

Schemata in Everyday Reasoning

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With 5 figures

If during a conversation I am asked "Will you be at the meeting?" I will usually be able to come up with an answer immediately. But in order to give this answer I have to access my knowledge about the topic of the ongoing conversation that I assume to be the context of the question, (e.g. meetings which are due in the immediate future or meetings in general). In the case where deductions from my knowledge are not explicit enough to give an answer I can either probe deeper into my knowledge or I can request more information from the speaker.

Without going into details about how common knowledge is generated and known to be mutual (the most recent overview from a more psychological point of view is CLARK & CARLSON (1982) this example is applied in order to shed light on the following facts: (i) people quite often are extremely fast in making long chains of inference from their knowledge, (ii) they are able to take into account not only standard knowledge but also new information necessitating the revision of the existing knowledge, (iii) in general they come up with a conclusion in finite time, and (iv) they are usually convinced of the correctness or at least aptness of the conclusion underlying their answer.

The analysis of different ways to model this kind of efficient utilization of vague or "fuzzy" information is the aim of this paper. Starting from TOULMIN's (1959) analysis of arguments and argumentation, different approaches are presented which can be used to model chainlike deductive structures. The results of these models are then compared to the facts I have pointed out about the informal way of reasoning in the initial example. One general result from these models is that the longer a deductive chain is, the less confident one should be about the final conclusion. While this is supported by experimental evidence from studies of the memory for unrelated items it is in conflict with the certitude expressed in the inferences underlying the interpretation of utterances in conversation. The reason for this difference is that in conversations the bits of information are usually related by a common context and structured by an underlying argumentative strategy. For the modelling of this kind of inferential chains I draw upon perceptual schemata as an analogy. I suggest a schema oriented way of evaluating conclusions drawn from world knowledge which takes into account the overall structure of this world knowledge.

Alternative Approaches to Problem Solving

BRUSCHLINSKI & TICHOMIROV (1975) suggest that the aim of any genuinely psychological analysis of problem solving consists in distinguishing human problem solving from the problem solving by machines.

Since, there does not exist any unique way of problem solving by computers this suggestion does not help in confining the scope of the psychological analysis of human problem solving. However, dating back to ARISTOTLE there exist a host of "tools" to resolve problems stated in logic (e.g. syllogisms) and the application of these tools have sometimes (e.g. BOOLE 1854 "An Investigation of the Laws of Thought") been identified with theories of thinking. From this point of view, any aberration of human attempts to solve these problems can be attributed to the 'bounded rationality' (MARCH & SIMON 1967) of humans.

The investigations of human syllogistic reasoning (e.g. WERTHEIMER 1925; WOODWORTH & SELLS 1935 or WASON & JOHNSON-LAIRD 1972 to cite only a few, albeit characteristic analyses) have shed light on certain aspects of human syllogistic reasoning the preference for certain forms of syllogisms over other logically equivalent forms, the difference between presentations of the same problem either in abstract form or embedded into trains of everyday actions; and the role of mental models. What is common to these approaches is the unquestioned assumption that syllogistic reasoning with its forms of quantification and its rules of combination is *the* very essence, albeit purified from ambiguities, of human reasoning. The initial example, however, has shown that the natural setting in which human problem solving capacities have emerged is characterized by ambiguities, non-classical quantifications, and an inquisitive reasoning which consists in the accumulation of circumstantial evidence governed by the search for the interpretation of the uttering which obeys the conversational rules best. It seems curious that the various psychological classifications of problems (from STÖRRING 1926; to KLIX 1971; or DÖRNER 1976) do not even mention this kind of problem which except for its importance in human conversation is also typical for legal reasoning and detective novels.

