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Computer simulation of dialogue and communication

The dialogue is the primary use of language and the study
of communication in dialogue is necessary for our understanding
of natural language. There has been an increased interest in
communication,in spite of the negative attitudes of Chomsky(1975).
(He does not even mention the word communication in the index
of his classical book Aspects of the theory of syntax,1965).

Even small-scale attempts at simulating dialogue by
computer are rewarding and further our understanding of language.
The insights may be used in practical applications such as
expert systems and operative systems.

This paper will look at dialogue from different angles.
An analysis of dialogue in cycles of two or three steps will
be presented. It can be described by extending the phrase
structure rules which have been used for sentence analysis.
With this background a model of a turn-taker, who can participate
in such a dialogue and produce the proper steps in the
cycles will be presented. This model has been implemented
in a small-scale computer system where two "persons" talk(Sigurd,1985)
to each other using different speech synthesis voices.This im-
plementation shows how well the current speech synthesis
devices can serve in human dialogue. The model allows the
operator to study the effect of pauses, willingness to give
backchannel items (supportivity), to respond and take initiatives.

Lastly the construction of a more advanced model where
the transfer of information is focused is discussed. It is
noted that many words in the dialogues serve to indicate how the in-
formation should be or has been accepted. An information
driven model must also focus the difference between the
"real" world and the verbal discourse world which is being

built during the dialogue. Metacomments, such as sort of,"",precise-
ly , typical play an important role in marking the relations
between the verbal expressions and the "real" world.

Dialogue as cycles

Fig.1 presents a sample dialogue and some rules to analyze
it. The rules show the main types of utterances occurring
in dialogue and their sequencing. The rules also show the
basic grammatical structure. Generative phrase structure
rules introduced in order to characterize sentences (cf
Chomsky, 1957,1965) are used in all the rules.

It may be convenient to start by looking at the sample
dialogue. It consists of utterances 1-7 by partners 1 and II.
Some utterances clearly belong together and consitute sections,
rounds or cycles. Utterances 1 and 2 make up one cycle
consisting of a statement and a response. The response is
called a backchannel item. Utterances 3-5 make up another
cycle including three constituents: a question, an answer and
a backchannel item and utterances 6-7 make up a cycle with
two utterances: an instruction (order) and a reaction which
we also classify as a backchannel item.

We note the punctuation marks: full stop, question mark,
mark of exclamation (which could perhaps have been used after
the other backchannel items as well). In speech, the intonation
contours would vary correspondingly.In speech, there would
have been pauses at least between utterances 1-2,3-4,4-5, and
6-7, where there is a shift of speaker. But when the speaker
is the same, as in 2-3,5-6, the utterances could have been
delivered without a pause (cf Oreström,1983,Stenström,1984).

It is assumed that a dialogue consists of a series of
cycles of this type - at least one. The types of cycles
are given in rule 1, where certain terms are introduced. The
terminology in the literature varies. between different authors
and fields. It could be oriented towards speech acts, game theory,
linguistic form or function. The terms _interchange, transaction_ and
move   have been used. Backchannel items have been called _supports_
which indicates the double nature of these utterances.

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The only type of question included in the rules
is the truth question, which could be answered by yes
or no. Traditional grammar has not analyzed dialogue
in the way we do and does not make a clear distinction between
yes as an answer and as a backchannel item (see below). On
the other hand, it is an interesting fact, that many
languages use the same word as a positive answer and as
a supportive backchannel item.

The subsequent rules in fig. are the familiar rules
indicating the basic structure of statements (S), questions (Q)
and instructions (I). The internal structure of the
constituents is not discussed in this superficial account.
The addressee may be mentioned in imperatives and in
questions, e.g. by pronouns, names or vocative terms such
as dear, you idiot. This is not shown in these rules, but
in fig.2 below.

The backchannel items (B) are an almost closed set
of words, including e.g. OK (almost a language universal
soon), quite, absolutely, certainly, really, yes, no and
various rudimentary utterances rendered by mm, mhm in writing.
They signal contact, support but at the same time reaction
and attitudes e.g.:agreement, dislike, surprise, doubt (see
Oreström,1983 and Sigurd,1984).

Non-verbal signals generally accompany dialogue and
play a very important role. Often backchanneling is handled
on the non-verbal channel, e.g. by nodding, eye movements,
shaking the head while the speaker is speaking. This is
very practical as it allows simultaneous communication
and avoids two voices on the same channel.

In practical analysis of dialogues the model presented
may seem too simplistic and many problems of identification
and categorisation occur , but for our present purpose it
is sufficient.

RULES

1. C(YCLE) ⟶ $\begin{cases} \text{S(TATEMENT)} \\ \text{I(INSTRUCTION)} \\ \text{Q(UESTION)} \quad + \text{A(NSWER)} \end{cases}$ (B(ACKCHANNEL))

A CYCLE IN A DIALOGUE MAY CONSIST OF A STATEMENT OR AN INSTRUCTION
RESPONDED TO BY A BACKCHANNEL ITEM BY THE PARTNER. A CYCLE MAY ALSO
CONSIST OF THREE UNITS: QUESTION, ANSWER AND BACKCHANNEL.

