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Cultural Network Analysis: A Cognitive Approach to Cultural Modeling

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Abstract

The purpose of this chapter is to describe a rigorous, end-to-end methodology for modeling culture as networks of ideas that are distributed among members of a population. The method, Cultural Network Analysis (CNA), represents an interdisciplinary synthesis of techniques drawn from the fields of cognitive anthropology, cultural and cognitive psychology, naturalistic decision making, and decision analysis. CNA is used to develop cultural models for groups and populations, typically depicted as a network representation of the culturally shared concepts, causal beliefs, and values that influence key decisions. CNA can be usefully employed for a variety of applications, including the design of tools to support multinational collaborative planning and decision making, the development of situated cultural training programs, and characterizing the cognition of target audiences to support strategic communications campaigns.

Introduction

An inherent challenge in understanding behavior in other cultures rests in gathering, analyzing, and representing the relevant cultural concepts, beliefs, and values that drive decisions in those populations. In this chapter, we present *Cultural Network Analysis* (CNA) as a broad approach that aids in providing the most relevant cognitive aspects of cultural groups for decision influence. CNA comprises a collection of methodologies for eliciting, analyzing, and representing the beliefs, values, and cognitive concepts that are shared by members of cultural groups. This paper provides a detailed description of CNA, including its applications to multinational collaboration, cultural training, and strategic communications.

The fields of psychology and anthropology have been increasingly challenged by the separation of the study of culture and the study of the mind. The interdisciplinary field of culture and cognition has emerged as a response to this challenge (Hirschfeld & Gelman, 1994; Hutchins, 1995; Nisbett, 2003; Sperber, 1985). The cognitive revolution that began in the late 1950s influenced the fields of psychology and anthropology, leading to the development of cognitive psychology and cognitive anthropology (D'Andrade, 1981; Gardner, 1984). These fields have since progressed with little interaction. Cognitive psychologists have focused on the fundamental building blocks or

“architecture” of cognition, largely ignoring the effects of content. Cognitive anthropologists have focused on the content of cognition, seeking to describe and explain knowledge that is shared among members of cultural groups.

The challenge facing these fields is rooted in a twin set of ideas that are pressuring researchers within each field to reconsider the significance of the other. In cognitive psychology, cultural variations in what were previously presumed to be universal aspects of the cognitive architecture have surfaced. These finds suggest that much of the work in cognitive psychology could potentially turn out to be ethnographical, rather than architectural in nature (Nisbett et al., 2001). For their part, cognitive anthropologists have been faced with a growing awareness that there are widespread commonalities in cognitive organization that point to the existence of some form of cognitive architecture, and that more recent cognitive models of knowledge acquisition, organization, and change could prove useful in developing explanations for those commonalities (Boyer, 1994).

There is also a third set of developments that offers the potential to further accelerate an interdisciplinary culture and cognition program. Work in naturalistic decision making and related areas have helped to promote a growing interest in field research within cognitive psychology. This progressive movement of cognitive psychology into the field has led to the adoption of perspectives and methods that overlap significantly with those of cognitive anthropologists, yet retain a distinctly psychological emphasis on core cognitive functions, such as decision making, planning, sensemaking, adaptation, and coordination (Klein, 1998; Klein et al., 2003). Cognitive field researchers thus have a key role to play in shaping the direction of investigations into culture and cognition, with particular emphasis on research that aims to support the cultural challenges faced by domain practitioners.

Culture as Distributions of Knowledge

Within cognitive anthropology, culture is typically defined as involving shared knowledge. One specific theoretical approach to culture that characterizes culture in terms of knowledge is the epidemiological view. Here, “epidemiology” is used in the general sense of describing and explaining the statistical distributions of any property within a population. Cultural epidemiology regards culture in terms of the ideas that are widely distributed throughout a population (Sperber, 1996).

The starting point from this view is to recognize that individual minds contain vast amounts of mental content. People typically use the word *idea* to refer to any content of the mind, including conceptions of how things are and of how things should be. Networks of ideas are often referred to as folk theories or *mental models*. Such networks constitute peoples’ explanations for how things work, and result in judgments and decisions that influence their behaviour (Gentner & Stevens, 1983). Furthermore, the specific nature of a person’s mental models depends heavily on their cultural background (Hirschfeld & Gelman, 1994). The emphasis on “ideas” or content knowledge is consistent with work in cognitive field research and naturalistic decision making that has consistently found experiences and mental models to have a primary influence on real-world decision making. The research from this community clearly identifies the contents of cognition, as opposed to cognitive processes often studied in laboratory experiments (such as working memory), as the major driving force of decisions and behaviour.

As implied by the name, mental models reside inside the heads of individuals. However, when people communicate with each other and otherwise shape their environment, their mental models

leave observable traces in the form of physical artifacts and representations, including ephemeral traces such as speech and non-verbal gestures (Sperber, 1996). People who come into contact with others' external traces generate associated thoughts, and so they produce mental models that resemble one another. Mental models can spread widely throughout a population and persist for long time periods, becoming "cultural" in the sense of being shared by many of its members across space and time. Cultural models represent these shared networks of ideas.

To take a concrete example, consider Figures 1 and 2 that illustrate American and British cultural models of planning. The set of ideas represented in Figures 1 and 2 were extracted from a study comparing American and British concepts of quality plans (Rasmussen et al., in press). As shown, a cultural model of collaborative planning contains a group's common concepts as well as their shared understanding of the causal relationships between concepts, i.e. the antecedents and consequences of planning activities and their outcomes. The cultural model influences communal expectations for how planning should unfold and provides a framework for individual selection of behaviors and goals within collaborative planning situations. Consider Figure 2, for instance. It depicts a number of shared ideas among British planners using circles, lines, and color. These ideas include concepts such as "plan complexity" and "flexible execution," represented as circles. The figure also depicts shared causal ideas such as the idea that complex plans decrease the ability to execute flexibly. These are represented as lines in the figure, with +/- indicating the direction of the causal belief. Finally, Figure 2 portrays ideas of desired states or value using color, as well as a logical flow across desired states. Flexible execution is a good thing, something a plan should support. On the other hand, a plan with many assumptions is something to be avoided.

