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COMMENTATOR. A COMPUTER SYSTEM SIMULATING VERBAL BEHAVIOUR

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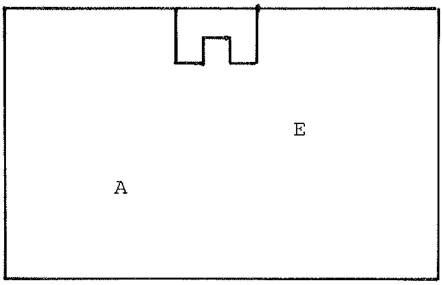
The COMMENTATOR system has been developed to test ideas about verbal production, but the system has also practical applications in automatic systems (robots) used to comment on situations or processes, e g automatic radar operators. The present version of the system is implemented in BASIC on a micro computer (ABC 80, produced by Luxor and Scandiametric, Sweden).

The system first generates a scene on the screen, which is used as the stimulus for the automatic comments. The comments are intended to simulate the comments human subjects could utter when watching the same scene. The scene is very simple, as it is designed to elicit simple comments on the movements and states of a few actors. The scene presently studied is a situation where two persons called Adam and Eve in the comments and marked by A and E on the screen move around in front of a gate (see fig 1). Human commentators tend to attribute an intention to get into the gate to the actors. Some spectators identify the gate with the gate of Paradise.

The two figures A and E move upwards or downwards, to the right or to the left. When each figure moves is controlled by random numbers, but the length of the jumps is set by the operator at the beginning of the program. Each new situation gives rise to a set of comments (see Appendix I). The computer generates new situations spontaneously unless the operator chooses to define the situation himself. The operator may place the two actors Adam and Eve at any place on the screen, if he choses this option. If not the two figures are placed automatically on the middle line of the screen, Adam to the left and Eve to the right and then moved from there according to the instructions of the random numbers.

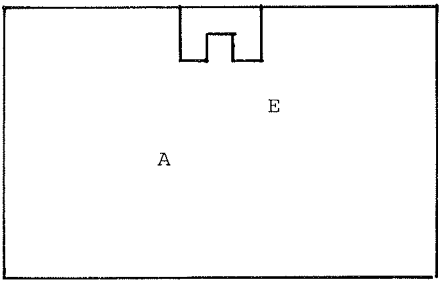
Försökspersoners kommentarer (Subjects comments)

Situation 1



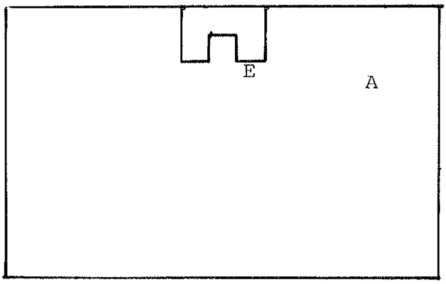
Jag tycker (P) att Adam närmar sig (P) sakteliga och Eva verkar nästan som hon går bortåt.
(I think Adam is approaching slowly and Eve seems to move away)

Situation 2



Nu (P) blir/kommer/är dom närmare varandra (P) Båda rör sig uppåt mot porten (P) Eva närmast nu.
(Now they are approaching each other. Both are moving towards the gate. Eve is closest)

Situation 3



Man undrar om Eva skall komma rakt in i porten (P) Adam är nu långt ute till höger
(One wonders whether Eve will get straight into the gate. Adam is far to the right now)

Fig 1 Sample comments from subjects watching the screen where Adam and Eve move around before the gate. P marks a pause (hesitation)

The Swedish text (paragraph) produced as comments on the scene by the computer may be focused on Adam or Eve or oscillate randomly between the two. A variable chosen between 0 and 1 has to be set at the beginning of the program. If it is set at 1 the program will only comment on Adam, if at 0 only on Eve. If it is set at 0.5 the program will divide its attention between the two. The automatic comments shown in the appendix are all generated with the focus variable set at 0.5. The alternation of focus on Adam (A), Eve (E) or both (A+E) is illustrated in fig 3, where the "question menu" followed in the comments is also shown. The comments (see Appendix I) are governed by a kind of check list (here called question menu) and concern the localization and movements of Adam and Eve in relation to the gate. In particular, the comments state whether Adam and Eve approach the gate or not, who is the closest, if any one of them is close or even in the gate. The comments elicited from human beings deal with such questions although in a rather refined way, which can only be imitated roughly at present (compare the human comments of fig 1 and the computer comments of Appendix I).

As the Commentator is a research tool it avoids e g ready-made sentences tailored to foreseeable situations. The system tries to incorporate psychological and linguistic knowledge about human communication. The sentences are created afresh applying known or assumed properties of the human perceptive, cognitive and linguistic capacites. In particular, ideas of text linguistics and sentence grammar are built into the system.

Even a simple project as this forces one to face many of the deep problems of human speech and language. Constructing the system requires making many interesting hyphotheses concerning human text production, and the computer implementation makes it necesarry to be concrete and exact which furthers scientific work. The commentator offers a valuable instrument for testing complicated models of speech production.

The main structure of the program

The main structure of the program is indicated in fig 2, where the components of the model and their tasks are outlined. The general direction of the process is from the top in the figure, but as some of the components are subroutines they could be called upon in any order. A print-out of the program is given in Appendix II.

In the beginning of the program (line 5) the operator is requested to tell who he wants the comments to focus on and to state what size steps he wants to use for their random jumps. Because of the limits used with the random numbers the choice has an effect on the general movement (Program: Dragning) of Adam and Eve. If the variable is set at 2 or more, the figures will move upwards and towards the left. If the step is set at 1 or 0 the figures will move gradually to the right and downwards. The program furthermore asks whether the operator wants to place A and E himself or let the program do it. If he answers N, the two figures will be placed automatically to the left and right in the middle of the screen and will move around according to the random numbers. If the operator decides to locate Adam and Eve himself, he has to answer J and give the coordinate values of the row (1-24) and the column (1-39) for A and E. All these preliminaries have been dealt with in lines 5-35. Line 40 deletes previous drawings from the screen, lines 45-57 draw the gate, A and E and their previous locations (marked a and e). So far we have only been concerned with the parts of the program which produce the stimulus to be commented on by the commentator program proper.

