure overlapping dyadic perceptions (Krackhardt & Kilduff, 1990), to the use of textual analysis with automated computer programs (Danowski, 1982; Jang & Barnett, 1994; Rice & Danowski, 1993), to the use of traditional content analysis with human coders (Stohl, 1993).

Semantic network analysis is becoming its own research paradigm as well as a method for analysis. However, the methods with which scholars develop their networks continue to vary. Implicit to the various techniques is a debate about valid measurements of meaning. This article considers recent publications which have been labeled semantic network analyses, delineates their methodologies, and explicates the meaning debate by arguing that there should be a clearer distinction between methods than simply naming the use of network analysis using perceptual or textual data as semantic network analysis.

In answer to Monge and Eisenberg's (1987) suggestion that communication network research should more explicitly tie meaning to its inquiries, semantic network analysis has become a

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method for studying the homogeneity or diversity of subgroups based on members' interpretations of organizational issues (rather than networks which represent who communicates with whom). The articles Monge and Contractor (in press) referenced in their review of semantic network analysis reflect three schools of thought on operationalizing semantic networks. Semantic networks have been constructed in the following ways: (1) based on the relationship among words in a text; (2) based on traditional content analyses of text; and (3) based on overlapping perceptions measured with scales.

These various methodologies may be a function of two distinct definitions of semantic networks. For example, Rice and Danowski (1993) described the essence of the semantic network as the analysis of text to measure the relationship among words. On the other hand, Monge and Eisenberg's (1987) conceptualization of semantic networks is described as associations based on shared interpretations. Essentially, these two definitions are at the heart of the division between types of semantic network research.

The following sections consider the history of semantic network analysis, scholars' contrasting methods, how the methods complement definitions of semantic networks, and argue that because of research methods and history, the label, 'semantic networks,' should be reserved for studies which consider explicit texts rather than indirectly measured attributes of texts or perceptions of individuals. After all, different methods yield different results (Carley, 1993).

THE HISTORY OF SEMANTIC NETWORKS

Rice and Danowski (1993) framed the history of network analysis as related to assumptions about cognitive processes. They compared semantic network analysis to Collins and Quillian's (1969) conceptualization of memory as a hierarchical ordering of words (network) in people's memories. Similarly, spatial models like the GALILEO system defined meaning as relations among words with multiple dimensional scaling (spatial manifolds) as opposed to graph theoretical (link-node) manifolds (Woelfel & Fink, 1980). Woelfel and Fink explained that the meaning of concepts are determined by separation relations with all other concepts. In other words, the meaning of a concept relative to other concepts. Barnett, Palmer, and Noor Al-Deen (1984) as well as Palmer and Barnett (1984) found evidence that such spatial models accurately determined meaning (see Barnett & Woelfel, 1988 for additional readings).

Based on the cognitive association of words, Rice and Danowski argued that words are nodes linked in relationships of facilitated and inhibited association. Similarly, map analysts (Carley, 1993) consider the content of texts by identifying concepts and the relationships between them. Carley (1993) argued that the mapping of concepts in relation to one another enables a picture of the web of meaning contained within a text. She argued that there is a strong theoretical grounding for extracting meaning from text based on theories such as the construction of meaning, mental models, and knowledge representation.

The meaning extracted from texts is not merely based on the presence of certain words or concepts. As Carley (1993) illuminated, two texts may contain the same concepts, yet represent different meanings. This is how semantic network analysis differs from word-count content analysis, because meaning is revealed by the relationships (networks) among the concepts. Carley argued, "differences in the distribution of concepts and the relationships among them

across texts provides insight into the similarities and differences in the content and structure of the texts (p. 92). She differentiated map analysis from the text analyses of Danowski and others because her analyses considered the direction of word association, whereas Danowski (and others) determined the relationship between words as they occurred within a window of *n* words wide that moves sequentially through the text, one word at a time. Rice and Danowski (1993) defended the ability of their methods to represent meaning because of the hierarchical association of words in people's minds (Collins & Quillian, 1969).