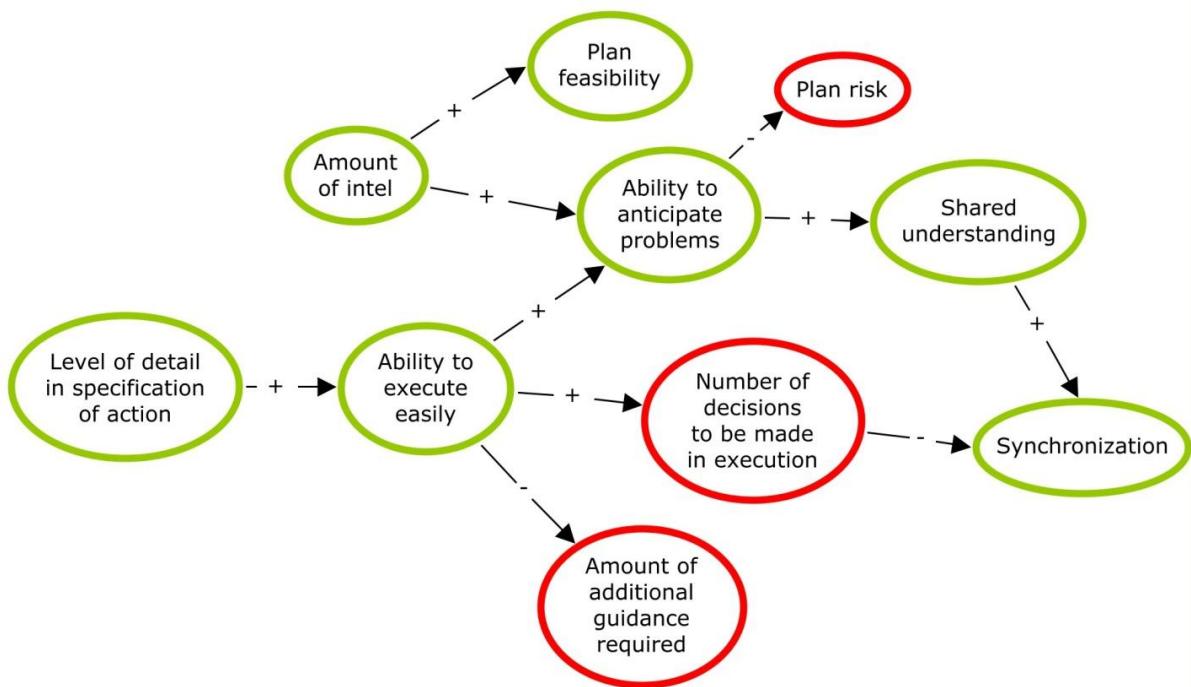


Figure 1: U.S. cultural model of planning

Holding this culturally-shared mental model is likely to have fairly strong consequences for how individuals from the group will decide and act in relevant situations. For example, if it is commonly held that detailed specifications of intent and rationale in a plan will improve the capability of executors to adapt the plan in order to meet changing conditions, and the ability to adapt is an

important value, then planning team members would be expected to focus on those components of the plan. Furthermore, multinational partners who attempt to collaborate while being guided by different cultural models may well find themselves frustrated and confused. For example, American planners who are focused on developing detailed actions so as to promote synchronization in execution may find themselves wondering why their British counterparts are still talking about goals.

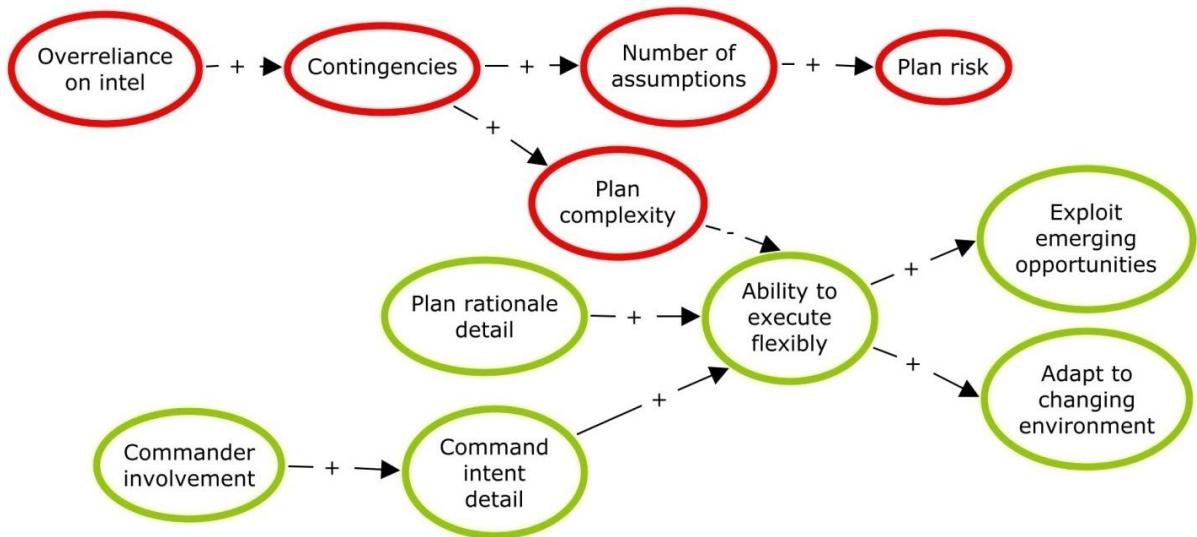


Figure 2: U.K. cultural model of planning

At this point, it is useful to summarize and define a few related terms. First, the term *culture* refers to mental models, and other contents of the mind, that are distributed across members of a population over a period of time. It also includes the resulting behaviors and other traces that foster the prolonged survival of shared ideas by providing “habitats” for them (Berger & Heath, 2005).

Cultural group refers to a set of people that hold shared networks of ideas, whereas a *social group* consists of people who interact with one another. Traditionally, members of groups were connected in many different spheres, including being neighbors, engaging in the same work, and participating in the same social and religious activities. High overlap in experiences like those, clearly leads to shared ideas within a large number of domains. Hence, there was little difference between people’s social groups and their cultural groups. More and more, people often identify with an increasingly wide assortment of groups that vary considerably in aspects such as purpose, size, and cohesion. Modern social groups may be best defined and described using tools such as social network analysis. Similarly, cultural groups are defined and described using cultural network analysis. Figure 3 provides an abstract representation of these two distinct levels of analysis. Figure 3 illustrates a network of people who also hold shared networks of ideas.

Generally, the size of a cultural group will depend on the *cultural domain*, that is, the kind and topic of knowledge of interest. This reflects the fact that some ideas are spread very widely among human populations, whereas others are much more narrowly held. Further, we sometimes use *cultural knowledge* in place of *culture* to refer to the networks of ideas for which there is some level of concordance among members in the cultural group.

Finally, *cultural model* refers to an external representation of a culture that is constructed by a researcher. A cultural model represents a consensus of the mental models for a particular cultural group and domain.