The Structure of Arguments

According to TOULMIN (1959) an argument consists of a series of propositions which are evaluated one for one by comparing them with the evidence provided by the context of the whole argument. Both the piecewise and the global evaluation are done in order to convince the user of the argument as well as his or her addressees. An argument consists of at least one claim (usually a hierarchy of claims), based on *evidence* and a *warrant*. In a warrant generally known and accepted rules about the world are stated or referred to. The argumentative reasoning takes place in the context of the *backing*, that is, the world knowledge from where the warrant is derived, and the *rebuttals*, that is, alternative claims. The successful refutation of plausible rebuttals strengthens the convincingness

of the argument. Warrant, evidence, and claim are analogous to the major premise, the minor premise, and the conclusion in the syllogistic schema. But, whereas the emphasis in syllogistic thinking lies in the pinpointing of inconsistencies, in argumentation the whole argument including the backing and the refuted rebuttals has to be evaluated in the face of inevitable inconsistencies. This evaluation is done by working through possible alternatives (rebuttals) and choosing the chain of claims which is least inconsistent and closest to the overall claim, that is, the claim highest in the hierarchy. This theory of arguments by TOULMIN (1959) can serve as a framework and a normative standard for formalizations of the rules underlying the usage of world knowledge.

Models for Reasoning with Inconsistent or Vague Premises

RESCHER & MANOR (1970) have proposed a formalization of plausible reasoning, that is, a connected system for the formal interpretation of statements which are neither completely true nor completely false, and of procedures underlying judgments and conclusions in this framework. The proposed methods consist primarily in (i) a strategy to cope with assertions which are neither true nor false but more or less plausible and (ii) a strategy to draw conclusions from inconsistent premises:

in (i) the plausibility for all premises is evaluated and subsequently integrated into the overall plausibility of the argument, that is, in TOULMIN's terms the *plausibility of the claim*, and

in (ii) one searches for the maximal consistent subset of premises in the argument.

Both strategies can be combined by: first, evaluating the plausibilities; second, determining plausibility thresholds which might be thought to depend on the overall importance of the argument; and, third, searching for the maximal subset consisting entirely of above-threshold plausible premises. RESCHER & MANOR propose the MIN-operator for the evaluation of the overall plausibility:
 $\text{plaus}\{\text{conclusion}\} = \text{MIN}(\text{plaus}\{\text{minor premise}\}; \text{plaus}\{\text{major premise}\})$

It can easily be seen that longer the chain of deductive steps is the smaller the overall plausibility will be.

This result is very similar to the results in fuzzy reasoning where three different approaches can be differentiated:

- (i) the evaluation of propositions by fuzzy truth values which is practically equivalent to RESCHER's strategy (ii)
- (ii) the interpretation of propositions by means of operations on fuzzy sets (e.g. "all X are Y" is interpreted as "X is a fuzzy subset of Y")
- (iii) the interpretation of quantifiers as possibility functions over the range of relative frequencies of instances.

Approach (i) enables use to resolve the old sophistic paradox of the bald man who is still bald if one adds one hair and then an-

other and so on until infinitum (GOGUEN 1969). The assumption of an initial truth value insignificantly smaller than 1.00 and the evaluation of every single situation by multiplying the truth values of all steps between the initial state and the present situation leads to ever decreasing truth values. By virtue of this kind of evaluation, approach (i) accounts well for unrelated steps of inference but fails for integrated arguments as much as RESCHER & MANOR's approach does.

The situation for approach (ii) is similar to that for approach (i) as can be seen from the definition of a fuzzy subset:
If A is a fuzzy subset of B then the membership function for any element in A is equal or smaller than its membership function for B.

If therefore the warrant of an argument is expressed as a statement about a fuzzy subset and the evidence is given by the membership function for an element of this subset then again the claim (the conclusion) can be only equally or less valid than either the warrant or the evidence.

