Creative and Evaluative Processes in Conversations about Potential Events

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Abstract

This working paper describes preliminary research on creative and evaluative processes in conversations in which alternative courses of action are being developed for a decision at hand. Research has identified five key conversational moves that form the basis of a process for creating, expanding, and evaluating concept networks, which are a type of semantic network. Tentative suggestions are offered regarding how this type of process could be employed in Decision Analysis as well as Chance Discovery. Consideration is given to how precedents from the practice of Decision Analysis might be applied in the practice of Chance Discovery.

Introduction

These working notes describe preliminary results of research designed to address one of the key challenges in Decision Analysis practice: generating the set of alternatives, or the "action space" for a decision model. In classical Decision Theory, on which Decision Analysis is based, the space of actions and possible future states are assumed to be known completely by the decision maker prior to the decision event, while in practice, these must be determined as part of the decision making process. Although decision analysts typically devote careful attention to generating alternatives and framing decisions, using techniques from various sources, there is neither a coherent theory describing how decision makers determine action spaces, nor well-defined, generally accepted, normative guidelines for the process. The research described here surely will not resolve these issues, but hopefully will lay the foundation for methods that will prove useful in certain classes of decision situations; in particular, those in which a comprehensive search of the action space is desired to uncover missed opportunities as well as false hopes.

The primary aim of this work is to develop methods to facilitate face-to-face conversations between decision analysts, domain experts, and stakeholders engaged in determining decision alternatives. Discourse analysis has been the foundation of the work. In some contexts the information processing requirements of the procedures may be accomplished best by a system involving both human and automated components. Since the methods being researched include systematic conceptual search and inference testing procedures, they might be applied to the discovery of chance events. Given that the procedures generate new concepts from existing concepts by repetition with variation, in accordance with inference rules and knowledge represented in a semantic network, they might support automating aspects of human design and discovery, including Chance Discovery.

Empirical research has focused on dialogic processes in groups of two or more persons, and certain classes of verbal protocols having key elements in common (as described below). Research has included participant observation in decision analysis, project formulation meetings, risk analysis, ethnosemantic interviews, and improvisational acting, as well as content analysis of methods employed in these and other contexts, including brainstorming and classical rhetoric. The results are preliminary and the conclusions tentative, as the rigorous application of formal grounded research methods is just getting underway. Limited analysis of video-taped planning conversations and brainstorming sessions has been performed, and while the formal methods of Protocol Analysis (Ericsson and Simon 1993) have not yet been applied in the empirical research, they have influenced the conceptual models employed.

The term *Amplex-Limit Process* (ALP) is a working name used to refer to the type of process being studied, which may be both descriptive and prescriptive. The term "*amplex*" is formed from the words "*amplification*" and "*exploration*", two key operations in the processes being analyzed. Amplex derives also from the Latin "*amplexus*", meaning, "embraced" or "surrounded", motivating the connotation that our conceived space of possibilities and actions is embraced by *limits*. These conceptual limits are generated by our perceptions, assumptions, inferences and judgments, and become explicit or operational during conversations, arising in response to introduction and elaboration of concepts.

The Process and the Concept Space

The aspects of conversation that can be described or guided by ALPs are modeled as a search through a concept space, in which concepts are introduced, developed, and evaluated, and knowledge (which may be subject to later revision) is accumulated as the search proceeds. Each concept is modeled as a node in a developing network. The nodes are semantically linked, and operations of the process spawn new nodes from existing ones. The total collection of nodes in memory, together with stored evaluations applying to nodes or groups of nodes, forms the *concept network*, a type of semantic network.

Newell and Simon (1972) define a *problem space* as consisting of a set of operators that produce new states of knowledge from existing states of knowledge; symbol structures representing a state of knowledge about a task; an initial knowledge state and a desired end state; and total knowledge available in a given knowledge state. The definition of a *concept space* used here is similar, with some important differences. First, five specific operations (described below) define an ALP, a method for generating the concept space. The concept space generated is considered distinct from the operations used to generate it. For example, the process might be modeled as sequences of states and transitions, while the concept space is not, since links between nodes in the concept network represent semantic relationships, not state transitions. Second, symbol structures (for example, figures of amplification, described below) are shared by the process and the concept space, and are extensible to meet the needs of specific contexts. Finally, the end state is not known in advance: the ALP generates, expands, and evaluates the concept space, but stopping criteria may be determined by an evolving social context, based on process parameters, or based on other considerations distinct from the concept space and the ALP[1].