Nearly 20 years later, Chang (1986) supported Collins and Quillian's experiments on semantic memory and argued that a database of semantic memory based on the hierarchical ordering of words is both rich and consistent with reality. Therefore, I concur with Rice and Danowski's conclusion that analyses of texts based on word association analyses (semantic networks) represent the meaning inherent in such texts. The following section cites research that analyzed meaning with network analysis with three different types of methods: (1) that which represents analyses of word associations within bodies of texts; (2) that which utilizes traditional content analysis of bodies of text; and (3) that which utilizes respondents' answers to close-ended scaled questions.

Table 1. ***Typology of Meaning-centered Network Analyses***

	Conceptualization		
Operationalization	**Analyses of Text**		**Shared Interpretations**
Word associations (quantitative)	Carley (1993); Danowski (1982; 1993); Doerfel & Barnett (1997); Jang & Barnett (1994); Rice & Danowski (1992)	→	Word associations = meaning
Traditional content analysis (interpreted by coders)	Coders interpret respondents' meaning	←	Contractor & Grant (1996); Contractor, Eisenberg & Monge (1994); Stohl (1993)
Perceptions scales (self-report closed-ended questions)	∅	≠	Krackhardt & Kilduff (1990)

WORD ASSOCIATIONS AND ANALYSES OF TEXTS

As Table 1 illustrates, the group of papers that analyzed word associations in texts adopted 'analysis of text' as the definition for semantic network analysis. Their methods were similar in that they analyzed frequencies, co-occurrences, and relationships among words in text, and therefore, classified their research as analysis of shared interpretations. Thus, their classification in Table 1 is at the cross section of 'Word associations' and 'analysis of text.' The right-arrow shows the underlying assumption of this research in that their operationalization of semantic networks enabled them to elicit meaning. This group of research includes (1) analyses of meaning networks, in which the nodes are words, and (2) analyses of social networks in which a link between two actors in the network is a function of their communicated meaning networks.

Meaning networks (nodes = words). In regard to communication research, Danowski predated Monge and Eisenberg's (1987) call to include meaning in network studies, with his analysis of the communication that took place in a computer-mediated conference (Danowski, 1982). He used a concept co-occurrence method in which he mapped the relationships among words by indexing the pairs of concepts. Specifically, he analyzed pairs of messages and their computer-mediated responses. He argued that this method represented two aspects of communication. First, it revealed the manifest conversational structure among participants as it appeared to an external observer, and second, it indirectly represented the collective cognitive structure among participants (Danowski, 1982, p. 911).

Rice and Danowski (1991) used similar methods to analyze comments about users of voice mail. They employed the NEGOPY network analysis program and found that the semantic network (words relations) discriminated between categories of voice mail users. They argued that "traditional content analysis would not have revealed much of these distinctions in respondents' perceptions" (emphasis retained, p. 137). This is because unlike traditional content analysis which requires a priori categories based on theory, their research was exploratory in that they did not have theoretical expectations about the use of voice mail on which to base coding categories. They concluded that their research supported the notion that "cognitive theories about communication provide a useful theoretical basis for integrating open-ended interpretations of a new medium, and distinctions in the type of use of such a communication system" (Rice & Danowski, 1991, p. 137).

Freeman and Barnett's (1994) research on organizational culture included a dual analysis of content. First, they developed a words-by-words matrix of co-occurrences upon which they conducted hierarchical cluster analysis. The results included the most prevalent words and how they clustered in relation to each other. Second, they developed a cooccurrence matrix in which a link was represented by the co-presence of words in the same 'sliding window' which could range from 3-10 words wide. The entire text was read as the window moved through it and then the data were analyzed with the NEGOPY network analysis program. The NEGOPY program enabled them to identify groups of words, words which linked groups of words, and others which were structurally isolated. Both sets of procedures provided a representation of language patterns used by the organization. The word clusters represented the cultural categories communicated in the organization's written messages which allowed for "a more objective, precise description of its culture" (Freeman and Barnett, 1994, p. 65).

In a similar vein, Lievrouw, Rogers, Lowe, and Nadel (1987) conducted a co-word analysis among terms used to index grants for the National Institute of Health (NIH) database. Specifically, the frequency of co-occurrence of pairs of indexing terms within individual research grants was computed, employing the assumption that indexing terms that co-occur frequently generally have an intellectual relationship. Grants indexed by a relatively large number of terms which cluster together should be strongly intellectually related (Lievrouw et al., 1987, p. 224).