The interpretation of quantifiers as possibility functions over the range of the relative frequencies of the occurrence of instances, approach (iii), (see Fig. 1) models fairly well the meaning

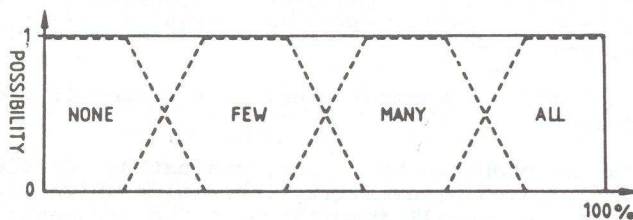


Fig. 1: Possibility functions for natural-language quantifiers, the scope gives the possibilities of events.

of quantifiers in natural language. Furthermore by means of scope-functions for the contexts in which quantified statements occur it becomes possible to model context dependent meanings of quantifiers (ZADEH 1982, ZIMMER 1982a). But again, the algorithm for deduction with these quantifiers implies that in a chain of inferences the possibility value of the complete line of arguments can be maximally as high as the possibility value of its weakest link.

It is possible to combine the three approaches by defining quantifiers as elastic constraints on statements:
If one defines the fuzzy sets \underline{X} and \underline{Y} by the membership functions $\mu_{\underline{X}}$ and $\mu_{\underline{Y}}$ then the following elastic constraints can be applied to model quantifiers:

$$\text{ALL } (\underline{X}; \underline{Y}) = \text{poss}\left[\frac{\mu_Y - \mu_X}{\mu_Y}, 0\right] \ll \text{poss}\left[\frac{\mu_Y - \mu_X}{\mu_Y}, 0\right] \quad (1)$$

$$\text{MANY } (\underline{X}; \underline{Y}) = \text{poss}\left[\frac{\mu_Y - \mu_X}{\mu_Y}, 0\right] < \text{poss}\left[\frac{\mu_Y - \mu_X}{\mu_Y}, 0\right] \quad (2)$$

$$\text{FEW } (\underline{X}; \underline{Y}) = \text{poss}\left[\frac{\mu_{\text{not } Y} - \mu_X}{\mu_{\text{not } Y}}, 0\right] < \text{poss}\left[\frac{\mu_{\text{not } Y} - \mu_X}{\mu_{\text{not } Y}}, 0\right] \quad (3)$$

$$\text{NONE } (\underline{X}; \underline{Y}) = \text{poss}\left[\frac{\mu_{\text{not } Y} - \mu_X}{\mu_{\text{not } Y}}, 0\right] \ll \text{poss}\left[\frac{\mu_{\text{not } Y} - \mu_X}{\mu_{\text{not } Y}}, 0\right] \quad (4)$$

The relations (\ll , $<$, $>$, and \gg) are assumed to be fuzzy (KAUFMANN 1975), thereby comparisons of evidence are made possible.

In this approach deductive chains can be modelled by assigning the following values to conclusions: if a conclusion falls in between the elastic constraints of a certain quantifier then the most typical value of this quantifier is taken to evaluate the conclusion (e.g. a conclusion A falling in between the elastic constraints of MANY would be evaluated by $\text{poss}(A) = .65$ according to Figure 1). This approach is hardly applicable to chains of arguments because if by chance information with $\mu(A) = 0$ is used as evidence in an inferential step then the overall evaluation might become NONE if no provisions are made to prevent this kind of instability in the deductive process. Furthermore this formalization has a bias towards negative conclusions.

The above sketched approaches of reasoning with vague concepts fail for lines of arguments or, at least, lead to conclusions which contradict known facts about natural inferences, because they imply independence of warrants and evidence. This kind of null assumption about the structure of knowledge is apparently wrong for human world knowledge. Most easily this can be demonstrated for the perception of visual scenes which form a major basis for the world knowledge internally represented. For the analysis of complex visual scenes a number of processing models have been suggested which assume that either perception is predominantly driven by stimuli provided in the environment or that it is mostly influenced by higher-order concepts, that is, the world knowledge. In the most extreme data-driven models the human visual system is equated to something like a camera. While such reductionist models fail even for simple phenomena like form, size, or color constancies, it is possible to develop robust data-driven models which are able to account for some of these effects. These models can be expanded to chains of inferential reasoning.