ALP's consist of five operations, revealed in dialogue as "conversational moves" or speech acts: *Introduce, Amplify, Explore, Limit, and Return*. *Amplify* and *Explore* support a creative process, and *Limit* supports an evaluative process, while *Introduce* and *Return* support a meta-process that drives the course of the conversation. In general, these operations are descriptive of natural speech acts interwoven throughout conversations that include other elements. In certain contexts, ALP-related processes have prescriptive guidelines constraining operations and operational sequences as well as conversational content.[2] Detailed descriptions of the five ALP operations follow.

Introduce

Introduce is the process of bringing into the conversation a new, incomplete concept, which could be an image of some future action, event or scene. The term *image* will be used for the initial concept introduced (for reasons that will be made clear in the following section on amplification).

INTRODUCE (N, e_1, e_2, …, e_m, E) denotes introduction of an image that will be uniquely designated node N in the concept network. The *elements*, or dimensions of the image are represented by e_1, e_2, …, e_m. (The nature of these elements will be clarified in later sections.) Parameter E is used optionally to introduce an image together with an associated evaluation; for example, the image may be designated "best so far" or even "crazy" when introduced.[3]

One key evaluation is a distinction made between the feasible, or credible, and the infeasible, or incredible. Introducing incredible concepts, and designating them as such, is used to overcome conceptual barriers, based on the idea that credible creative concepts come from incredible ones. As reported by Sutton and Hargadon (1996), practices at a leading product design firm that frequently employs a form of brainstorming "reflect the belief that many bad ideas can lead to a few good ones". Decision analysis practitioner Leo Hopf sometimes challenges groups to develop an alternative that would cause them to be laughed out of the room if anyone thought they were really serious. According to Hopf, these crazy alternatives have sometimes turned into the winners.[4] Introducing

[1] Theoretical consideration of stopping criteria in specific contexts based on process parameters will follow at a later time.
[2] For example, brainstorming, the HAZOP risk identification method, improvisational acting, ethnosemantic interviews.
[3] Making a distinction between evaluations and concept elements is essential, since both concepts and evaluations can evolve separately during the process.
[4] Personal correspondence with Leo Hopf, Strategic Decisions Group, Menlo Park, CA.

infeasible concepts could be an essential component of an ALP designed for Chance Discovery.[5]

Amplify

Amplify is the process of adding to a concept or image, details based on a *figure of amplification*. Each figure has elements that suggest natural ways to elaborate a concept, relative to that figure. The terms *amplification* and *figure of amplification* are taken from classical rhetoric, tracing to the ancient Greeks. "The goal of a renaissance rhetorical education was to render students in the discovery of ideas … students learned how to vary a given idea in manifold ways by putting it into different forms and figures", (Burton 2002). Of the many figures used in classical rhetoric, two are of particular interest here, *peristasis*, meaning "around a setting", which involves amplifying by including details about circumstances: time, place, occasion, personal characteristics, background, etc., and *diegema*, meaning "narrative", which involves amplifying based on a figure with the following elements: who took action, what action was taken, when was it done, where was it done, why was it done, and how was it done. Amplification using *diegema* was a basic preparatory exercise, or *progymnasmata*, of rhetorical pedagogy.

Decision analysts, ethnographers, journalists, and improvisational actors are trained to use models comparable to *diegema* and *peristasis* to structure conversations, expanding concept networks to reveal information and possibilities. Amplifying using explicit figures, in conjunction with the additional ALP operations described below, can greatly increase the concept space generated in a given situation, and the elements of the figures profoundly affect the concept network created. When figures such as *diagema* and *peristasis* are employed, the nodes of the concept network represent situated action.