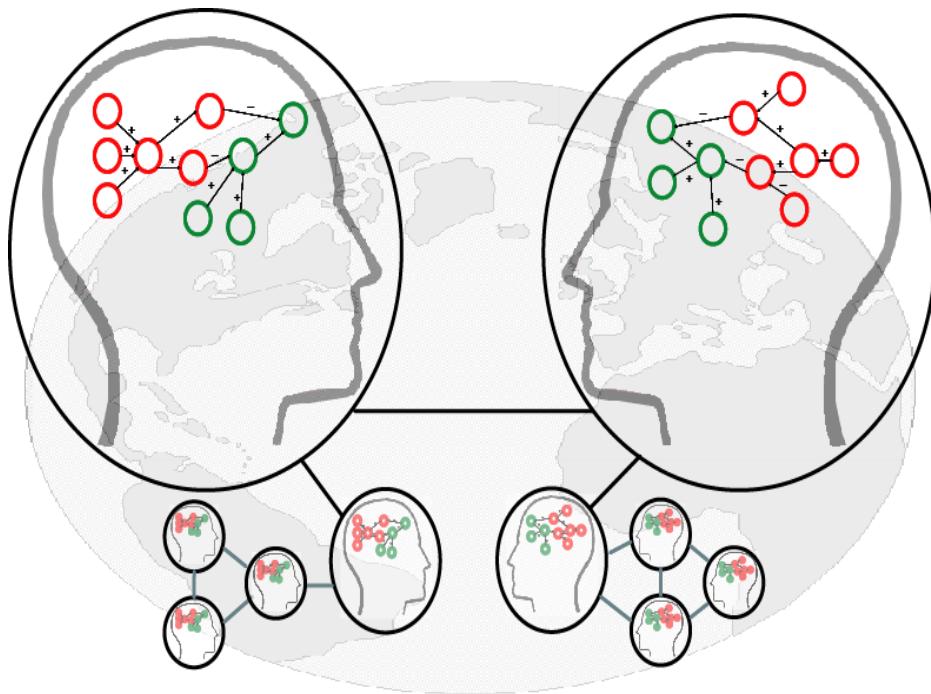


Figure 3: Cultural networks of ideas are distributed among members of cultural groups

Why Cultural Models?

Cultural models are formal descriptions of the knowledge possessed by members of particular groups. Cultural models describe and represent how the world is understood by the members of these cultural groups. A key premise is that cultural knowledge comprises many networks of causally-interconnected ideas. These mental models become activated within particular situations to drive thinking and decision making, and can change under suitable conditions. Cultural models also seek to account for relationships between cultural knowledge and social networks, and cultural change. Cultural dynamics across social networks is especially useful for modeling shared understanding among multinational partners, as well as anticipating effects in communications campaigns.

Cultural Models vs. Cultural Dimensions

Cultural psychologists have often conceptualized culture in terms of lists of domain general, stable traits, such as individualist-collectivist value orientations (Hofstede, 2001; Schwartz, 1994). The intent of this program is to find a core set of dimensions for characterizing cultures that are important across a wide variety of domains. The motive is to provide a priori, purely analytical predictions about cultural groups that are widely applicable to many particular problems. There is some evidence at this point that general cultural dimensions may not be applicable across situations. For example, Osland & Bird (2000) point to a number of cultural paradoxes that arise in particular contexts from cultural characterization in terms of general value dimensions. One compelling reason offered for such paradoxes is that the relative importance of values varies depending on the nature of the situation. Osland & Bird refer to this phenomenon as “value trumping.” From a cultural

models perspective, cultural dimensions provide an initial characterization of important values that may be relevant towards understanding members of a culture in specific contexts. However, they do not provide an understanding of what values will be most salient in what contexts. This suggests that it can be preferable to begin cultural analysis of a new domain in a more exploratory fashion, allowing the dimensions of value to emerge from the analysis (Sieck et al., *in press*). In addition, much research involving cultural dimensions tends to rely on the scientists' theories concerning the implications of value differences on causal beliefs, other values, or actions. The approach generally results in explanations that mix scientific concepts with cultural ideas. Cultural models instead aim to directly represent the various relevant cultural ideas and their interrelations, as held by members of the cultural group.

Cultural Models vs. Cognitive Customs

A more recent trend within culture and cognition in psychology has been to move beyond knowledge contents, and study national differences in cognitive processes such as reasoning and decision making (Norenzayan et al., 2002; Yates et al., 2002). For example, Nisbett et al. (2001) found differences between Western and South-East Asian populations in the extent to which they tended to rely on analytic and logical versus holistic and dialectical modes of thought. Yates et al. (*in press*) found Chinese to generate fewer arguments, and recruit a more polarized set of arguments than U. S. or Japanese participants. Corroborating these thinking modes or "cognitive customs," regarding argument recruitment, the Chinese were also consistently found to be more overconfident than U. S. or Japanese participants. This body of work is important in establishing that the mental representations studied by culture and cognition researchers should not be limited to the contents of cognition, but must ultimately include representations that govern thinking processes *per se*.

On the other hand, cognitive field researchers have repeatedly reported that the cognitive processes studied in laboratory experiments do not appear to be nearly as influential on real-world decision making as content knowledge in the form of episodic experiences and well-formed mental models (Phillips et al., 2004). The research from this community clearly identifies the contents of cognition as the major driving force of decisions. General cognitive processes may explain considerably less variance than content, at least in naturalistic situations. Even within laboratory settings, some researchers have shown the important influence of cultural content knowledge on decision making (Briley et al., 2000). Nevertheless, we do expect that cognitive customs will prove important, especially for understanding mechanisms underlying cultural change. Only, we expect that the research on cognitive customs could benefit from placing a greater emphasis on content. For example, content in the form of epistemological beliefs and other kinds of meta-knowledge likely contribute much to the cognitive customs of particular cultural groups, especially at the macrocognitive level. Such meta-knowledge includes folk theories about how certain macrocognitive processes function, e.g., mental models of negotiation or collaborative decision making.

Kinds of Cultural Domains

Mental models are naturally domain specific since they pertain to the workings of particular artifacts and natural processes. Furthermore, mental models can vary across cultures in ways that are constrained only by the domain itself and any cognitive universals that ground shared understanding across humanity (Hirschfeld & Gelman, 1994). A cultural model represents a consensus of the mental

models for a particular cultural group and domain. This leads to a question about the kinds of domains for which mental models, and by extension, cultural models exist.

Most work on mental models has focused on representations in the physical domain, including folk theories of artifacts like thermostats (Kempton, 1986) and folk theories of biological systems (Atran, 1998). For example, Kempton (1986) found that some people held mental models of thermostats that included the idea that turning a thermostat to a higher setting causes a room's temperature to rise at a faster rate (a "valve model"). Others held a correct "threshold model," in which the room heats at a constant rate until the threshold is reached. Furthermore, Kempton found that those with valve models tended to adjust their thermostats on a more continual basis, whereas those with threshold models tend to set their thermostats and leave them. As another example, Atran, Medin, & Ross (2005) found that cultural groups' mental models of plant/animal interactions in the rainforest were consistent with the environmental impact of those groups.

People also possess mental models that pertain to the psychological and social domains. Most fundamentally, people have theories about the workings of other people's minds (Gopnik & Wellman, 1994). People have mental models about negotiation and collaborative decision processes (McHugh et al., 2008; Van Boven & Thompson, 2003). Teammates have mental models of teamwork (Klimoski & Mohammed, 1994). Security forces have mental models of crowds (Sieck et al., in press). Just as in the physical domain, there is some evidence that mental models in the psychological and social domains guide perceptions and decisions. For example, Van Boven & Thompson (2003) found that negotiators who reached optimal settlements had mental models that reflected greater understanding of the payoffs and processes than those who did not reach optimal settlements.

Although cognitive field research and cognitive anthropology have informed each other's theory and methods, they remain distinct in terms of the domains that each pursues. For example, cognitive anthropological studies have aimed at describing and representing folk theories in domains such as kinship, subsistence, marriage, plant names, diseases, and ghosts. Cognitive field research has instead emphasized the study of mental models and experiences that support the decision making and other cognitive functions of experts working in complex, high-stakes domains.