Modelling Robust Inference for Independent Information

One interpretation of how complex visual scenes can be perceived as integrated wholes (Gestalten) is that "unconscious conclusions" (HELMHOLTZ 1896) are drawn to put together the available pieces of information. By virtue of their being unconscious these conclusions can be assumed not to be affected by the above shown impairments of chains of inferences. This can be modelled by a theory of robust inferences about imprecise statements which consists of a renormalizing procedure after each deductive step and a memory span limited to the most recent state. In (ZIMMER 1983) I have shown that the "availability bias" (TVERSKY & KAHNEMAN 1973) can be modelled fairly well with these two elementary processes. One problem connected with this model is that, due to the limited memory capacity, it does not account for the tendency of knowledge to resist changes which are too abrupt. This tendency seems to be of high evolutionary importance because it prevents instability. This model can be elaborated further by taking into account the belief strength in the existing knowledge (the inertia of the system) and the impact of new information (its saliency for the existing system).

Continuous processing of independent pieces of information as, for instance, in forecasting can be represented in this framework (ZIMMER 1982b). The belief strength (b_i) is assumed to be a monotonically decreasing function of the fuzzy distance between the quantified knowledge (Q) at time t (i) and at time t ($i+1$) normalized to the interval $[0,1]$.

$$b_i = f[d(Q_i; Q_{i-1})] \quad 0 \leq b_i \leq 1 \quad (5)$$

The saliency parameter for novel information, α , too is restricted to the interval $[0,1]$. The resulting change of the knowledge in the light of new information with a given-saliency can then be described by the following formula:

$$Q_{i+1}^{(x)} = \text{MAX}_x \left[b Q_i^{(x)} + (1-b) I_{i+1}^{(x)}; \frac{\text{MIN}_x [\alpha \cdot I_{i+1}^{(x)}; Q_i^{(x)}]}{\text{MAX}_x [I_{i+1}^{(x)}; Q_i^{(x)}]^r} \right] \quad (6)$$

The parameter 'r' reflects the degree to which the chain of arguments is integrated: for $r = 0$ the conclusions are independent and for $r = 1$ the conclusions are maximally interdependent ($0 \leq r \leq 1$).

In Fig. 2 the quantified old knowledge, the quantified incoming information, and the predicted versus the actual change in quantification are shown for an r-value of 1. The good match between the predicted and the observed possibility function indicates that the subjects had implied that the information gathered by them is tightly interconnected as shown by the high r-value.

It has to be kept in mind that in these models no structural assumptions about the knowledge and the active search for information

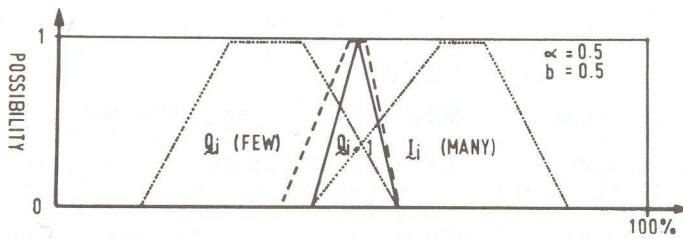


Fig. 2: Comparison of the predicted (—) and the actual change (---) of knowledge.

(the argumentative strategy) have been made, except for the saliency which is supposed to be given or otherwise set to .5, and except for the 'r' parameter which reflects the empirically determined interdependency of the warrants, evidence, and claims. In most approaches to reasoning they are assumed to be independent.

The research on judgmental processes as done by KAHNEMAN and TVERSKY (see KAHNEMAN, SLOVIC, and TVERSKY 1982) reveals that in many situations the reasoning based on simplifying heuristics leads the decision maker astray because it either neglects necessary structural information or it overgeneralizes structural assumptions. In order to avoid the pitfalls of reasoning mentioned, it is necessary to integrate the structural knowledge into the reasoning process. It can be shown that for a self-organizing system - and world knowledge seems to be such a system - it is necessary to be able not only to return to a stable state after perturbation but also to be able to investigate new developmental pathways through successive states of instability. The performance of a system in coping with its environment depends on how much its complexity is counterbalanced by its structural integration and its reliability (SAHAL 1979). While in the above sketched model the reliability has been taken care of by the "inertia" of the system as expressed in the belief function, ways to get hold of the structure of the system have still to be developed. As pointed out before, visual perception can serve as a good example for such a system insofar as it exhibits not only homeostatic features as, for instance, the constancy effects, but also it is highly integrated. This can be most strikingly demonstrated in the perception of complex visual scenes where the background knowledge, the intention in perceiving (see BARWISE 1982), and the physically describable stimuli give rise to an integrated perception about what is going on.