In typical group conversation, concepts rarely if ever are amplified to include all the elements that would follow from the use of a figure of amplification, apparently because the subject of the conversation usually changes as concepts are evaluated without being well amplified, new concepts are introduced before prior concepts are amplified, and prior concepts are not revisited. For this reason, the concept is considered an "*image*" when first introduced. The distinction between an *image* and a concept is context dependent, and a matter of degree; it is a relative distinction made to establish the idea of an amplification continuum. A new concept node is assumed to lie nearer to the *image* end of the continuum, particularly if no figure has been associated with the node through amplification, and is a strong candidate for the RETURN operation discussed further below.

Certain figures, such as *diegema*, are *closed*, in that their elements are fully specified in advance, while others, such as *peristasis*, are open, in that their elements are inherently extensible (note "etc.", in the definition above). A closed figure implies conceptual completeness, and so provides a theoretical end point to the amplification continuum, but only relative to that figure, since another figure could always be invoked or invented. Closed figures would simplify automation, while open figures are easily created and used in face-fo-face conversation. Open figures may be employed during a learning phase, and become closed figures as the learning phase completes and patterns are established. For example, decision analysts routinely construct ad hoc figures of amplification called "strategy tables" (McNamee and Celona 2001) which are used to structure the dialogue in which alternatives are generated. Once created, a strategy table is used as a closed figure, but the figure is open during a learning stage, and may be modified in later iterations of the analysis. Note that INTRODUCE specifies concept elements but no figure, and could be considered an open figure. In some situations, INTRODUCE could be constrained to employ a specific figure, particularly if the social context is well understood, or if the ALP-based method is prescriptive or automated, and only closed figures are included.

AMPLIFY (N, Figure_n, e_1, e_2, …, e_m,) denotes amplifying the designated node by specifying concept elements e_1, e_2, …, e_m contained in Figure_n. If no Figure is specified, then the operation would represent amplification of an *image* by adding e_1, e_2, …, e_m, to those elements already contained in the image, presumably during a learning phase when figures of amplification are still being determined.

For example, assume Jim says to Yan, "Call me," creating an action image through a request or imperative. This could be represented INTRODUCE (N, Yan, call Jim). Amplification according to *diagema* could involve specifying elements *when* and *why*- for example AMPLIFY (N, *diegema*, when=tonight, why=make plans). After the amplification, the concept represented by node N would be associated with the figure *diegema*, and would contain all the concept elements expressed in the INTRODUCE and AMPLIFY operations. Alternatively, the amplification could occur without specifying the figure: AMPLIFY (N, when=tonight, why=make plans). The choice of representation is based on the purpose; in this example, the speakers would probably not be aware of the figure, but may well use the words "when" and "why". The *diegema* figure could be used in coding the protocol. Amplification according to *peristasis* might include associating the following context information with the node: "if there is no answer, it will mean that I just stepped out for a moment".

[5] For those readers familiar with mathematical optimization techniques, an analogy can be made between introducing incredible concepts in a concept network, and exterior point algorithms, in which a search is initiated outside of the feasible region defined by the problem.

The key points regarding amplification are: the figures are considered distinct from the concepts being amplified; a variety of figures can be employed, including ad hoc figures; the process can be learned, practiced, systematically employed, and potentially automated to expand concept networks; the benefits of amplification for expanding a concept network are enhanced greatly when AMPLIFY is employed in conjunction with the other four operations.

Explore

Explore involves recognizing an object as a member of a class, searching the class, identifying an alternate member of the class, and substituting the new object for the original object- a process by which we could offer someone a pencil if they ask us for a pen and we don't have one. To accomplish this form of exploration, we move from a lower to a higher order of abstraction, and then back to the original level. Hayakawa (1947) used the analogy of a "Ladder of Abstraction" to describe this process, based on the prior work of Korzybski (1958). Movement up and down this "ladder" is a highly effective technique for spawning daughter nodes from a node in the concept network. In terms of an ALP, *explore* can be defined as branching from a node to create a new node by varying elements of the original node.