2. S ⟶ NP + VP (NP) (PREP PHRASE).   A STATEMENT MAY CONSIST OF
                                       A NOUN PHRASE AND A VERB
                                       PHRASE WITH ADDITIONAL UNITS

3. Q ⟶ VP + NP (NP) (PREP PHRASE)?   A QUESTION HAS INVERTED ORDER
                                       BETWEEN VERB AND SUBJECT

4. I ⟶ Vimp (NP)!   AN INSTRUCTION (COMMAND ETC)
                                       HAS AN IMPERATIVE FORM

5. A ⟶ $\begin{cases} \text{I DON'T NO.} \\ \\ \text{YES/NO} \end{cases}$ A TRUTH QUESTION IS
                                       ANSWERED BY YES OR NO,
                                       IF THE ANSWER IS KNOWN

6. B ⟶ I SEE, OK, QUITE...   BACKCHANNEL ITEMS ARE A
                                       FEW STANDARD PHRASES

SAMPLE DIALOGUE

1. I: A SHIP IS APPROACHING THE SUBMARINE.(S) } 1:st CYCLE
2. II: OK.(B)
3. II: IS IT A DESTROYER?(Q)
4. I: I DON'T KNOW.(A)   } 2:nd CYCLE
5. II: I SEE.(B)
6. II: SEND A HELICOPTER!(I)
7. I: OK.(B)   } 3:rd CYCLE

I, II are the partners of the dialogue. The letters S, B, A etc
are defined by the rules above. Different cycles are shown.

Fig.1. Prase structure rules indicating the grammatical
        structure of utterances in dialoge and how the
        main types of utterances occur in cycles in dialogue.
        The sample dialogue below illustrates the rules.

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A model of a turn-taker

A person who is to participate in a dialogue must know the
language, but that is not enough. He must also master the
turn-taking rules; he must react properly and be willing
to take initiatives. The rules of turn-taking are outlined
in fig.2. (It is in fact a flow chart which has been used
in computer simulation of communication, Sigurd 1985). It
is, of course, related to fig.1,

A person who participates in a dialogue must listen to
(and look at) his partner all the time in order to find out
whether he is being addressed or not. It is not even possible
to stop listening when one is talking, as the partner might
want to interrupt. The partner may also give backchannel
signals while one is speaking.

A participant in a dialogue must listen to certain signs which
indicate that he has to do something. If his name is mentioned
(which people, according to experience, notice even at very
noisy parties), he has to watch out. It might be a vocative
term, which means that he is being called upon to answer a
question, execute an instruction etc.

The main types of utterances are characterized by special
intonation contours and syntactic means as was noted above:
the question by inverted word order, the instruction by a special verb
form. When he finds that he is being addressed, there are various
possibilities as indicated by the flow diagram. If the participant
(2 in the diagram) is being asked something, it is proper to
answer the question. Studies of dialogue indicate that questions
are rarely left unanswered. It is considered impolite not to
answer a question and it can be considered to be breaking the
contract of cooperation which is signed when two persons carry
on a dialogue. In order to answer, the memory - which may be
thought of as a data base - must be searched. Generally, this
takes time and there is naturally a delay before the answer is
given. If an answer is given immediately, it sounds strange -
as if the answer is completely self-evident or the question is
not taken seriously. Truth questions require searching for the
fact questioned, e g "Is the ship a destroyer?" WH-questions
require searching for the parts of the fact given and filling
in the lacking piece, if it can be found, e g "Who is in charge
of the helicopter operations?"

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If one is not being asked a question one might have been in-
structed or ordered to do something. This case is shown next in
the diagram and it also requires a reaction. Normally one has
to say whether one is going to carry out the request or not.
(The important thing is, of course, to carry out the instruction.)

The next situation depicted in the diagram occurs when a
statement has been uttered. If one is doubtful, one might, as
indicated in the diagram, utter a back question, e g "Really?"
This is a truth question and has to be answered by the partner
by yes or no? Should the dialogue participant not be doubtful,
however, he may acknowledge the statement by saying "OK, I see,
Fine" etc, or some other backchannel item after having registered .
the fact in memory - adding it to his data base.

The right hand part of the diagram shows typical responses
to the initiatives of the partner.   It is, however, also important
to take initiatives. The proper moment to take an initiative is
when the word is free, after a cycle has been completed. One
might, of course, also break in before, but that case is not
illustrated by the diagram.