Schematic Perception as a Model for World Knowledge in General

Following CASSIRER (1944), a "schema" in perception can be defined as consisting of

- (i) a set of primitives which are not further analyzable in the given context
- (ii) a set of organizational rules which can be paralleled to HELMHOLTZ' logic of unconscious inferences

- (iii) a set of admissible transformations, that is, transformations which define the class of invariants of the objects in questions.

It has been shown that in general these schemata do not exist in separation but that they are structurally organized in hierarchies or in other structures. Hierarchical structures are of special importance because they exhibit the feature of near-decomposability (SIMON 1965) while at the same time higher level schemata impose constraints on the sets of admissible transformations in lower level schemata (see Fig. 3). The application of fuzzy set theory to syntactic pattern recognition (FREKSA 1981; JAIN & HAYNES 1982)

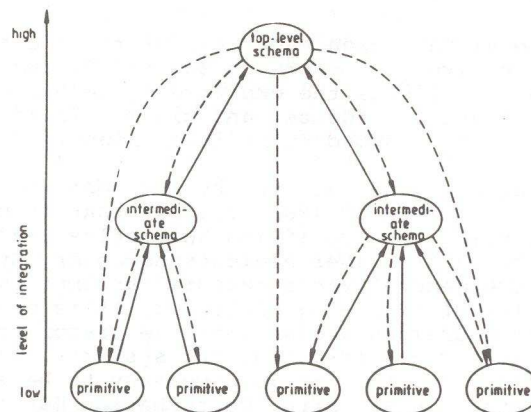


Fig. 3: A hierarchy of schemata

fits well into this theoretical framework because it enables people to discriminate between the different meanings a blurred part of a picture or a sloppily drawn line might carry. For instance FREYD (1983a) has experimentally demonstrated that in the recognition of handwriting the very same line can have different meanings under the variation of handwriting methods: in one case it might provide structural information while in the other case it can be regarded as a dismissable error.

In Fig. 4(b) through (d) it is shown how different elements of the original scene 4(a) are picked up in the different drawings, which were intended to enable an onlooker to find out from which point of view they had been taken. In drawing 4(b) the fuzziness consists entirely in a sort of wriggling while drawing straight lines. By the application of low-pass filtering the original drawing could be restored easily because the artist has applied the same kind of transformational constraints - that is, those of projective geometry - which are captured by a camera. The situation in drawings 4(c) and (d) is different: here subjects have decomposed the integrated perspective scenes into only loosely connected subparts. However, these subparts exhibit the kind of downward constraints on transformations typical for integrated wholes. It turned out that for human observers the representations (a) to (d) were equally informative for the task at hand, that is, determining from which point of view these pictures had been taken (ZIMMER in pre-