Cultural Network Analysis

Cultural Network Analysis (CNA) refers to a collection of methodologies for building cultural models. CNA includes methods to:

- **elicit** the mental models of a sample of individuals within the population,
- **analyze** the mental models in terms of their culturally-shared elements across individuals and consolidate the elements as cultural models, and
- **represent** the cultural models in accessible format for a variety of uses.

CNA is an approach for building external cultural models that have been extracted from the group. CNA is based on a view of culture as comprising networks of ideas, shared to some degree within the populations under investigation. CNA builds on a synthesis of conceptually related methods for knowledge elicitation, analysis, and representation that stem from the diverse fields of naturalistic decision making, cognitive anthropology, cognitive psychology, marketing, and decision analysis.

None of these fields alone offers a comprehensive, end-to-end approach for cultural modeling. CNA fills that gap.

Cultural Network Analysis encompasses both qualitative, exploratory analysis, and quantitative, confirmatory analysis. In exploratory CNA, concepts and other mental model elements are extracted from qualitative sources, such as interviews and open source media (web news, blogs, email), with little presupposition regarding the elicited contents. A primary goal of exploratory CNA is to develop an initial understanding of the concepts and characteristics that are culturally relevant within the domain. Qualitative analysis and representation at this stage yield insights that can be captured in initial cultural models. Qualitative cultural models reflect the “universe” of ideas for the cultural group; that is, they seek to capture all relevant ideas mentioned. Influence diagrams are an important representation format for cultural models, as illustrated in Figures 1 and 2. Qualitative analysis may be all that is needed for some applications.

Exploratory CNA also generates hypotheses and a wealth of material for constructing structured data collection in a confirmatory CNA. Confirmatory CNA serves to test the structure of previously developed qualitative cultural models, as well as to elaborate the models with quantitative data concerning the prevalence of ideas in the population(s) of interest. In confirmatory CNA, structured interviews, field experiments, and automated semantic mining of web-based sources are used to obtain systematic data that is more amenable to statistical analysis. Statistical models used by cognitive anthropologists and market researchers are employed to assess the patterns of agreement and derive statistics describing the distribution of concepts, causal beliefs, and values. Finally, influence diagram representations of the cultural models are constructed that illustrate the statistical properties, as well as the qualitative information. Formal quantitative representation makes it possible to use cultural models in a variety of applied contexts.

Exploratory CNA

Elicitation

A mental model is a person’s intuitive explanation about how something works, and the explanation consists of an inter-related set of concepts, beliefs about causality, and values. Hence, in order to elicit a mental model in an interview, one needs to find ways to prompt the respondent to verbalize those key elements in great detail. Researchers from various fields have been working the issue, and considerable progress has been made regarding specific lines of probing and other techniques to tease out mental models. It is important to note that such interviews are often semi-structured, and tend to be highly dynamic, intercultural interactions. Actually conducting such interviews requires considerable skill that goes well beyond developing guides to support a particular line of questioning.

An example of mental model elicitation is provided in a study examining the cultural knowledge and understandings related to diabetes causation in a Native American community (Garro, 2000). The researchers conducted interviews following an “explanatory model framework” (Kleinman, 1978). All of the participants were members of the Anishinaabe community who had been previously diagnosed with diabetes. The researchers ensured that the following aspects of their experiences were covered in the interview:

- The cause of their illness

- Why it started and when it did
- The history of the illness
- The kinds of effects it has
- Possible and appropriate treatments for the illness

Participants were also encouraged to talk more generally about possible causes and ways of dealing with diabetes, and to answer additional related questions that arose from the responses given. Based on the results, Garro constructed a graphical outline of the culturally available understandings relevant to a cultural schema for sickness. The outline organized hierarchically the most common explanations of illness mentioned in the interviews. First, the different types of sicknesses and sickness explanations were identified. The identity and labels for these explanations were both mentioned explicitly and referenced implicitly in the different types of causes and ‘treatments’ mentioned. After having inferred the major types of sicknesses, the causes, or perceived causes, were sorted into sickness categories. The level of detail and abstraction of the cause descriptions was dictated by the amount of information made available by informants.

In a medical illness domain like “diabetes,” the general direction of peoples’ subjective values regarding the disease state is probably fairly transparent (i.e. a cultural preference to avoid the disease state exists). However, that transparency does not necessarily translate to other domains, or even to various treatment options and effects within the diabetes domain. In such cases, values and objectives can be elicited directly, along with the causal beliefs that link more fundamental values with the means intended to achieve them (Gutman, 1982; Keeney, 1994). The essential idea of such “value-focused thinking” is to ask why a particular objective is important in order to elicit the more fundamental values that are anticipated in consequence. Interview approaches like this are sometimes termed “laddering” in the marketing literature (Reynolds & Gutman, 1988).

These same questioning strategies that have been used to elicit physical and biological products and processes can also be used to elicit mental models of social and cognitive functions and processes, such as collaborative planning and decision making (Rasmussen et al., in press). The data underlying the cultural models illustrated in Figures 1 and 2 were elicited using an explanatory models framework combined with a value-focused thinking approach in order to capture descriptive and prescriptive components of the mental models. In general, an explanatory framework for mental models of social-cognitive functions and processes should aim to capture the following:

- Positive/negative states and outcomes
- Conceptions of quality in process and outcomes
- Causal factors that influence the quality concepts
- Consequences of low/high quality functioning
- Artifacts, procedures and tools intended to support the natural process
- Functions of ingrained artifacts

An important consideration in eliciting knowledge about social-cognitive domains like “collaboration” or “decision making” is the difficulty inherent in discussing abstract concepts. One approach to achieving some concrete grounding in such abstract domains is to elicit specific

incidents on the topic, and use them to tease out clues to participant's mental models. For example, Sieck et al. elicited incidents from Arabs in Lebanon and the US who had participated in protests as a means to gain access to Middle Eastern crowd members' understandings and expectations of how crowds work (Sieck et al., 2006). The idea is to elicit a real-lived incident from the participant, and then use that concrete example as a starting point for more abstract discussions of causality introduced through hypotheticals ("What if?" questions).

Another useful technique for getting at abstract mental models is the "nearest neighbor method" (Klein & Hoffman, 2008). This is a useful method to use when participants may have difficulty articulating their beliefs, such as when they have an understanding and expectations about how something works, but that understanding is represented in non-verbal forms. Respondents are presented with cartoons, diagrams, other pictures, or vignettes that depict different possible variations of the mental model. The respondent selects the depiction that most closely matches their conception, and then explains where and how it does not quite fit. As with the incident-based methods, this approach can be valuable for providing some common ground between the interviewer and respondent, though it is clearly more directive than the open questioning methods.

Analysis

In contrast with elicitation, analysis of qualitative data for the specific purpose of characterizing mental models has not appeared to be developed in any great detail. In some cases, researchers seem to work individually using rather opaque processes to finally emerge with an idiosyncratic representation of a cultural model or schema. We have thus been developing our own analytical procedures with the aims of achieving a traceable, repeatable, and reliable process for extracting culturally shared mental models from text. In the most recent application of our process (described below) to some interviews we conducted with Afghans, we achieved 95.2% reliability and developed fully traceable cultural models.