EXPLORE (N_1, N_2, $\mathbf{e}_o$, $\mathbf{e}_n$), denotes the process of creating daughter node N_2, based on parent node N_1, by substituting the vector of new elements $\mathbf{e}_n$ in the daughter node, for the vector of original elements $\mathbf{e}_o$ in the parent node. All concept elements of N_1 not specified in the EXPLORE operation are retained in the daughter node. For example, assume as before, Jim says to Yan, "Call me," represented INTRODUCE (N_1, Yan, call Jim). Yan replies, "Why don't I just stop by your house instead?" which could be represented: EXPLORE (N_1, N_2, call Jim, stop by Jim's House). The elements when=tonight and why=make plans would be unaffected by the explore operation.

Note that many elements implied in these concepts are not specified, and hence, EXPLORE and AMPLIFY could spawn numerous daughter nodes for either node, for example, by specifying types or locations of phones, means of transportation used to accomplish "stop by", etc. In natural conversation, this exhaustive generation of nodes is not done, but in some situations, thorough and exhaustive generation of possibilities may be warranted.

Motivated by the precedent of *figures of amplification*, *figures of exploration* are proposed for facilitating exploration. For example, in an acquisition decision, often there is a choice available to make, buy, or modify an item in order to meet the acquisition requirement. Hence, when an image involving acquisition is introduced, a *make-buy-modify* figure can be used to spawn creative alternatives that may not be recognized otherwise. Domain specific figures could be developed or adopted for Chance Discovery. For example, the HAZOP[6] method of risk analysis employs a figure of exploration in the form, *intention-deviation-cause-consequence*, along with specific techniques involving key words, to help analysts and engineers generate images of system failure modes (Safety Factor Associates, 1998).

Limit

The operations described so far concern processes that make the concept network grow. With the exception of INTRODUCE, which may associate the evaluation parameter (E) with the concept at introduction, the operators do not incorporate evaluative factors that can limit growth of the concept network. In general, any evaluation could be associated with a node or groups of nodes, but there is an important class of evaluations of key importance, those implying exclusion, and these will be referred to as *limits*.

In simple terms, a *limit* is defined here as a statement containing (or implying) the words "no" or "not" – a verbal ruling out. Space does not allow for full discussion of the subtleties of limits in conversation, but the simple definition provided here applies in a wide variety of cases, and is sufficient for providing the key insights. Note that here a *limit* is defined as a spoken statement, not cognitive state, or physical condition, hence limits are observable in conversations.

LIMIT may apply to any combination of individual nodes or concept elements, and may be stated as a rule that applies to an entire class of nodes. The general form is: LIMIT (N_1, $\mathbf{e}_1$, N_2, $\mathbf{e}_2$,…, N_n, $\mathbf{e}_n$, L), where N denotes a node, **e** denotes a vector of concept elements, and L is the limit. The type that arises commonly in conversation is of the form: LIMIT (N, e, L), where a limit statement is made in reference to some aspect of a concept being discussed. For example, "I can't call Jim," or, "I can't drive," or, "I won't be home."

Four types of limits have been identified that are of key importance in decision making, relating to action, possibility, relevance, and value. A limit on the action space is of the form "It can not be done"; a limit on the possibility space is of the form "It will not happen"; a limit on relevance is of the form, "It does not matter"; and a limit on the value model is of the general form "It is not valued". Concepts having elements that are ruled out as infeasible, impossible, irrelevant or undesirable are usually dropped from the discussion, a tendency that may impede Chance

[6] Hazard and Operability Study.

Discovery, since limits are often revised or retracted when tested. While the subtleties of limit types are very important, we can think of all limits as separating nodes into two sets: *credible*, and *incredible*.