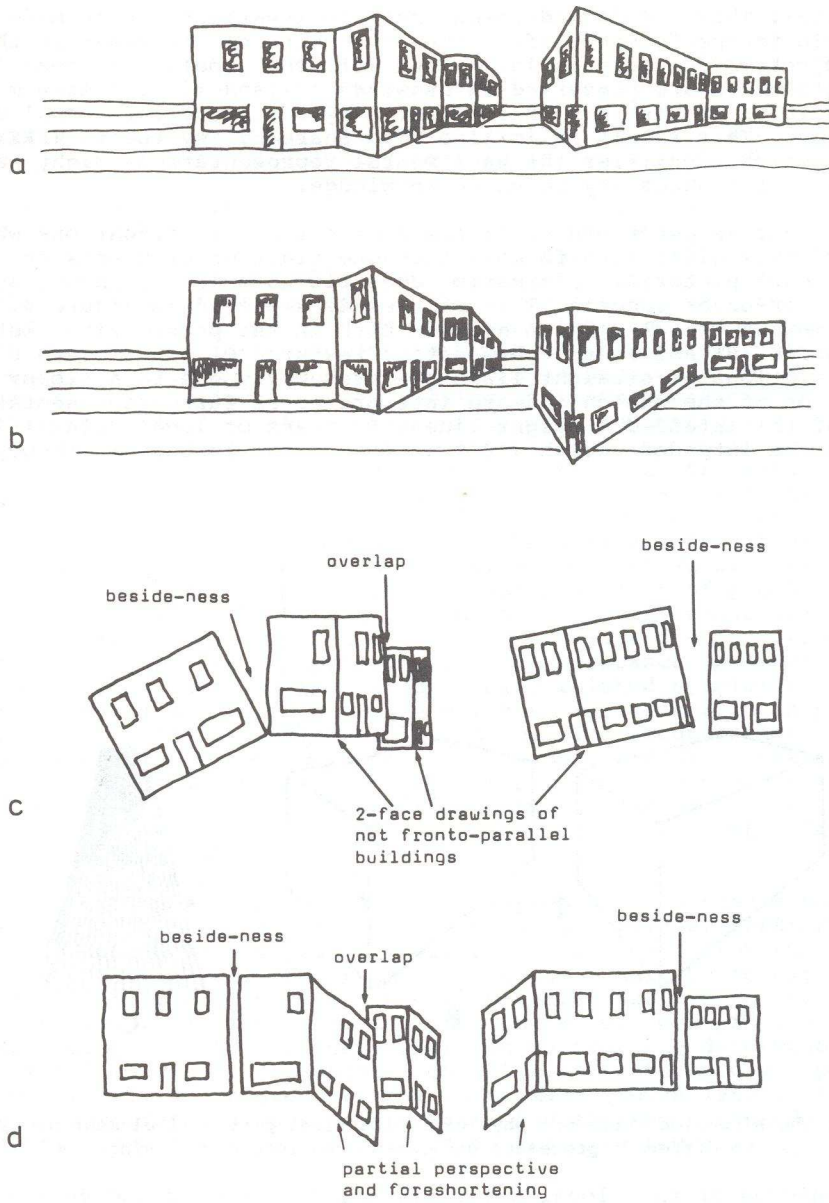


Fig. 4: Line drawing of a photograph depicting a perspective scene (a), the same scene as drawn by a graphic designer (b), and by two students without training in drawing (c) and (d).

paration). This result indicates that the invariants which made possible the performance of the observers are not necessarily those of projective geometry as in (a) and (b). The topological constraints which are preserved in drawings (c) and (d) resemble more the features of visual scenes selected by observers for verbal descriptions. This result is in line with Shareability theory (FREYD 1983b) which identifies the ways mental representations might be molded by the necessity to share knowledge.

The process as described up to now does not handle situations where the evidence gives rise to more than one train of arguments or where local pictorial information does fit into more than one scene (or higher-order schema). This problem is depicted in Figure 5. The somewhat wiggly line A appears both in the perspective sketch of a brick (B) and in the perspective texture (C). In picture B the deviations of straight lines are presumed due to a sloppy execution of the sketch and are interpreted as fuzzy representations of the intended straight lines. By means of local defuzzification the intended sketch ('B') is recovered. In Gestalt theory