The process we have developed starts by conducting an initial coding of transcripts or other data records to identify and record local concept-causal belief-value (CBV) chains. Transcripts from all participants in the cultural group are analyzed together as a unit. This step is performed by two coders working independently. The analysis team then performs a reliability check on the initial results, and holds a meeting to establish consensus codes. The reliability check is performed by tracking the conflicting codes and total number of codes. Codes are conflicting if the concepts, direction, or valence are inconsistent or incompatible. Such conflicts are resolved in the consensus meeting, and the issues discussed may include the level of abstraction/detail used to describe the CBV chains, appropriate places to divide the causal linkages, any assumptions and inferences the analysts are making. The resulting consensus descriptions are used to consolidate the local CBV codes into an overall model. This step is generally performed by one analyst. Finally, the team members perform independent reviews of the model against the data, and iteratively revise and refine until a consensus of the model is achieved. Comments and revisions to the model include flagging any concepts reflected in the consensus file that are missing from the model, pointing out inconsistencies between the consensus document and model, commenting on the overall level of abstraction of the model, and providing suggestions for reorganizing the model to make it clearer, or more succinct.

The analysis process we use relies on explicit verbalizations by the participants. Other research suggests that systematic analysis of the way people talk can offer additional insight into the nature of mental models. Metaphors are a linguistic manifestation of tacit knowledge, and hence provide a window of access to such difficult-to-verbalize thoughts. Researchers have proposed that metaphor is an indispensable part of our ordinary and conventional way of conceptualizing the world and our everyday behavior reflects our metaphorical understanding of experience (Lakoff & Johnson, 1980). A metaphor consists of the projection of one schema (the source domain of the metaphor) onto another schema (the target domain of the metaphor). Schmitt (2005) proposed a systematic approach to uncovering the origins of metaphor models, the historically-defined changes in metaphors across time, and the context-sensitivity of metaphors. These are dimensions which, according to Schmitt, are often overlooked in purely cognitive anthropological and linguistic examinations of metaphor.

As an example use of metaphor analysis for developing a cultural model, Quinn asked American husbands and wives to talk about 'marriage' and collected hours and hours of minimally guided conversations with them on that topic (Quinn, 2005). She then analyzed the data categorizing linguistic metaphors into a set of central or commonly shared conceptual metaphors that her informants used to reason about different aspects of marriage. She extracted metaphors, such as "marriage is a journey," as well as the abstract concepts and values that were being associated with each, including 'lastingness', 'sharedness', 'compatibility', and 'difficulty'. Quinn noticed that these metaphors, in isolation, did not appear to tell the whole story. She also noticed that her informants often followed the same causal chain to reach their conclusions. For example, a certain causal relationship exists between compatibility and lastingness. The resulting cultural schema that describes how Americans reason about marriage, represented as a causal chain in narrative form, is: *Marriages are successful if they last. In order to last, a marriage must be beneficial, and in order for it to be beneficial, its difficulties must be overcome, and this requires effort* (Quinn, 2005).

Graphical Representation

As with analysis, current approaches for representing cultural models appear to be relatively idiosyncratic, or even non-existent. A default approach to representation for CNA might prove quite useful, if it could accomplish the following:

1. Provide a standard pictorial form that shows the concepts and causal linkages in a manner that can be readily digested by end users who need to routinely comprehend cultural models in varied domains
2. Permit a direct means of representing the statistical distributions of cultural knowledge, rather than just the shared knowledge
3. Yield representations in a useful form for developers of intelligent systems

One such representation format that meets these requirements is an influence diagram. In an influence diagram, each node-link-node combination represents causal influence, in the sense that the value of the concept at the beginning of an arrow affects the value of the concept at the arrow's point. Fully-specified influence diagrams can also represent numerical quantities, as described in the confirmatory CNA section, but the basic structure is useful as well. Specifically, an influence diagram can present a relatively simple and useful representation of an individual's mental model of a domain that is related to key judgments and decisions that rely on that mental model. For example,

Bostrom et al. provide an example of an influence diagram that illustrates an expert's mental model of radon, as related to the expert's judgment concerning risk of lung cancer (Bostrom et al., 1992). Sieck and colleagues used an influence diagram to represent an expert mental model of crowd functioning, as related to key judgments of threat level and populace attitudes (Sieck et al., in press).

Likewise, influence diagrams can also be used to represent qualitative cultural models. In this case, the diagram represents the complete set of concepts and linkages for all members of each cultural group considered in the analysis. For example, Figures 1 and 2 illustrate cultural models for American and British campaign planners, respectively, each of which is related to a key judgment concerning the quality of the plan and planning process. As shown, the specific values along which such judgments are rendered were found to differ between the two cultural groups, such that the Americans rely more heavily on synchronization in judging plan quality, whereas British planners focus more on the ability of the plan to support flexible execution (Rasmussen et al., in press).

Confirmatory CNA

Elicitation

Structured approaches for the elicitation of complete mental models have only recently begun serious development. Most surveys and structured questionnaires treat ideas as independent entities, and so do not provide any means for revealing their interrelated, network form. There are, however, a few studies in which causal relations between concepts have been directly assessed (Atran et al., 2005; Garro, 2000; Sieck et al., 2009). For example, Sieck et al. selected twelve security force actions and five categories of crowd responses from an earlier qualitative cultural study in order to develop a mental models questionnaire. Each security force action was then paired once with each crowd member response. For each pair, the participant was asked whether the crowd member behavior or attitude will increase, decrease, or stay the same. The purpose of these questions was to elicit the participants' causal beliefs between security force actions and crowd member behavior. Such causal linkages form the basis of their mental models. More recently, we have begun developing questionnaires that permit the analysis of longer causal belief chains.

Analysis

One issue with purely qualitative approaches to the development of cultural models is the lack of transparency or consistent guidelines in what knowledge was deemed sufficiently shared to include in the model. Strauss and Quinn state, "At what point in the continuum of sharedness we decide to call a given schema 'cultural' is simply a matter of taste," (p 122). Structured, quantitative approaches are required for testing the qualitative discoveries about culturally shared mental models, and further analyzing and representing their distributions within and between populations. Cultural consensus theory and mixture modeling are two statistical methods that can be usefully employed to meet those needs.

Cultural consensus theory is a collection of formal statistical models designed to assess concordance in knowledge and beliefs among a set of respondents (Romney et al., 1986). When a cultural consensus is found, it provides the consensual responses that indicate culturally shared knowledge and estimates of the strength of consensus for those responses. Individuals will also vary in the extent to which their responses agree with the consensus, and that variation is captured explicitly for each individual as a measure of "cultural competence." Cultural competence should not be confused with expertise, but rather with the degree of concordance with the culturally shared

knowledge. The instigating issue that prompted development of the theory was the recognition that an anthropologist who goes in to a new culture and asks questions does not know the answers to the questions or the cultural competence of the respondents (Romney et al., 1987). An important feature of CCT is that, assuming the data collection taps into reasonably well-shared cultural knowledge, then the number of respondents can be quite small, e.g., 10 or fewer respondents. This is important for field research, which often aims at understanding knowledge within small populations.