Handling Limits

Several postulates suggest that handling limits carefully is of key importance in designing ALP's for Chance Discovery. First, limits can be wrong, meaning an incredible node may actually represent a concept that will be perceived as credible after further discussion (so the limit may be removed as the conversation proceeds.) This could represent a significant problem for Chance Discovery, since ruling out a node may amount to ruling out all the daughter nodes that could be spawned from that node through amplification and exploration.[7] Second, incredible nodes can spawn credible daughter nodes. Third, the nodes spawned by incredible nodes are of key interest. This third postulate is based on two assumptions: first, that Chance Discoveries, like creative concepts, are more likely to arise when incredible concepts are entertained; and second, that amplifying and exploring daughters of incredible nodes may motivate revision of limits on the parent nodes, or generate credible nodes similar to the incredible parent. These postulates are ordered from weakest to strongest- the first two are easily observed empirically in a variety of circumstances. Together, these assumptions motivate prescribing a standard that incredible notes not be ruled out of the process, or simply ignored, when they are ruled out of the credible concept network.[8] In fact, the most effective means of chance discovery may require an explicit focus on incredibility, rather than credibility, since remote or non-obvious possibilities can be closely related to impossibilities.

The three basic processes for handling limits are *surfacing, testing, and suspending*. Testing limits includes *restating*, *conditioning*, *reversing*, and *evaluating* the limits, as well as choosing to *defer* testing until a later time. Preliminary field work suggests the level of inquiry required to thoroughly handle limits is beyond what is natural in conversation, and it is necessary to establish *preconditions* for the process, for example, getting agreement that such inquiry is worth the effort and will be tolerated.[9]

The first consideration in handling limits is *surfacing* them, which involves processes leading to clear verbal expression of the limits. In natural conversation, assertions and vague evaluative statements are often made implying beliefs about credibility, but stated limits do not clearly relate to credibility. For example, someone might say "Let's not try that." From a Decision Analysis perspective, this is clearly a limit on the action space; however, it could be based on any number of value or possibility-related limits that might surface in response to questions, for example, "Why not?" Details of inquiry techniques can become quite elaborate, and are beyond the scope of this discussion, other than to mention that many precedents exist.[10] Simply asking, "Why?" and "What if?" in response to evaluative statements almost always leads to statements containing "not" or "no", and this technique can be quite effective.

After the limit is surfaced and conditioned, several operations can be used to *test* it. The first step in testing a limit is to *restate* it clearly. The originator of a limit frequently will revise, clarify, or even abandon a limit when it is repeated back.[11] Once a limit has been surfaced and stated in a stable form, it can be *condition*ed, which takes the general form of inquiry, "Under what conditions…?" or in common speech, "When would…?", completing the question by incorporating a phrase taken from the limit. A variation of *restate*, which can be used to develop conditions as well as test the stability of the limit, is the *reverse* operation, which involves restating the limit in some form of its opposite, and then pursuing a rationale to support the reversed judgment.[12]

A general method proposed to *evaluate* limits has its roots in the theory of abstraction and inference described by Korzybski (1958), and later adopted by Hayakawa (1947, 1949), and others (see Senge et. al. 1994). This method has both descriptive and prescriptive elements. Korzybski described inference as a stage in the following process:

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[7] However, some of these daughter nodes may eventually be reached by other exploration paths not passing through the ruled out node.

[8] The credible concept network means the portion of the concept network containing only nodes not ruled incredible by a limit.

[9] People may become stressed, impatient, defensive, or irritated in response to the repeated questions required. Also, they may respond as if the questions are statements, and become argumentative. Social factors may impede or preclude open discussion of limits. Full treatment of social factors and preconditions for handling limits is beyond the scope of this paper. The elements covered here outline only the basic structure of the process, and research on preconditions is ongoing.

[10] For example, there are established precedents in the field of risk analysis, including the "What if?" method; the "What if?/Checklist method, and the HAZOP (hazard and operability study) method (see Safety Factor Associates, 1998).

[11] A surprising empirical observation, the high frequency with which limits are revised or retracted when restated by someone other than the originator, motivated the designation of "restate" as a form of test, rather than a prerequisite to testing.

[12] This technique was emphasized in certain schools of classical Greek rhetoric, for example students of *eristics* practiced arguing either side of any issue with equal effectiveness.