Lines	Component	Task	Result (sample)
10-35	Primary information	Get values of primary dimensions	Localization coordinates
100-140	Secondary information	Derive values of complex dimensions	Distances, right-left, under-over
152-183	Focus and topic planning expert	Determine objects in focus (referents) and topics according to menu	Identif. of subject, object and instructions to test abstract predicates with these
210-232	Verification expert	Test whether the conditions for the use of the abstract predicates are met in the situation (on the screen)	Positive or negative propositions and instructions how to proceed
500	Sentence structure (syntax) expert	Order the abstract sentence constituents (subject, predicate, object); basic prosody	Sentence structure with further instructions
900	Sentence connection (textual, information) expert	Insert conjunctions, connective adverbs; prosodic features	Sentences with word such as också (too), dock (however)
600- 800-	Reference expert (subroutine)	Determine whether pronouns, proper nouns, or other expressions could be used	Pronouns, proper nouns, indefinite or finite NPs
700-	Lexical expert (dictionary	Translate (substitute) abstract predicates	Surface phrases, words
1000	Phonological (pronunciation, printing) expert	Pronounce or print the assembled structure	Uttered or printed sentence (text)

Fig 2 Components of the text production model underlying Commentator

The primary input values (coordinates) of the subsequent verbalization components may be considered primary human information. Lines 100-140, however, produce a kind of secondary, derived information. In this part of the program some conclusions are drawn concerning Adam and Eve and their relations to each other and the gate. The program calculates values (H and U) which allow the program to tell whether A and E are to the right or to the left of and above or below each other and the gate. Furthermore the distances (D) between A, E and the gate are calculated (using Pythagoras' theorem). These facts are used when the verbal comments are being constructed, but they do not automatically result in simple comments telling if A is above or below E etc. The verbal comments often summarize several of these facts in one simple word.

The primary coordinate values, the secondary values derived by various calculations, and the memories of the previous situations and what has been said, make up the basis of the process of verbalization (lines 152 onwards). The verbalization part of the program consists of a planning section (lines 152-183), a verification section (lines 210-232), a sentence construction section (line 500), referential subroutines (600- and 800-), a lexical section (700-) where the proper words equivalent to the concepts chosen are found, a sentence connecting section (900-) where connective adverbs and conjunctions are inserted, and a pronunciation (or printing) section (1000).

The planning section consists of two parts, lines 152-166 where Adam is in focus, and lines 170-183, where Eve is in focus. The lines choose the subject (S) and if necessary an object (O) or additional arguments. These lines also include instructions to go to the verification section and test the propositions suggested. The order of the lines corresponds to the menu of questions (topics). The planning section also sets variables H1,H2,F1,F2 etc to be used to avoid repetion of sentences uttered. Random numbers are used to guide the jumps between the two sections focusing Adam and Eve.

The verification section lines 210-232 tests whether the proposition suggested is true or false. The conditions of a predicate make up a kind of pragmatic or operational definition. If the conditions for a term are met the line sets the deep predicate variable (P) and instructs the processor to go to line 500 to construct a sentence.

The referent sections test whether pronouns can be used. They include several ad hoc solutions in the present version of the program. Referents are first identified by numbers (Adam=1, Eve=2, the gate=3) and the referent subroutines determine how these referents are best expressed, given the sentence under construction, the previous text, and the communicative situation. The basic ideas of this approach are developed in Sigurd (1980).

The lexical section translates the semantic primes (concepts identified by a Swenglish notation) into real Swedish words and phrases and inserts them in the variables (parts of speech) which are to be the constituents of the surface sentence. In the present version this part is very crude, but in future versions this grammatical machinery will be much more complex and flexible to allow e g inverted word order, a characteristic of Swedish used when some constituent other than the subject introduces the sentence. Roughly speaking the content of the sentence is expressed in terms of case grammar plus some additional information and the constructor tries to build a surface representation using whatever grammatical categories and variables are needed. The extended Basic used is in fact quite versatile for expressing grammatical operations.

Lines 1000-1005 control the printing of the sentence. A phonetic version would need the equivalent of the speech mechanism and its motor organization. The program also has to memorize (store) previous subjects (S1) and predicates (P1), set variables used at zero etc. This is handled in several lines, in particular 183, which also handles the jump back to line 16, which starts the process anew.

Producing comments

We will now follow the generation of some comments according to the program described. As an example we will show how the set of comments labeled A in Appendix I were generated. All details of the program cannot be run through as such explanations would require many more pages. Some knowledge of extended Basic is certainly helpful.

Line 5 asks the operator to determine the size of the step. After having set it at 2 and deciding to focus on Adam and Eve interchangably by setting the variable X at 0.5, the operator has to decide whether he wants to place Adam and Eve. He decedes to place Adam to the right of Eve and the gate (the exact values of the coordinates will not be given). Lines 40-57 draw the gate and the two persons according to the values specified for R (row) and K (column) for 1 (Adam), and 2 (Eve) and 3 (the gate).

Line 100 will compute H, i e the right-left value, by subtracting the column value of Eve (K(2)) from the column value of Adam. Since the column value of Eve is smaller than that for Adam, H(1,2) will be positive (H>0). This fact is later used for testing in line 210. Similary, line 105 computes a value (U(1,2)) which is positive as the value of the row for Adam (R(1)) is greater than the corresponding value for Eve (R(2)). Line 110 computes the distance between Adam and Eve (D(1,2)) by adding the squared vertical difference to the squared horizontal difference according to Pythagoras' theorem.

The line 150 opens a file (#1) for printing and sets a number of variables at 0. Line 151 lets a random number decide whether the comments should begin on Adam or Eve. As the random number was greater than 0.5 the processor goes to line 170. Line 170 sets the subject (S) as 2 and the object (0) as 1. The next instruction is to go to the subroutine at line 210 to verify a proposition suggested by the question menu.