The authors argued that their identification of an invisible college in the biomedical field would have otherwise been undiscovered had they depended on only traditional networks measured via co-citation analyses. In other words, the content of the database is what enabled their discoveries.

Meaning networks (nodes are actors linked by their meaning networks). The above analyses were network descriptions of the texts. With similar methods, Jang and Barnett (1994) created a companies-by-companies relations matrix based on word cooccurrence in the organizations' public communication. They explained their semantic network as a configuration of relationships among nodes who used the same symbols. The strength of links was the degree to which the organizations shared meanings. Thus, organizations' relative positions could be classified in a meaning network. They argued, "in this respect, semantic network analysis has an advantage over traditional network analysis in that it provides a precise description of the content of messages while at the same time allowing researchers to differentiate characteristics of actors based on what they communicate" (Jang & Barnett, pp. 34-35). Their network analysis of 35 Fortune-500 companies' letters from chief operating officers differentiated the Japanese versus American corporations. In addition, they found that Japanese organizations clustered tightly, and their content was mostly focused on organizational operations, while the American organizations were loosely clustered and their content was primarily about financial information and the organizational structure.

Doerfel and Barnett (1997) conducted an analysis of the International Communication Association (ICA) in which the nodes were the association's divisions and the links were based on overlapping research themes in the titles of papers presented to ICA's divisions and interest groups (1992-1996). In addition to describing the semantic network of the association, Doerfel and Barnett found a significant correlation between their semantic network and the structure of the membership network measured by Barnett and Danowski (1992).

Central to all of the aforementioned studies was the analysis of text based on relationships among the content's words. A strength of these articles is that they captured the relationship among words in texts, and the authors did not force content elements into a relatively small set of categories (Danowski, 1993). Furthermore, it "represents the semantic content of message in the actual, natural language in which they were originally expressed, resulting in greater external validity and [it] reduces translation error in moving from what is said to the representation, resulting in greater internal validity" (Danowski, 1993, p. 219). A weakness of this methodology, however, is that the valence of attitudes was not necessarily captured. These studies represent the majority of published semantic network analyses, however, there are a few network studies in which different methodologies were employed. These alternate methods enabled the analyst to capture the valence of attitudes. The next two sections address the alternate methods.

TRADITIONAL CONTENT ANALYSIS AND SHARED INTERPRETATIONS

Monge and Contractor (in press) reviewed the semantic network research that has occurred since Monge and Eisenberg's (1987) argument that more network analyses should also focus on meaning. Among the research they referenced were papers which are categorized in Table 1 as having defined a link in semantic networks as the situation when two nodes share interpretations, and their operationalization for constructing their networks was based on traditional content analysis methods. Table 1 illustrates the difference of these analyses from the word-associations studies in that they are first, interpretive (as they are in the conceptualization column, 'shared interpretations'). The left arrow denotes that these projects

are 'once removed' from the texts because first categories of shared interpretation were created then coders were used to interpret the meaning in the texts.

Contractor et al. (1994) analyzed the interpretive diversity of organizations with multiple methods, including a network analysis of traditional content analysis data. They conceptualized a semantic network as a representation of multiple meanings present at any given time in an organization. They argued that it is possible to "consider all organizational members as belonging to a semantic network where the web of linkages depicts the degree to which members converge (or diverge) in their interpretation of the organization's mission" (p. 4). They coded answers to various open-ended questions with coding schemes which were based on the authors' readings of the responses. One scheme included three substantive categories plus a fourth 'don't know' option, and the other two schemes included six substantive categories with a seventh 'don't know' option. The content analyses resulted in three networks whose measures were used to compute members' agreement with others in their group and the organization.