1) Sub-linguistic *observations* give rise to 2) recognized *objects*[13], or first-order abstractions, that are given 3) *labels* and *descriptions*, some subset of which are used along with prior knowledge to construct and communicate 4) *inferences* and *judgments*, which give rise to 5) *creeds*; and ultimately, the prior stages in the process determine our patterns of 6) *action*.

According to Hayakawa (1949), "Inferences may be carelessly or carefully made. They may be made on the basis of a great background of previous experience with the subject matter, or no experience at all." His statement is consistent with the observation that limits are often revised or retracted when restated. Hayakawa observes that judgments can "stop thought" and induce "temporary blindness". Limits are a type of judgment, so modeling the inference process is of key importance for chance discovery using an ALP. Judgments of credibility/incredibility can involve concepts lying at the extreme limits of probability, and the operation is binary, so Bayesian models are not appropriate for the inference processes used in establishing limits[14]. The following model is based on Hayakawa and Korzybski.

Inference can be described as a chain, each link of which must remain intact for the limit to remain in place. Evaluating a limit is analogous to a "pull test" on the chain. If the chain breaks, the limit will be revised or retracted; if the chain does not break, it means only that the test was passed, but does not necessarily mean the chain is of high quality, since other defects could be present, not detected by that particular test. The five links in the chain of inference, ordered from lower to higher levels of abstraction, are named as follows: *perceptions*, *reports*, *inferences*, *analyses*, and *judgments*.[15] To test a limit (which is a type of judgment), we steer the conversation down the chain to understand the lower order abstractions on which the limit is based; to surface limits, we ascend the chain to discover limits which could arise from the lower order links.

The first two links, perceptions and reports, involve screening from an essentially infinite amount of data a small subset which is perceived and reported.[16] Reports include labels and descriptions of perceptions. The screening process at the level of perceptions and reports strongly influences inferences, analyses, and judgments. The next three links, inferences, analyses, and judgments always involve incorporating information or knowledge from prior experience or other sources to the information from the perceptions and reports. The influence of experience, knowledge, and values increases as we ascend the chain. However, biases based on experience and values are well known to affect the screening out of information at the lower end of the chain.

General approaches for using these concepts to improve the quality of inference processes are proposed in Korzybski (1958), Hayakawa (1947. 1949), and Senge et. al. (1994). *Restate*, *condition*, and *reverse* operations all tend to direct attention to lower links in the chain. In general, the goal during evaluation is to become conscious of things that were left out, or added in, during the inference process that generated the limit. This is accomplished by descending the chain, considering other approaches to analysis, broadening attention to include additional information, recognizing and addressing biases and limits in perception, and seeking disconfirming evidence. This process could be facilitated by attention to the various types of biases identified by decision making research (Cohen 1993) and employing strategies designed to overcome them (Russo and Shoemaker 1989).

Defer is a choice to handle a limit at a later time. This may be appropriate based on various situational factors and procedural considerations. If handling a limit is deferred, the item is queued and later taken up in a *return* process (discussed below).

Suspend involves establishing an agreement to temporarily ignore the limit, treating the stated impossibility as a possibility, for example, "Ok, it can not happen, but let's talk about what things would be like *if it did* happen" or "We've heard that you can not hire any new people, but let's talk about how things would be *if you could* hire." Variations of the "What if?" method used to surface limits can be applied also to suspend them. Note that this operation requires *restating* the limit in some sense, and so may become intertwined with *testing* in natural conversations.

Return

Return is the process of directing attention to a prior node in the space for further amplification, exploration, or limit operations. Newell and Simon (1972) observe that in problem solving, people generally use very few nodes and when they do return, normally it is to either the previous node, or to the first node in the process. This is consistent with observations of conversations involving alternative generation as well. An ALP suited to Chance Discovery

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[13] Note Korzybski's idea was that everything is in reality a process, so that the "object" referred to here should not viewed as a static or material thing, but as a recognizable aspect of "what is going on."

[14] In Decision Analysis, Bayesian models would be introduced later, after an initial set of actions and possibilities is determined.

[15] In decision making, we can place alternatives and recommendations at the high end of the chain, in the range from analyses through judgments. Decisions themselves, are at the top of the chain, where Korsybski places "action".