Cultural consensus theory has been applied to research questions in a number of cultural domains, including disease concepts and folk theories of disease processes, characterizations of alphabetic systems, national consciousness, folk theories of biology and ecology, and others. CCT can be used to analyze fixed-format questionnaires (e.g. true-false, fill-in-the-blank, multiple choice, rank order) and classification data (e.g. card sort, hierarchical taxonomy). It has also been used to analyze free-listings of concepts (Ross & Medin, 2005). CCT has most often been used to analyze data on simple concepts. However, it has also been successfully employed to analyze relationships between concepts, such as causes, consequences, and other interactions (Atran et al., 2005; Garro, 2000). This use of CCT is critical for the purposes of analyzing mental models.

Mixture modeling is a statistical technique that is growing in general popularity for a variety of uses, and provides a competing approach to CCT for cultural data analysis. Mixture models have been applied in many scientific fields, including marketing, biology, medicine, and astronomy. McLachlan and Peel (2000) provide a general description of mixture models, along with example applications.

A mixture model, or “finite mixture model,” is given as a combination of different groups, each described by a distinct probability distribution. Mixture models sort through the data and group them into sets of relatively homogeneous cases or observations. For concreteness, we describe the process in an example application to market segmentation. Finite mixture modeling was used to examine whiskey usage in 2218 households (Grun & Leisch, 2007). Information on whiskey type (single malt or blend) and 21 specific brands was included in the data set. A mixture of binomial distributions was fitted to the data set, and the analysts varied the possible (“finite”) number of groups between 1 and 7. Model fitting was conducted using a statistical package called “FlexMix” originally developed earlier by one of the authors (Leisch, 2004). FlexMix uses an iterative maximum likelihood procedure called the, “EM algorithm,” for model estimation. The best fitting model was selected using the Bayes Information Criterion (BIC) statistic. BIC suggested that the best fit was achieved with 5 groups or segments. The largest segment was not found to consume much whiskey on the whole, used a wide variety of brands when they did partake, but avoided single malts. The largest users consisted of about 10% of the sample, and were spread across two groups best delineated by whether they consumed single malt whiskey.

Mixture modeling has also been successfully used in cultural analysis (Mueller & Veinott, 2008; Sieck & Mueller, 2009; Sieck et al., 2009). In this application, the distinct segments resulting from the analysis represent *cultural groups*, i.e., groups defined by the similarity of their ideas. Mueller and Veinott (2008) compared the technique with CCT by applying it to some of the same classic cultural data sets for which CCT was first used. The primary advantage they found for mixture modeling was in the case where CCT does not find a consensus. In that situation, one cannot tell whether there is simply no pattern to the data, or whether the data reflect multiple cultural groups. Mixture

modeling can also provide a wider number of metrics for assessing the cultural groups within the population (Mueller et al., 2007). In particular, we define here the following five cultural metrics as essential in characterizing a family of cultural models:

- Number of cultural models identified
- Consensus within a model
- Prevalence of each idea within a model
- Cultural competence of individuals
- Distinctiveness between cultural models

Although these measures stand independently of any particular statistical technique, analyses using mixture models provide quantities that can be used to assess each of these metrics.

Graphical Representation

We find influence diagrams to be useful for representing quantitative cultural models, and they provide additional information to their qualitative counterparts. When completely specified, an influence would be defined in terms of conditional probabilities, where a influences b if the probability distribution of b conditioned on a is different from the unconditional distribution of b (Howard, 1989). The full specification of influences is typically performed by experts in the domain who consult external resources and render all the probabilities themselves (Edwards, 1998; Edwards & Fasolo, 2001). This process presents a serious technical challenge to the expert and raises questions concerning the reliability and validity properties of the judgments. Fortunately, we do not need to require respondents to assess probabilities in order to develop quantitative cultural models. That is, although numerical values are incorporated in the final result, the use of influence diagrams to represent cultural models only requires that individuals be able to convey the qualitative components and directions of the influences in the diagram.

In the application of confirmatory CNA, the influence diagram represents the “culturally correct” concepts, values, and causal linkages as determined by CCT or mixture modeling for each cultural group that was found. Furthermore, the results concerning prevalence of each idea within a group are used to populate the numerical probability values in the diagram. The result in this case is a summary of not only the shared influence links across the population, but rather the full distribution of ideas, with probabilities indicating the consensus on any particular causal link (or node). An example is provided in Figure 4, illustrating a simple quantitative cultural model of Middle Eastern crowd functioning, derived using mixture modeling (Sieck et al., 2009). As shown, there is a relatively strong consensus (87%) within the represented cultural group that Americans speaking Arabic to Middle Eastern crowd members will have a positive effect on the crowd’s attitudes towards the U. S. The idea that firing a warning shot will have just the opposite effect is even more prevalent within this group (93%).

Applications of Cultural Network Analysis

Culture is made up of contagious ideas, that is, ideas that propagate effectively and durably within a population (Sperber, 1996). Two broad objectives of research within this cultural epidemiology viewpoint are to:

- Characterize the current distribution of mental models within the cultural group
- Understand the dynamics of culture

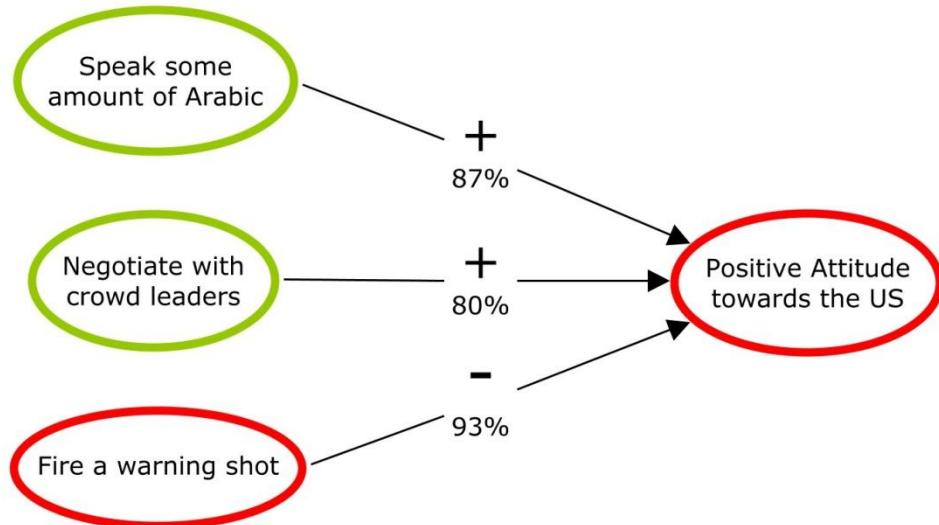


Figure 4: Example of a quantitative cultural model

A fundamental cultural research program seeks to address why some ideas are more infectious than others, and to explain the most widely distributed and long-lasting ideas within a population. Research for practical purposes has a slightly different focus. From a decision-making standpoint, for example, we recognize that many ideas may be pervasive but inconsequential to decisions of practical interest (Bostrom et al., 1992; Sperber, 1985). Hence, a decision-centered approach to culture and cognition begins with critical judgments and decisions that are made by members of a cultural group. Using Cultural Network Analysis, we can then study the networks of ideas that are relevant to those decisions in order to answer a host of questions, such as:

- How are networks of ideas organized in mental models?
- What is the distribution of mental models in a cultural group?
- Why are the mental models distributed in that way?
- How did the distribution get to be that way?
- How stable are those distributions?
- In what ways are the distributions changing over time?
- Why are they changing in that way?
- What makes some ideas successful in the culture?
- Why is the culture more vulnerable to some ideas than to others?