Similarly, Stohl (1993) conducted a cultural analysis of European managers' responses to open-ended questions. She conducted a traditional, categorical content analysis, in which categories for coding were based on Hofstede's (1984; 1991) dimensions of cultural variability. She operationalized two nodes as linked if they had overlapping interpretations based on categories of culture. Four categories of culture included pairs of opposites, which resulted in a coding scheme of eight possible categories. Stohl argued that her coding enabled a representation of the data's richness because if two managers overlapped on one category, the corresponding cell, ij, was assigned a "1." If they were coded as having overlapping perceptions on two categories, the corresponding cell, ij, was assigned a "2." Therefore, while limited by the categories she developed out of Hofstede's work, she argued that the network retained the richness and complexity of her data because it took into account multiple meanings.

Similar to the word associations research, these traditional content analysis projects considered the actual communication (text) of respondents' communication about their organization. The strength of traditional content analysis is that the coders are able to capture the valence of responses. However, their shortcoming is that the "richness of the data" and "multiplicity of meanings" are reduced to a few categories. This shortcoming was reemphasized in Barnett, Danowski, and Richards' (1993) introduction in Progress in Communication Sciences when they argued that Lewin's (1931) criticism of social sciences still stands:

> It is excessively Aristotelian in its focus on categories and on nominal variables... In prevalent categorical thinking the focus is on elements and their classification, not on their relationships to one another, except indirectly, by way of common membership in categories. In network terms, it has been common to think of two nodes as simply being linked or not linked (p. 5).

The Aristotelian concern Barnett et al. described is even more prevalent in the last section of this article, in that the "semantic" networks were not constructed based on nodes' communication.

PERCEPTION SCALES AND SHARED INTERPRETATIONS

The research categorized on Table 1 as perception scales and shared interpretations is depicted as such because the networks of shared meaning were constructed with ordinal scales of

perceptions rather than with some form of content analysis of communication. Monge and Eisenberg (1987) emphasized that unlike Danowski (1982) they were less concerned with frequency of word usage. As such, the following articles' approaches were certainly consistent with Monge and Eisenberg's "concern with the interpretations and meanings as seen by communicators" (1987, p. 333).

Contractor and Grant's (1996) simulation of communication processes included network measures of shared interpretations of organizational members. Their goal was to use self organizing systems theory to explain and model the emergence of shared interpretations. They constructed the semantic network based on nodes' overlapping agreement measured with a 12-point scale. In other words, cell *ij* and *ji*, "indicated individuals *i*'s and *j*'s agreement (on a scale from 0 to 12) with a particular interpretation at time *t*" (Contractor & Grant, 1996, p. 221). Interpretation scores ranged from 0 (no agreement) to 12 (high agreement). Likewise, the Contractor et al. (1994) study on organizational interpretive diversity also measured members' perceived interpretive diversity with a 7-point scale. A shared interpretations network was constructed with answers to questions regarding how similar respondents perceived others to have similar interpretations. Finally, although Krackhardt and Kilduff (1990) did not refer to their research as a semantic network analysis, Monge and Contractor (in press) included this in their reivew. Like Contractor et al. (1994), Krackhardt and Kilduff operationalized a dyadic connection with a coefficient of similarity. They did this by calculating the correlation between person *i*'s vector of ratings with the corresponding vector for person *j*.

Clearly, these studies utilized substantively different methods from those which conducted content analyses. As Table 1 illustrates, the method is related to the other research because it is concerned with shared interpretations, however, the method does not involve the analysis of comprehensive texts or responses to open ended questions. In other words, this method is completely subject to preconceived categories imposed by the researchers and is not an analysis of meanings in texts (i.e., semantic).

CONCLUSION

Monge and Eisenberg (1987) clearly differentiated the methods for constructing these shared interpretations networks in that the "semantic network" is one that is constructed based on the content analysis of organizational members' open-ended responses to or organizational texts about the organization's culture. On the other hand, they explained, "individuals could complete attitudinal scales regarding important issues, and linkages in the resultant attitudinal network could be identified based upon degree of similarity across a core set of attitudes" (emphasis retained, p. 333). Thus, as Table 1 depicts, the attitudinal scale methods do not result in a semantic network. The methods are clearly distinguishable between semantic networks versus attitudinal networks.