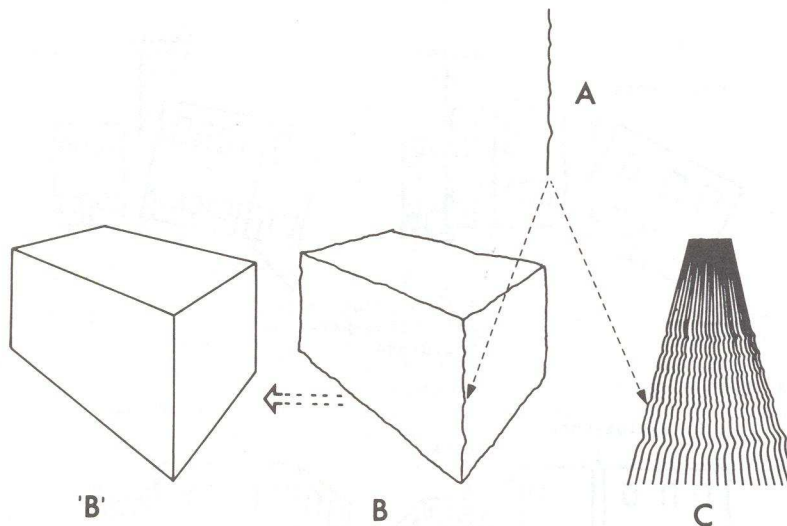


Fig. 5: The situation where one physically identical pictorial element gives rise to different processes discovering the intended meaning.

the analogue of this local defuzzification is the 'tendency towards the good form'. However, the same 'wiggly' line conveys the impression of an undulating plane seen in perspective if repeated and converging at the same vanishing point (C). In this case the deviations carry information about the texture of the plane and any kind of local defuzzification would genuinely change the picture. In terms of Gestalt theory the 'factor of same fate' gives rise to this interpretation. The fuzziness in this picture lies in the variations of distances between the lines and in the slight aberrations of the directions off the vanishing point. Ecological

optics (GIBSON 1979) would suggest that different 'intelligent mechanisms in perception' (RUNESON 1977) give rise to the two contradictory interpretations of the same 'wiggly line'. Nevertheless, the question remains open how - apparently without any conscious effort - the decision is made to apply the intelligent mechanism of defuzzification in the case of B and that of recovering spatial information from the undulating texture in the case of C.

NEISSER's (1975) suggestion of a cyclical processing by means of perception, schemata, and action might resolve this puzzle. The way Gestalt psychologists (KÖHLER 1917; DUNCKER 1945; WERTHEIMER 1945) have approached problem solving bears a strong resemblance to their treatment of perception. Most clearly KÖHLER (1917, 1920) has modelled problem solving as the transformation of one field characterized by strong and contrary forces into forces into another field which to uphold minimal work is necessary. KLIX (1971) among others describes problem solving as transformations in the problem space linking the initial state with the state of the intended goal, the solution. What is lost in this model in comparison to KÖHLER's is the importance of autochthonous processes which structure automatically the applicability of transformations; these processes are reminiscent of GIBSON's (1979) concept of affordances. What is common to these approaches is the distinction between initial states transformations (or means) and one or several final states. As mentioned above current classifications of problems according to these concepts bear strong similarities especially in the point that they do not include problems like the conversationally appropriate interpretation of an utterance as described in the introduction. Another structurally related problem is that of the typical detective story in which an active search is performed for mostly circumstantial evidence. The accumulation of circumstantial evidence is governed by the goal to exclude the innocents and to find the most probable culprit. The case against a possible culprit is strengthened by every refutation of arguments which speak against his or her guilt (see TOULMIN, RIEKE, JANIK 1979).

The contextual constraints work not only on the invariants but also on the definition what is to be regarded as fuzziness SPERBER and WILSON (1982) have analyzed discourse understanding from the point of view of contextual constraints. They claim that by merely applying the principle of maximal relevance it is possible to decide which utterance is informative and which is not. One problem connected with SPERBER & WILSON's approach is that the determination of maximal relevance presupposes that for any utterance all possible non-trivial inferences have to be made (MOORE 1982). In the case of integrated arguments, however, the exerted downward constraints prevent the possibility of an infinite regress.