Line 210 will find out whether H(S,O) with S=2 and 0=1 is greater than 0. As this is not the case the predicate variable

(P) will get the string "TOLEFT" and the further instruction to go to line 500. The subroutines of line 500 give instructions to develop a surface subject (S5XX), a surface predicate (P5XX), and a surface object (O5XX). The printing instruction illustrated does not print the whole unit (M) but prints the constituents in order. By then the processor will know what the surface subject, predicate and object will look like and perhaps whether a connective has been added.

Line 500 gives the instruction to go to subroutine 900 where connectives may be introduced. Line 900 checks whether both the current deep predicate (PXX) and the preceding predicate (P1XX) are negated and similar. In that case the connective (CXX) would be given the string "HELLER" (either). This may only be the case in the present program when the predicates are NCLOSE (not close) and the rule is therefore defined in an ad hoc way based on this fact. As the conditions are not fulfilled in our example the processor moves on to line 905 to test whether the current and the previous predicate are identical (without being negated as in NCLOSE). If so, the sentence would include the connective adverb OCKSÅ (too). This is not the case now as we are in the beginning of the comments, but as can be seen from the other comments both OCKSÅ and HELLER occur later. In a phonetic version of Commentator various phonetic (prosodic) features such as contrastive accents could be assigned in this section. As none of the conditions are met in our example, the processor returns to line 500 to find the next instruction to go to line 600, where the subject referent expression is determined. Line 600 checks whether the special subjects S8 and S9 contain 1 and 2, if not the conditions for using the male pronoun "HAN" (he) are tested next. In the present version "HAN" may be used if 1 is the current subject (S) and has been referred to either in the preceding subject (S1) or the preceding object (O1). As none of these conditions are met and S is 2 which has not been used before, the program ends up with S5="EVA". After returning, the processor goes to line 700 and finds out that "TOLEFT" is rendered (in Swedish) by "ÄR TILL VÄNSTER OM", which is given to the predicate variable P5$. In a more sophisticated version of Commentator "ÄR" will be given after consultation of a tense veriable (tense is not handled in the present system) and "ÄR" will probably be included in an AUX variable. The rest of the expression "TILL VÄNSTER OM" will also be distributed on proper constituents. This will allow the application of general word order rules and the insertion of the proper phonetic features in a future phonetic version of Commentator.

Having found the predicate the processor returns to line 500, finds a proper referent expression for the subject by going to line 800 and prints the sentence created by line 1000. It then returns to line 210 and further back to line 170 of the planning section. As can be seen the referent subroutines work nicely producing the names Adam and Eve and the proununs han, hon, honom, henne at proper places. The grammatical situations are, however, rather simple compared to all the situations dealt with in discussions of pronominalization.

Being back on line 170 the variable H2 is set at 1, which prohibits the system from repeating the same sentence while on line 152. Since H1=0 and the new random number is smaller than 0.5 the processor decides to go to line 152, i e focus on Adam. It will find out that it is proper to say that Adam is to the right of Eve and since it cannot then focus on Eve again, as H2>0 it proceeds to say something about Adam's right-left relation to the gate. He is found to be to the right of the gate as well (OCKSÅ). The following steps can be seen in fig 3. At line 183 the processor returns to line 16 and the process may start all over again.

Some theoretical aspects

The Commentator is not just a computer program but a research method. The system suggests lines of research and experiments in human communication. Such experiments may be oriented towards linguistics, phonetics, psychology, artificial intelligence, computer science or they may be directed towards practical applications such as systems for alarm, vigilance, guidance etc. There is some interest in similar systems all over the world (see references) but the Commentator is probably the only of its kind producing Swedish text. We will now discuss the primary and secondary information used as input in the verbalization parts of the program. The present program gets some primary coordinate values and derives some secondary information by processes which perhaps may be called cognitive. These secondary facts, some of which are needed by the verification processes, are calculated for every situation in section 100-140. These calculations are sufficient for the present predicates, but how about human beings? How many facts and conclusions are derived by humans without being used in the verbalization process for communication. This problem touches the general problem of the relation between language and thought. The present model assumes that human beings experience some primary information and derive some additional information during the flow of consciousness. Behind each utterance there is, however, a decision to focus on a few referents, select a few problems to be commented on and an intention to communicate this to a listener in the situation at hand. Out of the enormous number of sensations from the outside or inside which reach a person only some are selected to be packed into a proposition and communicated.

The planning section (lines 152-183) decides which questions are to be put about which referents. The consequences of these decisions are positive or negative sentences. The design of this section determines the direction and coherence of the text. It is important to note that one of the reasons for a planning section of the type demonstrated is that it produces positive as well as negative sentences in a convenient and natural way. Negative sentences occur as the result of decisions to find out whether something is true or not.

In the present version where Adam and Eve move around in front of the gate it is natural to comment on their localization, movements and advances towards the gate. Experiments with human subjects indicate that comments vary with time. The first comments state the localizations of the actants but later comments may only concern changes. If nothing is said, the situation may be assumed to be the same - a convention relied upon by both speaker and listener. Experiments with subjects also indicate that the number of comments decreases and the comments focus on the assumed attempts of the actors to get into the gate. Later comments seem to make the most of the competitive features of the scene and treat it as a hockey match. Human commentators feel the need to vary the comments as well. The present computer program cannot compete with human commentators in these respects. Its comments get monotonous and boring pretty quickly, as can be verfied in Appendix I.

The planning section determines which referents should be focused on (1,2 or both) and which questions should be answered about these referents. One might ask whether the referents or the questions to be asked come to mind first in human beings or both. The problem is related to the problem whether the predicate determines (is subordinate to) the subject or vice versa. The present program focuses the units to be commented on first and then goes to the predicate subroutine to verify a hypothesis concerning the subject.