This shift in theoretical focus provides an opportunity to enhance the content of existing tools and procedures that have been developed to support multinational collaboration, but it also inspires the design of different approaches to supporting multinational collaborations altogether. Explicit representations of the distribution of implicit knowledge within two cultures can make it possible to assess differences and potential similarities between the cultures in question, including in terms of knowledge about how people should interact in order to work together effectively. The high-level goal here is to promote the development of hybrid cultures in multinational collaborative planning and decision making (Earley & Mosakowski, 2000). Hybrid cultures comprise a simplified set of shared assumptions, rules, expectations, and procedures that permit multinational teams to function effectively. Hybrid cultures develop naturally over time as teams converge on a common process of interacting. However, cultural models can be used to inform the design of tools and processes that promote the natural process.

For example, with respect to reconciling the American and British cultural models illustrated in Figures 1 and 2, we might consider a collaborative planning tool with functionality, and interfaces tailored to support distinct roles by the partners in a coherent, comprehensive coalition planning process. In this case, we could ensure that the distinct roles each national partner would be assigned to align with the respective nation-specific processes. In particular, this suggests a division of labor that has the British members of the team contribute to developing the intent, plan rationale, and the logic between ends, ways, and means, whereas the Americans would focus on developing the detailed specification of actions.

Another design idea is to develop a coalition plan evaluation tool that relies on multinational metrics of plan quality. Such a tool would ideally incorporate an automated assessment of plan content using an ontological representation of cultural models (Rasmussen et al., in press). The idea is to provide measures of plan quality that include value dimensions from each coalition partner (e.g. action, rationale specification). Such a tool would provide a concrete basis for discussion among planners about evaluations of plans, for example, enable them to explicitly examine and discuss the right “mix” of elements to make a good plan. Providing such online feedback to a team about what they are trying to accomplish is expected to speed up the natural process of hybrid culture building.

An explicit representation of the distribution of implicit content knowledge within a culture can also serve as a foundation for developing situated cultural training programs (Sieck et al., 2008). Explicit cultural models can provide a meaningful basis for inferring otherwise implicit goals and intentions, which is essential for successful communication. Whereas traditional training programs often provide a set of dos and don’ts, training the ability to infer intentions within a novel cultural knowledge structure provides a generative platform which can be used in a variety of multinational situations.

Finally, explicit representations of content knowledge within a culture can also serve as a basis for composing effective strategic communications. The models of culturally-shared content knowledge within a certain domain can serve as a basis for determining what makes for culturally meaningful messages. The CNA would allow for making predictions concerning the effectiveness of a message by providing the opportunity to assess potential unintended inferences that individuals with a certain knowledge structure might make. Specifically, in a cultural models diagram, each concept and causal belief represents an opportunity to affect a change in beliefs or concepts. Hence, such diagrams can

provide a basis for determining the content of communications. Messages are created so as to affect the values of the most vulnerable concept nodes (i.e. those for which there is the least consensus) which then propagate across perceived influences to affect the values of other concepts. These effects spread through the cultural knowledge network, ultimately changing the value in overall perceptions or cognitions. With this CNA approach, information efforts focus on transmitting the most relevant information to affect conceptual change in a way that makes sense within the cultural group's understanding.

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References

Atran, S. (1998) Folkbiology and the anthropology of science: Cognitive universals and cultural particulars. *Behavioral and Brain Science*, 21, 547-609.

Atran, S., Medin, D. L., & Ross, N. O. (2005) The cultural mind: Environmental decision making and cultural modeling within and across populations. *Psychological Review*, 112(4), 744-776.

Berger, J. A., & Heath, C. (2005) Idea habitats: How the prevalence of environmental cues influences the success of ideas. *Cognitive Science*, 29.

Bostrom, A., Fischhoff, B., & Morgan, M. G. (1992) Characterizing Mental Models of Hazardous Processes: A Methodology and an Application to Radon. *Journal of Social Issues*, 48(4), 85-100.

Boyer, P. (1994) Cognitive constraints on cultural representations: Natural ontologies and religious ideas. In L. A. Hirschfeld & S. A. Gelman (Eds.), *Mapping the mind: Domain specificity in cognition and culture* (pp. 391-411). Cambridge University Press, New York.

Briley, D., Morris, M., & Simonson, I. (2000) Reasons as carriers of culture: Dynamic versus dispositional models of cultural influence on decision making. *Journal of Consumer Research*, 27, 157-178.

D'Andrade, R. G. (1981) The cultural part of cognition. *Cognitive Science*, 5, 179-195.

Earley, P. C., & Mosakowski, E. (2000) Creating hybrid team cultures: An empirical test of transnational team functioning. *Academy of Management Journal*, 43, 26-49.

Edwards, W. (1998) Hailfinder: Tools for and experiences with Bayesian normative modeling. *American Psychologist*, 53(4), 416-428.

Edwards, W., & Fasolo, B. (2001) Decision technology. *Annual Review of Psychology*, 52, 581-606.

Gardner, H. (1984) *The mind's new science: A history of the cognitive revolution*. Basic Books, New York.

Garro, L. C. (2000) Remembering what one knows and the construction of the past: A comparison of cultural consensus theory and cultural schema theory. *Ethos*, 28(3), 275-319.

Gentner, D., & Stevens, A. L. (1983) *Mental Models*. Lawrence Erlbaum Associates, Hillsdale, NJ.

Gopnik, A., & Wellman, H. M. (1994) The theory theory. In L. Hirschfeld & S. Gelman (Eds.), *Mapping the Mind: Domain Specificity in Cognition and Culture* (pp. 257-293). Cambridge University Press, New York.

Grun, B., & Leisch, F. (2007) FlexMix: An R package for finite mixture modelling. *R News*, 7(1), 8-13.

Gutman, J. (1982) A means-end chain model based on consumer categorization processes. *Journal of Marketing*, 46(2), 60-72.

Hirschfeld, L., & Gelman, S. (Eds.) (1994) *Mapping the mind: Domain specificity in cognition and culture*. Cambridge University, New York.

Hofstede, G. (2001) *Culture's consequences* (2 ed.). Sage, Thousand Oaks, CA.

Howard, R. A. (1989) Knowledge maps. *Management Science*, 35, 903-922.

Hutchins, E. (1995) *Cognition in the Wild*. MIT Press, Cambridge.

Keeney, R. L. (1994) Creativity in decision making with value-focused thinking. *Sloan Management Review*, 35(4), 33-41.

Kempton, W. (1986) Two theories of home heat control. *Cognitive Science*, 10, 75-90.

Klein, G. (1998) *Sources of Power: How People Make Decisions*. MIT Press, Cambridge.