Consequences for the Evaluation of Arguments

In developing convincing strings of arguments people seem to follow a strategy quite analogous to the top-down analysis in visual perception of complex scenes: (i) the general claim, or the ultimate goal of the argument, is stated; (ii) in a top-down search a string of subclaims is generated that connects the available evidence and relevant world knowledge to the ultimate goal of the argument;

(iii) new evidence is searched for if necessary; and finally, the available knowledge is checked for alternative strings leading to the same general claim or the string of claims is scrutinized to see if it supports alternative claims too. The organizing structure underlying this strategy can be assumed to be provided by the inferential schemata available. At least in our culture, causal schemata seem to make up the most convincing strings of arguments. Why this is the case can be seen from what people take as evidence for causality. For instance, SCHUSTACK and STERNBERG (1980) report that their subjects' judgments of the strength of a causal relationship could be accounted for by the following variables: (a) joint presence of the cause and the effect, (b) violation of sufficiency, (c) violation of necessity, (d) joint absence of the cause and the effect, and (e) the strength of alternatives. In modelling the revision of world knowledge these variables can be used in order to determine the parameter of saliency, α , and the parameter of interdependence, r , in Equation (6) which capture structural information about the world knowledge. With the saliency of information as depending on the underlying causal structure the proposed formalization becomes a model for integrated argumentative reasoning.

Admittedly, this suggested approach for modelling the revision of world knowledge in an argumentative discourse or in an inferential search falls short of providing a fullfledged formalization or a general theory of plausible reasoning. I hope to have shown, however, that schematic perception can serve as an fruitful analogy for the research on argumentative reasoning in relation to the revision of world knowledge.

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Summary

It is assumed that world knowledge in general consists of representations analogous to quantified statements. Usually the truth value for these statements about real-world events or rules is neither 1 nor 0 but usually in between. Approaches to formalize plausible reasoning on the basis of world knowledge are successful in modelling single deductive steps or chains of independent inferences. However, a general consequence of these models is that the longer the chains of inferences are, the less plausible is the final conclusion. This is apparently not the way people usually evaluate their conclusions because they exhibit considerable (and quite often justified) confidence in the final result of their reasoning. The alternative way of evaluating world knowledge as proposed here starts from the analysis of arguments and the way they are evaluated. Fuzzy schemata are defined which describe the rules underlying the above described revision of world knowledge in the face of either new situations which necessitate decisions or new information which is corroborating, contradicting, or irrelevant. The application of this notion of a fuzzy schema is demonstrated in the analysis of visual scenes. It is argued that visual information processing can be used as a model for information processing in general which is dependent on world knowledge.

Zusammenfassung

Als Ausgangspunkt dieses Artikels steht die Überlegung, daß unser Wissen über die Umwelt allgemein aus Repräsentationen besteht, die formal quantifizierte Aussagen entsprechen. Normalerweise ist der wahre Wert solcher Aussagen über reale Umweltereignisse oder regelhafte Zusammenhänge weder 1 noch 0, sondern bewegt sich zwischen diesen Extremen. Forschungsansätze, in denen versucht wird, den Prozeß sinnvollen Schlußfolgerns auf der Basis von Umweltinformationen zu formalisieren sind in der Lage, einzelne deduktive Schritte oder Aneinanderreihungen voneinander unabhängiger Schlußfolgerungen zu modellieren. Allerdings wird innerhalb dieser Modelle das Denkresultat umso unplausibler, je länger die Kette der Folgerungen ist. Da wir für gewöhnlich (und zumeist berechtigt) unseren Schlußfolgerungen durchaus einiges Vertrauen entgegenbringen, scheinen diese Formalisierungen kaum geeignet die Art und Weise, in der der Mensch seine logischen Denkschritte überprüft, adäquat zu beschreiben. Die hier vorgeschlagene alternative Art der Bewertung von Umweltinformationen beginnt bei der Analyse von Argumenten und der Art ihrer Überprüfung. Es werden Fuzzy Schemata definiert, die die Regel beschreiben, die der oben dargestellten Überprüfung von Umwelterfahrung angesichts unbekannter, eine Entscheidung verlangender Situationen oder neuer, bestätigender, widersprechender oder unbedeutender Informationen zugrundeliegen. Die Anwendung dieser Idee eines Fuzzy-Schemas wird für die Analyse visueller Szenen aufgezeigt. Es wird darauf hingewiesen, daß die visuelle Informationsverarbeitung als ein Modell für jede Form umweltbezogener Informationsverarbeitung angesehen werden kann.

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