The verification takes place in lines 210-232. If Adam is in focus, he is tested successively on a number of points. The variable S is then set at 1 (Adam's identification number) and the processor checks whether he is to the right or left of Eve (2) and the gate (3), whether he is approaching (NÄRM) or going away from (DISTÖK) the gate and Eve. The question menu includes the instructions to go to the sections of verification. In the present system, the fact that the conditions of a predicate are not met does not generally result in a negative sentence. The result is generally no sentence and a reader is assumed to draw his conclusions from what is said and not said according to the conventions of communication. The system delivers positive sentences as does human text most of the time. The only exception is line 230, where closeness is tested. The failure to meet the conditions of verification there results in the predicate NCLOSE which will be rendered as "är inte nära" (is not close to) by the lexical rules. The program raises an interesting question concerning negative sentences which has to be answered experimentally and by extensive studies of genuine texts. How often and when do human beings use negative sentences? Why is it that negative sentences are so rare? They seem to make up only a small percentage of the sentences of texts. Why do people avoid making negative statements? How can this feature be built into a text production model?

The Commentator also forces its constructor to take a stand on some grammatical issues. The present version, although grammatically not very refined, uses a case grammar or predicate calculus notation as the deep semantic representation. The arguments are seen as mental units to be given labels later for identification by the listener. They are only identified by numbers in the beginning, which raises the questions of the psychological and cognitive status of these elements.

The construction of a sentence is then made in several steps which are only vaguely reminiscent of the processes of transformational grammar. There is no order among the deep semantic units: the deep predicate, the deep subject (S), the deep object (0) and any other variable stored which might be used to derive the surface sentence. The order of calling the subroutines is introduced in line 500 of the program and this makes it possible to add the results of the subroutines successively and print them in future experiments. Studies of speech errors (cf Linell, 1979) indicate that the planning may proceed on several levels (in parallel) or that the process may proceed between different roads. In future versions of Commentator experiments will be made with different orders between the subroutines called upon, which will make it possible to show how different word orders may occur. In particular the different placements possible with connectives such as <u>however</u> may be explained as differences in the order of calling the connective subroutine. The commentator offers an instrument to test grammatical models as performance models which is very valuable. It is also possible to simulate speech errors or foreign accent by changing the contents or the order of the components at work.

Producing text by a question menu and a list of referents

The Commentator is based on a theory of text production whose main components are a kind of check list which may be called a questionnaire or a question menu and a list of referents to be checked. We may call this model the Questionnaire model or for short the Q-model of text production. Although the model is illustrated by a closed list of questions and referents in the present system its components may well be open or gradually changing.This is clearly a better model of human communication. Experiments with bigger and more flexible question menus and referent lists simulating associative behaviour (thinking) will be made in the future.

The rationale for such a model is the fact that a situation may give rise to infinitely many comments, but a human commentator selects a few comments as relevant. Human commentators tend to make roughly the same choice of comments, but the amount of variation has to be studied in detail before any generalizations can be made. Some of the economic principles of communication have been encoded by the philosopher Grice, but the attempt to make a computer simulate human text production indicates that his principles have to be supplemented and made more specific and concrete.

One of the principles of human communication is to avoid repetition - but this principle is not upheld too rigorously. The Commentator makes the mistake of repeating information for each new situation instead of resticting itself to comments on changes. In a better version the system will note e g that Adam is to the right of Eve only at the beginning and if he has been to the left for some time. It might sometimes state that Adam is still to the left if this is the case, but not as monotonously as in the current program.

The present program avoids a lot of repetition, however, by setting a variable for each sentence uttered, and checking this variable whenever it is on the point of uttering a new sentence. Still, the system seems to produce repetitions or at least near-repetitions when it says e g that Adam is to the right of Eve and also that Eve is to the left of Adam. From this we may learn that converse terms have to be avoided or at least treated with care. It is clear that the program can be improved in order to avoid or delete a number of unnecessary or seemingly irrelevant sentences. But it is not quite clear which sentences are communicatively redundant and experiments with computer generated text is a suggestive supplem nt of empirical studies of ordinary texts.

The use of a question menu also allows the use of informative (complex) predicates instead of an enormous number of primitive predicates. It is thus more economical to state that Adam is approaching the gate than to say if he is to the left of and below the gate that he has moved a little to the right and a little upwards. It is also more interesting and to the point from a human point of view. The complex predicates do not, however, only summarize a certain number of primitive predicates indicated by the conditions defining the predicates. The complex predicates often add a special aspect of particular interest to human observers. One might get a general idea of the complexities of different predicates by looking at the number and types of conditions to be met in the definitions in lines 210-232. It is not, however, always clear how verbal concepts should be defined. The definitions used in the program are operationally correct although they might not be psychologically correct. Närma sig (approach) is e g defined as having a smaller distance to the object than at the preceding moment of measurement. This is a repeated static way of defining rather than a dynamic and it might be difficult to uphold this definition when it is to be contrasted with definitions of such words as circle, zigzag, roam, stroll, return, bounce, chase etc which might be used in other comments. The program raises several interesting questions about the definitions and use of predicates and other words.

There are four main ways of continuing a text. One may (1) repeat what has been said, which means using the same subject and the same predicate, although perhaps with some minor stylistic variation by synonyms etc. One may (2) keep the subject and ask a new question about it, which leads to a new affirmative or negative sentence. A further way to proceed is (3) to keep the same question and ask it about a new referent (subject). A last alternative (4) is to ask a new question about a new referent. In this case the sentence is without any connection with the preceding text and this would be considered a break in the coherence of the text. In genuine texts it is not, however, so easy to identify such clearcut cases, but the types can be distinguished in the texts produced by the Commentator. In fig 3 type 2 is represented by a vertical line, type 3 by a horizontal line and type 4 by a diagonal.

The Commentator jumps along the question menu either in the lines 152-166 or the lines 170-183. In the lines 152-166 Adam is in focus and in 179-183 Eve is in focus. The jumps are controlled by random numbers and the variable set in the beginning of the program by the operator. If the variable is set at 1 the program follows the instructions in the lines 152-166, if it is set at 0.5 the processor will jump from section 152-166 to 170-183 and back one or several times (see fig 3). When the processor proceeds in the same section it follows the second way of text continuation, asking a new question about the same subject (except when going to line 177). When it jumps to the second section it follows the third type of continuing a text, asking the same question about a new (although by now rather well-known) referent. The processor is prohibited from jumping back and producing the same sentence again by setting variables each time a sentence is produced. Human beings often seem to repeat themselves by going back to the same part of the question menu and this human feature could easily be imitated in Commentator.