[16] This is by definition, not observation- if information is added, the verbalizations display aspects of inferences and analyses, and therefore are not truly perceptions and reports.

would be designed to generate many nodes and branches; hence the return process would be key.

Discussion

The overall goal of this research is to develop an ALP that mediates between the creative and evaluative processes, to productively resolve the tension between them. It is easiest for a group to generate concepts that are credible, but obvious and unimaginative. It is relatively easy for a group to generate concepts that are imaginative and creative, but incredible. It is challenging for a group to develop concepts that are creative, imaginative, and credible as well. This challenge could be met with procedures that spawn credible imaginative nodes from nodes that are credible, but unimaginative, and with procedures that spawn credible, imaginative nodes from nodes that are incredible, but have desirable aspects. This may be accomplished through the careful application of figures, key words and phrases, and inference tests. The key operations are *amplify*, which provides a rich conceptual basis for exploration, *explore*, which generates new concepts from existing concepts, and *limit*, which rules concepts credible or incredible. The key challenge is to prescribe guidelines for effective sequences of operations in the ALP.

Consideration of Brainstorming (Osborne 1963, Sutton and Hargadon 1996) provides a useful illustration. One commonly observed sequence in conversations is *limit* in response to *introduce*. A rationale behind Brainstorming is that this sequence impedes the generation of creative concepts. Brainstorming could be considered an ALP with a reduced set of operations and symbols, in that *limit* is ruled out of the conversation, figures of amplification are not explicit, and detailed operations for building on previously introduced concepts are not specified. In addition, brainstorming traditionally is conducted in a single intense, face-to-face conversation, while dialogue employing ALPs may take place over a longer period of time, proceeding in stages, in varying social circumstances appropriate to phases of the process. In ruling out the *limit* operation, Brainstorming eliminates the opportunity to creatively push limits by sharing and reflecting upon the inference process that generates them, and leaves out an essential operation in the movement from imagination to action.

This research is motivated by the idea that an ALP could support iterative modeling in Decision Analysis practice, in particular, to elicit the action space for an initial decision model, and to appraise and revise the model as required; but in general, an ALP could use virtually any model as a starting point, and could be applied to the model structure and problem frame to develop a better starting point for the next iteration. A model representing situated action, consisting of an actor allocating resources within spatial, temporal, and social contexts is currently the focus of this research. Other promising models include value models, resource models, and of course, decision models. Westrum (1991) describes "requisite imagination" as the ability to imagine key aspects of the future we are planning, and Adamski and Westrum (Forthcoming) argue that by using a sound conceptual model to enhance intuition, designers can improve requisite imagination to foresee side effects and avoid unintended consequences. In Westrum's view, a number of elements could make up such a model, and he presents one version having nine task components.

Certain techniques of iterative modeling developed for Decision Analysis practice might provide an overall structure for Chance Discovery, even if a decision theoretic model is not employed. Such constituents of Decision Analysis practice include: a dialogue process involving periodic meetings between stakeholders, domain experts, and modelers to appraise the model and share insights (McNamee and Ceylona 2001); periodic examination and revision of the problem frame (Matheson 1990); information gathering phases driven by insights gained from the model (Howard 1968); iterative appraisal and revision of the model based on insights generated and information acquired (Howard 1983); and a clear distinction between the problem frame and the model (Barrager et. al. 2001).

Conclusions

Practical application for Chance Discovery could involve combining the results of ALP research with other established techniques in AI, as well as expert elicitation, risk analysis, and Decision Analysis. The five operations could be automated or partially automated to support the process. Automating the operations could help cope with the potential combinatorial explosion of the concept space. Several aspects of the proposed ALP methods could be valuable in Chance Discovery: first, representing concepts in a network that captures parent-child and other semantic relationships among them; second, expanding the network by generating new concepts from existing concepts using the small set of ALP operations; third, surfacing limits, which are inferential reactions to the nodes of the concept network; fourth handling limits with specific procedures for testing the inference process that generated them; and finally, entertaining incredible concepts to find concepts near the limits of credibility.

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