This difference is simple and straightforward. On the other hand, the other two types of research reviewed in this article represent a controversy among methods. Word analyses versus traditional content analyses each have their own differences as well as strengths and weaknesses. For example, they differ in that the former extracts concepts from texts and considers the relationship among concepts, while the latter focuses on the extraction of contexts from texts (Carley, 1993). A significant shortcoming of content analysis, though extensively used, is that

it "has met with only limited success for a variety of reasons, including lack of simple routines, time consuming data preparation, difficulties in relating textual analysis to other data, and lack of a strong theoretical base" (Carley, 1993, p. 77). To its credit, however, traditional content analysis does not face the problem with the word associations method of constructing networks in that homographs, words that have the same written form but a different origin and meaning (Carley, 1993), can be recognized and managed.

Rice and Danowski (1993) argued that semantic network analysis was more advantageous than traditional content analysis because their methods did not employ a priori categories based on theory, which might have suppressed unexpected emergent meanings. Thus, the network analyses that employed traditional content coding still embody the same shortcomings of traditional content analysis, because they use traditional content analysis to construct their matrices. Furthermore, as Barnett et al. (1993) noted, this type of research suffers the same problems as much other social scientific research, as criticized by Lewin (1931), in being overly dependent on categorical data. The word associations method enable texts to be handled as continuous variables without loss of richness and multiplicity of the information. As Danowski (1993) noted, it retained the richness of the data and enabled comparisons of qualitative information across respondent groups.

This brings the focus back to the original question posed at the beginning of this article. What constitutes a semantic network analysis? By going back to Monge and Eisenberg's (1987) call to consider meaning in network research, we can see that the three types of studies cited in this article are all studies of interpretation that utilize network techniques to analyze the data. However, they are not all semantic analyses. The operations differentiate three categories of network research: (1) semantic networks; (2) interpretations networks; and (3) attitudinal networks. Semantic network analyses are those which are classified in the first row of Table 1. They are those studies in which word associations in texts were analyzed, and those word associations represented the meaning inherent to the data. Therefore, a link in a semantic network represents the extent to which two nodes, *i* and *j*, share meaning as measured by their overlapping use of language as representation of meaning. Interpretations network analyses are those classified in the second row in Table 1. The analysts employed traditional content analysis of texts to summarize meaning in texts. Therefore, a link in the interpretations network represents the extent to which two nodes, *i* and *j*, share meaning as inferred by coders' interpretation of nodes *i* and *j*'s language. Attitudinal networks are those which are classified in the third row of Table 1. They were constructed with answers to close-ended, ordinal-scaled questions created by the researcher. Therefore, a link in the attitudinal network represents the extent to which two nodes, *i* and *j*, answered an attitudinal scale similarly.

An interesting issue to which scholars should attend is that all three of these network approaches have been categorized as semantic networks, however, a more appropriate description would be to refer to their general nature as meaning networks. Meaning networks differ from traditional network analysis because the focus is on perceptions of relationships or organizational culture rather than who communicates with whom. However, the various meaning networks differ in their construction and therefore, the role of the researcher in data collection also varies. Put another way, they differ in the amount of researcher bias that is imposed on responses.

Table 2 summarizes the three different types of meaning networks, semantic, interpretation, and attitudinal, and the operations and relative level of imposition of researcher on respondent. Note

that the least researcher bias is with semantic networks because no *a priori* categories are used. The imposition is only minimal, to the extent that the investigator might formulate open-ended questions to probe respondents' attitudes. In regards to interpretations networks, the researcher might use the same techniques for data collection as semantic network analysts, however, they will depend on coders and a priori categories for content analysis. Finally, attitudinal network analysts construct close ended questions which force respondents into perceived categories.

Table 2. *Three Categories of Meaning Networks*

Network Type	Operationalization of Meaning	Analyst Imposition on Data
Semantic	Word frequencies and associations	Minimal: Does not use *a priori* categories in content analysis
Interpretation	Traditional content analysis	Moderate: Uses *a priori* categories (either based on theory or researchers' reading of data)
Attitudinal	Questionnaires	Maximum: Uses closed-ended perceptual scales

In conclusion, the purpose of this article was to elaborate on and make distinctions between the types of approaches that have been used in dealing with meaning in social networks. Specifically, this article clarified the definition of semantic network analysis, identified it as different from other types of meaning networks, and provided a typology for three different methods used in constructing meaning networks.

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