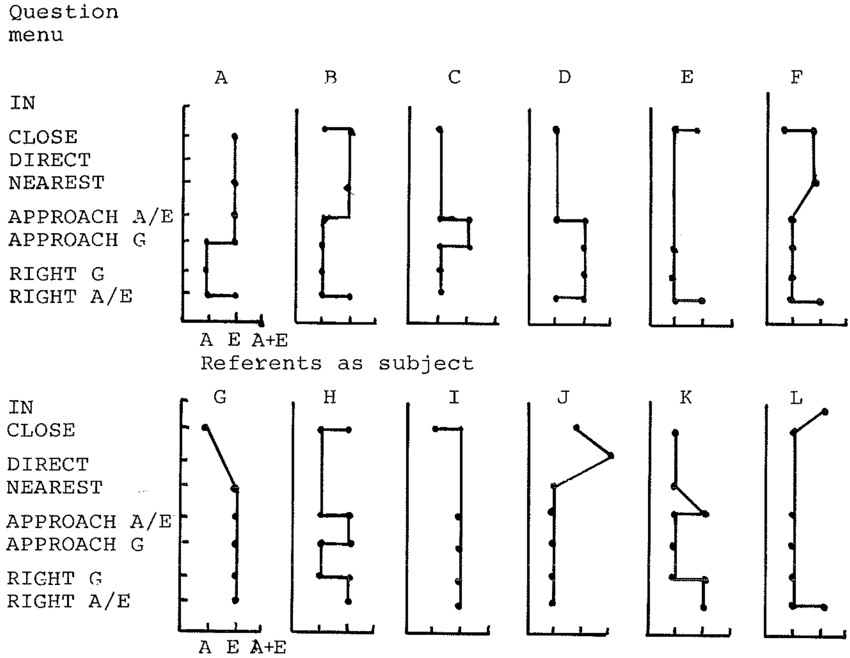


Fig 3 Graphic representation of the roads taken by the planning section (lines 152–183) when constructing the comments A-L in Appendix I. The computer is instructed to focus equally on Adam and Eve, but the choice between the two is also controlled by random numbers. A=Adam, E=Eve, G=Gate. The questions are indicated by the words in the question menu. These words are not completely identical with predicates used in the program. The word DIRECT denotes the question which results in the surface predicate "rör sig åt samma håll" (move in the same direction). A dot indicates that the corresponding question of the menu has been asked about the corresponding subject on the X-line and that the question has resulted in a positive or negative sentence. The process starts from the bottom. A horizontal jump indicates that the same question has been asked about the other referent (subject). A vertical jump indicates that a new question has been asked about the same subject.

The question menu used in the present system seems to fit the situations quite well, although the comments tend to be boring and there is a need for new questions to be asked after a while to satisfy the curiosity of human readers or listeners. The concept of question menu seems to be important, however, as it explains some of the success human beings have, when they try to communicate. They use the same question menu and they learn a number of standard menus to be used in standard situations. It is probably also biologically important to have a number of standard menus to follow when observing the world. They allow a quick estimation of the state of events and the processes to take into account. It is a matter of habit to apply such question menus and adults are probably more rigid and children more fanciful in their approach to life. Education and experience teach us good but conventional ways to ask questions, approach situations and communicate our experience to others. Experiments with different types of subjects: children, adults, specialists in different fields etc, will produce valid data illustrating variations in question menus.

The question menu used by the program is a primitive standard type used whenever we watch the world. It is natural to note the actors in motion and determine their localizations. One might imagine a number of other standard menus to be used in other standard situations. Such menus may exist for e g parties, walks, the school, fights, shoppings, visits to restaurants etc. It is clear that it is natural to ask certain questions in a certain order when telling about a person who visits a restaurant: will the visitor find a table, will there be somebody to serve him immediately, what will he choose, how does the food taste, when does he pay the check, etc. Such situations have also been discussed in so called frame semantics (cf Schank & Abelson, 1975).

There are some general conclusions to be drawn from our approach (the Q-model). Following a standard question menu may create a correct text, but the result may soon get very boring. When telling a story or writing a novel it is important to ask fresh and interesting questions and to focus on different actors interchangeably. It is, however, not so easy to teach a computer how to follow this advice.

Experimental potentials

It is possible to make a number of experiments with the present version of Commentator or variants or extensions of it. The scene may be used to elicit comments from groups of subjects of different kinds. Such texts were the starting point of the project, but the details of such texts remain to be studied. It would be interesting to elicit data from groups such as: children of different age, old persons, verbally disordered persons (e g aphasics). The stimulus scene is also suitable for experiments with speakers of different languages. It is clear even from a quick comparison between Swedish comments and equivalent English comments or translations of the Swedish comments that the system pinpoints interesting differences between localization and movement expressions. A system producing English comments containing similar grammatical and lexical rules for English will be developed in the near future. One advantage of the present stimulus scene is that it elicits combarable comments using concepts which can be expected to occur in all languages. The following notes illustrate the type of differences which can be expected to be found and mapped in this restricted semantic field. Swedish uses reflexive verbs närmar sig and avlägsnar sig från (as French s'approcher, s'éloignerde but English uses a transitive verb approach and a phrase move toward or go away from in the two cases where an increase or decrease of the distance is observed.

Comments may include many other terms and concepts than those discussed so far. The analysis of the whole set of verbs used in comments to describe localization and movements of different types would be interesting. Comments are expected to include many more words denoting e g moving in steps, in circles, back and forth moving rapidly and slowly, approaching while moving in the same direction (chasing), getting behind, overtake etc.

Verbs of movement have been studied a great deal but to my knowledge no studies have used elicitation by a scene such as the one under discussion. Compared to most tests the program is special as it offers a changing scene.

The Commentator is designed to produce written text, but a future version producing spoken text is being planned. There are several speech production systems being developed in the world, but most of them are restricted in one or several ways. The system developed by Carlsson and Granström (1975) produces speech from written text but the quality of such systems cannot be perfect until the system understands what it is reading. The Commentator offers other posibilities as it simulates the whole verbalization process. The system does indeed "understand" what it is saying. (On the other hand it cannot say very much). It is possible to insert whatever phonetic markers are needed along the line of production in the different components. This has in fact been indicated in fig 2.