Klein, G., & Hoffman, R. R. (2008) Macrocognition, mental models, and cognitive task analysis methodology. In J. M. Schraagen, L. G. Militello, T. Ormerod & R. Lipshitz (Eds.), *Naturalistic Decision Making and Macrocognition* (pp. 57-80). Ashgate, Aldershot.

Klein, G., Ross, K. G., Moon, B. M., Klein, D. E., Hoffman, R. R., & Hollnagel, E. (2003) Macrocognition. *IEEE Intelligent Systems*, May/June, 81-85.

Kleinman, A. (1978) Concepts and a model for the comparison of medical systems as cultural systems. *Social Science and Medicine*, 12B, 85-93.

Klimoski, R., & Mohammed, S. (1994) Team mental model: Construct or metaphor. *Journal of Management*, 20, 403-437.

Lakoff, G., & Johnson, M. (1980) *Metaphors we live by*. University of Chicago Press, Chicago.

Leisch, F. (2004) FlexMix: A general framework for finite mixture models and latent class regression in R. *Journal of Statistical Software*, 11(8), 1-18.

McHugh, A. P., Smith, J. L., & Sieck, W. R. (2008) Cultural variations in mental models of collaborative decision making. In J. M. C. Schraagen, L. Militello, T. Ormerod & R. Lipshitz (Eds.), *Naturalistic Decision Making and Macrocognition* (pp. 141-158). Ashgate Publishing Limited, Aldershot, UK.

McLachlan, G. J., & Peel, D. (2000) *Finite Mixture Models*. Wiley.

Mueller, S. T., Sieck, W. R., & Veinott, E. S. (2007) *Cultural Metrics: A Finite Mixture Models Approach (Technical Report DAAD19-01-2-0009)*. Applied Research Associates, Fairborn, OH.

Mueller, S. T., & Veinott, E. S. (2008) *Cultural mixture modeling: Identifying cultural consensus (and disagreement) using finite mixture modeling*. Proceedings of the Cognitive Science Society, Washington, DC.

Nisbett, R. E. (2003) *The geography of thought: How Asians and Westerners think differently...and why*. The Free Press, New York.

Nisbett, R. E., Peng, K., Choi, I., & Norenzayan, A. (2001) Culture and systems of thought: Holistic versus analytic cognition. *Psychological Review*, 108, 291-310.

Norenzayan, A., Smith, E. E., Kim, B. J., & Nisbett, R. E. (2002) Cultural preferences for formal versus intuitive reasoning. *Cognitive Science*, 26(653-684).

Osland, J. S., & Bird, A. (2000) Beyond Sophisticated Stereotyping: Cultural Sensemaking in Context. *Academy of Management Executive*, 14(1), 65-79.

Phillips, J. K., Klein, G., & Sieck, W. R. (2004) Expertise in judgment and decision making: A case for training intuitive decision skills. In D. J. Koehler & N. Harvey (Eds.), *Blackwell Handbook of Judgment & Decision Making* (pp. 297-315). Blackwell, Malden, MA.

Quinn, N. (2005) How to reconstruct schemas people share, from what they say. In N. Quinn (Ed.), *Finding culture in talk*. Palgrave MacMillan, New York.

Rasmussen, L. J., Sieck, W. R., & Smart, P. (in press) What is a Good Plan? Cultural Variations in Expert Planners' Concepts of Plan Quality. *Journal of Cognitive Engineering and Decision Making*.

Reynolds, T. J., & Gutman, J. (1988) Laddering theory, method, analysis, and interpretation. *Journal of Advertising Research*, Feb/March, 11-31.

Romney, A. K., Batchelder, W. H., & Weller, S. C. (1987) Recent applications of cultural consensus theory. *American Behavioral Scientist*, 31(2), 163-177.

Romney, A. K., Weller, S. C., & Batchelder, W. H. (1986) Culture as consensus: a theory of culture and informant accuracy. *American Anthropologist*, 88, 313-338.

Ross, N., & Medin, D. (2005) Ethnography and experiments: Cultural models and expertise effects elicited with experimental research techniques. *Field Methods*, 17, 131-149.

Schmitt, R. (2005) Systematic metaphor analysis as a method of qualitative research. *The Qualitative Report*, 10(2), 358-394.

Schwartz, S. H. (1994) Cultural dimensions of values: Towards an understanding of national differences. In U. Kim, H. C. Triandis, C. Kagitcibasi, S. C. Choi & G. Yoon (Eds.), *Individualism and collectivism: Theory, method, and applications* (pp. 85-119). Sage, Newbury Park, CA.

Sieck, W. R., Grome, A. P., Smith, J., & Rababy, D. A. (in press) Expert cultural sensemaking in the management of Middle Eastern crowds. In K. L. Mosier & U. M. Fischer (Eds.), *Informed by Knowledge: Expert Performance in Complex Situations*. Taylor and Francis.

Sieck, W. R., McHugh, A. P., & Smith, J. L. (2006) Use of cognitive field research methods to investigate cultural groups: The case of individual decision making in Middle Eastern crowds. In R. Sun & N. Miyake (Eds.), *Proceedings of the 28th Annual Conference of the Cognitive Science Society* (pp. 2164-2168).

Sieck, W. R., & Mueller, S. T. (2009) Cultural variations in collaborative decision making: Driven by beliefs or social norms? In *Proceedings of the International Workshop on Intercultural Collaboration* (pp. 111-118). Palo Alto, CA.

Sieck, W. R., Smith, J., Grome, A. P., Veinott, E. S., & Mueller, S. T. (2009) *Violent and Peaceful Crowd Reactions in the Middle East: Cultural Experiences and Expectations*. International Academy for Intercultural Research, Honolulu, HI.

Sieck, W. R., Smith, J., & Rasmussen, L. J. (2008) *Expertise in making sense of cultural surprises*. Interservice/Industry Training, Simulation, and Education Conference (I/ITSEC), Orlando, FL.

Sperber, D. (1985) Anthropology and psychology: Towards an epidemiology of representations. *Man*, 20, 73-89.

Sperber, D. (1996) *Explaining culture: A naturalistic approach*. Blackwell, Malden, MA.

Van Boven, L., & Thompson, L. (2003) A look into the mind of the negotiator: Mental models in negotiation. *Group Processes and Interpersonal Relations*, 6, 387-404.

Wilson, M. L., Russell, A., Smart, P. R., Shadbolt, N. R., Carr, L., & schraefel, m. c. (2005) *Using Semantic Web Technologies to Support Enhanced Situation Awareness*. 4th International Semantic Web Conference (ISWC), Galway, Ireland.

Yates, J. F., Ji, L.-J., Oka, T., Lee, J.-W., Shinotsuka, H., & Sieck, W. R. (in press) Indecisiveness and thoroughness: Cultural variations in customs, values, and expectations. *Journal of Cross-Cultural Psychology*.

Yates, J. F., Lee, J.-W., Sieck, W. R., Choi, I., & Price, P. C. (2002) Probability judgment across cultures. In T. Gilovich, D. Griffin & D. Kahneman (Eds.), *Heuristics and Biases: The Psychology of Intuitive Judgment* (pp. 271-291). Cambridge University Press, Cambridge.