The prosodic features of speech are of particular interest and it would be most interesting to build sentence prosodic features into the model. The study of prosody will probably give many cues to the understanding of the production process. There are several ideas which can be built into a phonetic version of Commentator (Lindblom et al, 1976, Bruce and Gårding, 1978).

The Commentator may be used to demonstrate verbal disorders of different types. Disturbances in the different components of fig 2 can be recognized in different types of disorders. Dysphonological disorders can be demonstrated by introducing constraints in the printing function. The present version does not include any phonological (graphemic) rules operating at the output, but it is quite simple to include phonological rules written in BASIC deleting certain consonants, changing certain vowels etc. Such programs have been written at the institute.

The printing function can be varied to allow experimentation simulating different size of short term memory. In that case the printing function might take into account the length of the string stored in the different variables to be printed. If only a short string is allowed and the system is designed to print whenever the memory is full it will often print before the whole sentence is completed.

Anomia can be located to the lexical rules of the present model. The model allows us to distinguish between cases where the speaker has not observed the situation correctly, has not made the verification correctly, has an incorrect definition of a concept and cases where he cannot find the proper word for a concept he wants to express. Aggrammatism might be located in the referential routines or sentence coherence routines or agreement routines which are not, however, worked out in the present version.

Difficulties in planning discourse and keeping the topic can be localized to the planning section (and the sentence connection section). Difficulties in the long term planning of discourse and sudden changes of the topic is a charicteristic of thought disordered schizophrenic speech. We may characterize such schizophrenic speech in terms of the model as speech produced with an interupted question menu or with sudden shift of the menu. Other features of schizophrenic speech involve other components.

The study of verbal disorders is important as it may suggest how a production model is best organized. A model has to be evaluated according to its potentials in explaining both normal and abnormal verbal behaviour.

The Commentator may also be changed by using other stimulus scenes, different question menus, diferent primitive predicates, different language as output etc. A sophisticated system should be flexible enough to handle complex real life situations and comment on unexpected events. As all other projects the Commentator is far from this goal.

Practical applications

Commentator is designed to serve as a tool in basic psycholinguistic research, but it has a number of potential practical applications. Among those one might imagine cases when instrument readings are better summarized in words. There might be several situations in industrial processes, space voyages, diving expeditions etc where one would prefer words. Instrument readings give exact figures, but communicating tables of figures is in many cases both too time consuming and too paper-consuming. Human language is an economic system for handling what is important in a functional way. Coding situations in human language is often the best way to communicate facts. When used by humans who know all the conventions of language communication discussed earlier, words are extremely powerful.

Among the most obvious applications are automatic systems for radar surveillance (automatic radar operators or robots). It is easy to imagine a version of Commentator where the values of the radar screen are taken as input. The coordinates will identify echoes of airplanes or ships, and the system may give each echo a label as is the habit in military radar surveillance. The system may easily keep track of the objects observed and comment on changes of interest. Such comments could in fact be very similar to the ones discussed in the present system. Generally, they deal with distance, direction, probable goals, speed. Comments may be given in writing or, if a phonetic version of Commentator is constructed, in spoken language.

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EVA ÄR TILL VÄNSTER OM ADAM		Eve is to the left of Adam
HAN ÄR TILL HÖGER OM HENNE		He is to the right of her
HAN ÄR TILL HÖGER OM PORTEN OCKSÅ		He is to the right of the gate too
HAN NÄRMAR SIG DEN		He is approaching it
EVA NÄRMAR SIG DEN OCKSÅ		Eve is approaching too
HON NÄRMAR SIG ADAM OCKSÅ		She is approaching Adam too
HON ÄR NÄRMAST PORTEN		She is closest to the gate
HON ÄR INTE NÄRA DEN	A	

EVA ÄR TILL VÄNSTER OM ADAM
HAN ÄR TILL HÖGER OM HENNE
HAN ÄR TILL HÖGER OM PORTEN OCKSÅ
HAN NÄRMAR SIG DEN
HAN NÄRMAR SIG EVA OCKSÅ
HON NÄRMAR SIG HONOM OCKSÅ B
HON ÄR NÄRMAST PORTEN
HON ÄR INTE NÄRA DEN
ADAM ÄR INTE NÄRA DEN HELLER

ADAM ÄR TILL HÖGER OM EVA
HAN ÄR TILL HÖGER OM PORTEN OCKSÅ
HAN NÄRMAR SIG DEN
EVA NÄRMAR SIG DEN OCKSÅ
HON NÄRMAR SIG ADAM OCKSÅ C
HAN ÄR INTE NÄRA PORTEN

ADAM ÄR TILL HÖGER OM EVA
HON ÄR TILL VÄNSTER OM HONOM
HON ÄR TILL VÄNSTER OM PORTEN OCKSÅ
HON NÄRMAR SIG DEN
HON NÄRMAR SIG ADAM OCKSÅ
HAN NÄRMAR SIG HENNE OCKSÅ D
HAN ÄR INTE NÄRA PORTEN

EVA ÄR TILL VÄNSTER OM ADAM
HAN ÄR TILL HÖGER OM HENNE
HAN ÄR TILL HÖGER OM PORTEN OCKSÅ
HAN NÄRMAR SIG DEN
HAN NÄRMAR SIG EVA OCKSÅ
HAN ÄR INTE NÄRA PORTEN
EVA ÄR INTE NÄRA DEN HELLER E

EVA ÄR TILL HÖGER OM ADAM
HAN ÄR TILL VÄNSTER OM HENNE
HAN ÄR TILL VÄNSTER OM PORTEN OCKSÅ
HAN NÄRMAR SIG DEN F
HAN NÄRMAR SIG EVA OCKSÅ
HON ÄR NÄRMAST PORTEN DOCK
HON ÄR INTE NÄRA DEN
ADAM ÄR INTE NÄRA DEN HELLER

APPENDIX I Text produced by COMMENTATOR

EVA ÄR TILL HÖGER OM ADAM
HON ÄR TILL VÄNSTER OM PORTEN
HON NÄRMAR SIG DEN
HON NÄRMAR SIG ADAM OCKSÅ
HON ÄR NÄRMAST PORTEN G
ADAM ÄR INTE NÄRA DEN

EVA ÄR TILL VÄNSTER OM ADAM
HON ÄR TILL VÄNSTER OM PORTEN OCKSÅ
ADAM ÄR TILL VÄNSTER OM DEN OCKSÅ
HAN NÄRMAR SIG DEN
EVA NÄRMAR SIG DEN OCKSÅ H
HON NÄRMAR SIG ADAM OCKSÅ
HAN NÄRMAR SIG HENNE OCKSÅ
HAN ÄR INTE NÄRA PORTEN
EVA ÄR NÄRA DEN

EVA ÄR TILL HÖGER OM ADAM
HON ÄR TILL HÖGER OM PORTEN OCKSÅ
HON NÄRMAR SIG DEN
HON NÄRMAR SIG ADAM OCKSÅ I
HON ÄR INTE NÄRA PORTEN
ADAM ÄR NÄRA DEN

ADAM ÄR TILL VÄNSTER OM EVA
HAN ÄR TILL HÖGER OM PORTEN
HAN NÄRMAR SIG DEN
HAN NÄRMAR SIG EVA OCKSÅ J
HAN ÄR NÄRMAST PORTEN
BÅDA RÖR SIG ÅT SAMMA HÅLL
HON ÄR INTE NÄRA PORTEN

EVA ÄR TILL HÖGER OM ADAM
HON ÄR TILL HÖGER OM PORTEN OCKSÅ
ADAM ÄR TILL HÖGER OM DEN OCKSÅ
HAN NÄRMAR SIG DEN
HAN NÄRMAR SIG EVA OCKSÅ K
HON NÄRMAR SIG HONOM OCKSÅ
HAN ÄR NÄRMAST PORTEN DOCK
HAN ÄR NÄRA DEN

EVA ÄR TILL VÄNSTER OM ADAM
HAN ÄR TILL HÖGER OM HENNE
HAN ÄR TILL HÖGER OM PORTEN OCKSÅ
HAN NÄRMAR SIG DEN L
HAN NÄRMAR SIG EVA OCKSÅ
HAN ÄR NÄRA PORTEN
EVA ÄR INNE I DEN

```
5 PRINT "VILKEN DRAGNING? 1/2 (2=UPPÅT VÄNSTER)" : INPUT S : PRINT "INTRESSE FÖR
 ADAM?VÄLJ TAL NÄRA 1 ANNARS 0"
6 INPUT X
10 R(1)=12 : K(1)=13 : R(2)=12 : K(2)=26 : R(3)=1 : K(3)=20
16 PRINT ;CUR(22,2);"VILL DU PLACERA ADAM OCH EVA SJÄLV?SKRIV J/N" : INPUT Q$
17 IF Q$="N" THEN GOTO 20
18 ; "SKRIV KOORDINATER FÖR ADAM.RAD 1-24" : INPUT R(1) : PRINT "KOLUMN" : INPUT
 K(1)
19 ; "EVA RAD?" : INPUT R(2) : PRINT "KOLUMN" : INPUT K(2) : GOTO 40
20 RANDOMIZE : I=RND : IF I>.7 THEN R(1)=R(1)+1 ELSE IF I>.4 THEN R(1)=R(1) ELSE
 R(1)=R(1)-S
25 I=RND : IF I>.7 THEN K(1)=K(1)+1 ELSE IF I>.4 THEN K(1)=K(1) ELSE K(1)=K(1)-S

30 I=RND : IF I>.7 THEN R(2)=R(2)+1 ELSE IF I>.4 THEN R(2)=R(2) ELSE R(2)=R(2)-S

35 I=RND : IF I>.7 THEN K(2)=K(2)+1 ELSE IF I>.4 THEN K(2)=K(2) ELSE K(2)=K(2)-S

40 PRINT CHR$(12) : REM RENSA SKÄRMEN
45 PRINT CUR(1,19);CHR$(127);CUR(1,20);CHR$(127);CUR(1,21);CHR$(127)
50 PRINT CUR(2,19);CHR$(127);CUR(2,21);CHR$(127) : REM RITA PORTEN
55 PRINT CUR(R(1),K(1));CHR$(65);CUR(R(2),K(2));CHR$(69) : REM RITA A OCH E
57 PRINT CUR(R1(1),K1(1));CHR$(97);CUR(R1(2),K1(2));CHR$(101)
100 H(1,2)=K(1)-K(2) : REM HÖGER OM
102 H(2,1)=K(2)-K(1)
105 U(1,2)=R(1)-R(2) : REM UNDER
110 D(1,2)=H(1,2)^2%+U(1,2)^2% : D(2,1)=D(1,2)
115 H(1,3)=K(1)-K(3)
120 U(1,3)=R(1)-R(3)
125 H(2,3)=K(2)-K(3)
130 U(2,3)=R(2)-R(3)
135 D(1,3)=H(1,3)^2%+U(1,3)^2%
140 D(2,3)=H(2,3)^2%+U(2,3)^2%
150 OPEN "PR:.1" ASFILE 1 : S=0 : O=0 : S9=0 : C$=" "
151 F=0 : F1=0 : E1=0 : D5=0 : D7=0 : S1=0 : O1=0 : I=RND : IF I>X THEN GOTO 170

152 S=1 : O=2 : GOSUB 210 : H1=1 : I=RND : IF H2=0 AND I>X THEN GOTO 170
153 S=1 : O=3 : GOSUB 210 : P1=1 : I=RND : IF I>X AND P2=0 THEN GOTO 171
154 S=1 : O=3 : GOSUB 215 : D5=1 : I=RND : IF I>X AND D6=0 THEN GOTO 173
156 S=1 : O=2 : GOSUB 215 : D7=1 : I=RND : IF I>X AND D8=0 THEN GOTO 175
158 S=1 : O=3 : J=2 : GOSUB 222 : N1=1 : I=RND : IF I>X AND N2=0 THEN GOTO 176
163 S=1 : O=3 : GOSUB 230 : E=1 : I=RND : IF E1=0 AND I>X THEN GOTO 179
165 S=1 : O=3 : GOSUB 232 : F=1 : I=RND : IF F1=0 AND I>X THEN GOTO 181
166 GOTO 183
170 S=2 : O=1 : GOSUB 210 : H2=1 : I=RND : IF H1=0 AND I<X THEN GOTO 152
171 S=2 : O=3 : GOSUB 210 : P2=1 : I=RND : IF I<X AND P1=0 THEN GOTO 153
173 S=2 : O=3 : GOSUB 215 : D6=1 : I=RND : IF I<X AND D5=0 THEN GOTO 154
175 S=2 : O=1 : GOSUB 215 : D8=1 : I=RND : IF I<X AND D7=0 THEN GOTO 156
176 S=2 : O=3 : J=1 : GOSUB 222 : N2=1 : I=RND : IF I<X AND N1=0 THEN GOTO 158
177 S8=1 : S9=2 : GOSUB 225 : S8=0 : S9=0
179 S=2 : O=3 : GOSUB 230 : E1=1 : I=RND : IF E=0 AND I<X THEN GOTO 163
181 S=2 : O=3 : GOSUB 232 : F1=1 : I=RND : IF I<X AND F=0 THEN GOTO 165
183 R1(1)=R(1) : K1(1)=K(1) : R1(2)=R(2) : K1(2)=K(2) : D1(2,1)=D(2,1) : GOTO 18
4
184 D1(1,2)=D(1,2) : D1(1,3)=D(1,3) : D1(2,3)=D(2,3) : D1(2,1)=D(1,2) : GOTO 16

210 IF H(S,O)>0 THEN P$="TORIGHT" : M5$=S5$+P5$+O5$ : GOSUB 500 : RETURN ELSE P$
="TOLEFT" : GOSUB 500 : RETURN
215 IF D(S,O)>D1(S,O) THEN P$="DISTÖK" : GOSUB 500 : RETURN ELSE P$="NÄRM" : GOS
UB 500 : RETURN
222 IF D(S,O)<D(J,O) THEN P$="NEAREST" : GOSUB 500 : RETURN ELSE RETURN
```

APPENDIX II The COMMENTATOR programme.

```
225 IF R1(S8)-R(S8)=R1(S9)-R(S9) AND K1(S8)-K(S8)=K1(S9)-K(S9) THEN P$="MOVES" :
 O=0 : GOSUB 500 : RETURN ELSE RETURN
230 IF D(S,O)<9 THEN P$="CLOSE" : GOSUB 500 : RETURN ELSE P$="NCLOSE" : GOSUB 50
0 : RETURN
232 IF D(S,O)<3 THEN P$="IN" : GOSUB 500 : RETURN ELSE RETURN
500 M5$=S5$+P5$+O5$ : GOSUB 900 : GOSUB 600 : GOSUB 700 : GOSUB 800 : GOSUB 1000
 : RETURN
600 IF S8=1 AND S9=2 THEN S5$=" BÅDA " : RETURN
601 IF S=1 AND S1=1 THEN S5$=" HAN " : RETURN
602 IF S=1 AND O1=1 THEN S5$=" HAN " : RETURN
604 IF S=1 THEN S5$=" ADAM " : RETURN
606 IF S=2 AND S1=2 THEN S5$=" HON " : RETURN
608 IF S=2 AND O1=2 THEN S5$=" HON " : RETURN
609 IF S=2 THEN S5$=" EVA " : RETURN
700 IF P$="TORIGHT" THEN P5$=" ÄR TILL HÖGER OM " : RETURN
705 IF P$="DISTÖK" THEN P5$=" AVLÄGSNAR SIG FRÅN " : RETURN
710 IF P$="NEAREST" THEN P5$=" ÄR NÄRMAST " : RETURN
712 IF P$="TOLEFT" THEN P5$=" ÄR TILL VÄNSTER OM " : RETURN
715 IF P$="NÄRM" THEN P5$=" NÄRMAR SIG " : RETURN
720 IF P$="MOVES" THEN P5$=" RÖR SIG ÅT SAMMA HÅLL " : RETURN
730 IF P$="CLOSE" THEN P5$=" ÄR NÄRA " : RETURN
732 IF P$="NCLOSE" THEN P5$=" ÄR INTE NÄRA " : RETURN
735 IF P$="IN" THEN P5$=" ÄR INNE I " : RETURN
800 IF O=1 AND O1=1 THEN O5$=" HONOM " : RETURN
801 IF O=1 AND S1=1 THEN O5$=" HONOM " : RETURN
802 IF O=1 THEN O5$=" ADAM" : RETURN
804 IF O=2 AND O1=2 THEN O5$=" HENNE " : RETURN
805 IF O=2 AND S1=2 THEN O5$=" HENNE " : RETURN
806 IF O=2 THEN O5$=" EVA " : RETURN
810 IF O=3 AND O1=3 THEN O5$=" DEN " : RETURN
812 IF O=3 AND S1=3 THEN O5$=" DEN" : RETURN
814 IF O=3 THEN O5$=" PORTEN " : RETURN ELSE O5$=" " : RETURN
900 IF P$="NCLOSE" AND P1$="NCLOSE" THEN C$=" HELLER " : RETURN
905 IF P$=P1$ THEN C$=" OCKSÅ " : RETURN
910 IF S1=S AND P1$="DISTÖK" AND P$="NEAREST" THEN C$=" DOCK " : RETURN
912 IF S1=S AND P1$="NEAREST" AND P1$="DISTÖK" THEN C$=" DOCK " : RETURN
920 IF S<>S1 AND P1$="NÄRM" AND P$="NEAREST" THEN C$=" DOCK " : RETURN
930 IF S<>S1 AND P$="NÄRM" AND P1$="NEAREST" THEN C$=" DOCK " : RETURN ELSE C$="
 " : RETURN
1000 PRINT #1,S5$+P5$+O5$+C$ : S1=S : P1$=P$ : O1=O : C$=" " : S8=0 : S9=0 : O5$
=" "
1005 RETURN
```