Two of the types of initiatives encoded by special syntactic
means by natural languages have to do with information. The
statement is used to inform the partner: the question is used
when the speaker wants to be informed. Thinking about human
knowledge in terms of data bases, we might say that the speaker
makes a statement when he wants to add something to the listeners
data base. Why the speaker wants to add this fact to the memory
of the listener is a separate question, but a model of a com-
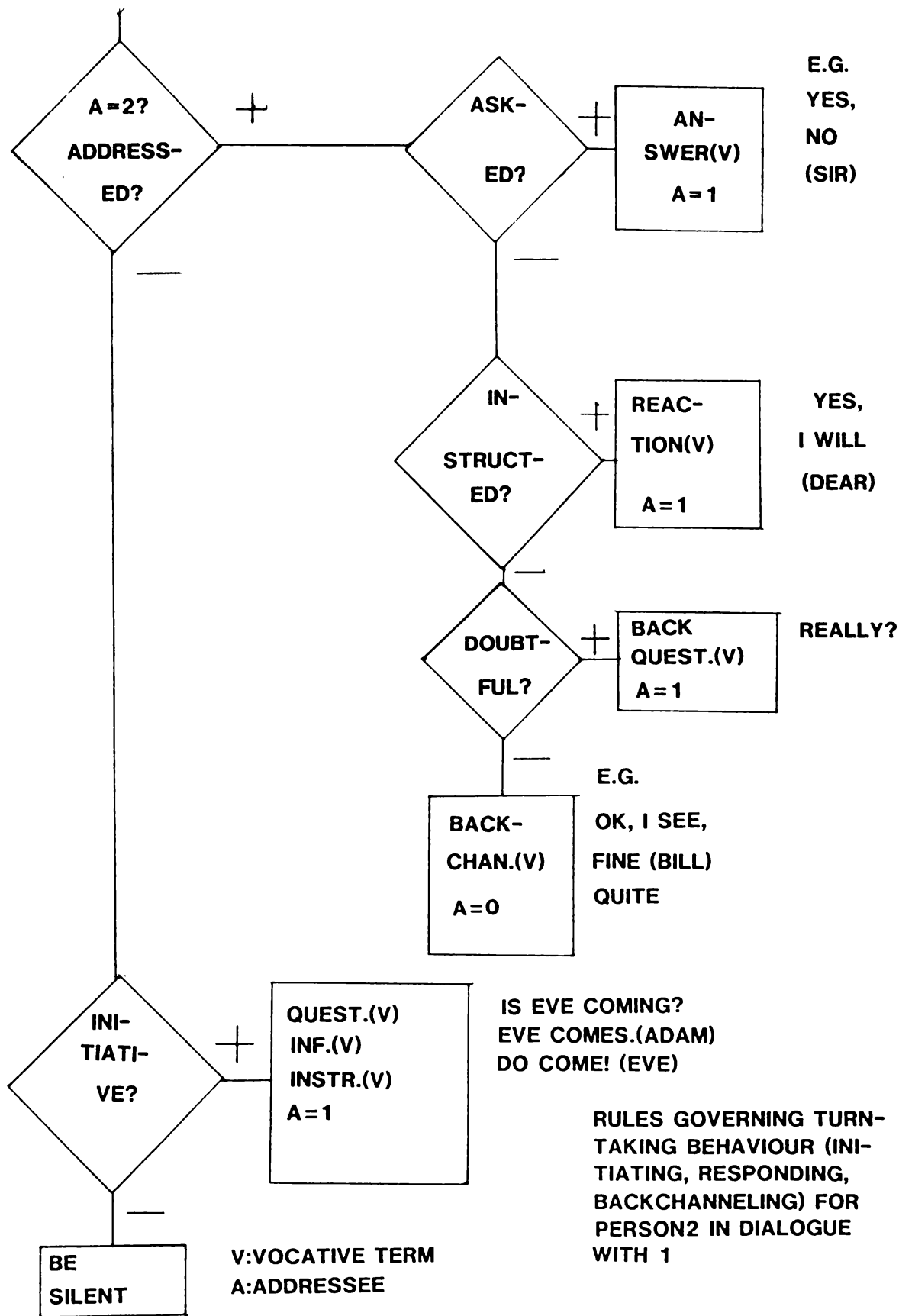municator must have an intention to communicate.

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A=2?
ADDRESS-
ED?

+

ASK-
ED?

+

AN-
SWER(V)

A=1

E.G.
YES,
NO
(SIR)

—

—

IN-
STRUCT-
ED?

+

REAC-
TION(V)

A=1

YES,
I WILL
(DEAR)

—

DOUBT-
FUL?

+

BACK
QUEST.(V)

A=1

REALLY?

—

BACK-
CHAN.(V)

A=0

E.G.

OK, I SEE,
FINE (BILL)
QUITE

INI-
TIATI-
VE?

+

QUEST.(V)
INF.(V)
INSTR.(V)
A=1

IS EVE COMING?
EVE COMES.(ADAM)
DO COME! (EVE)

RULES GOVERNING TURN-
TAKING BEHAVIOUR (INI-
TIATING, RESPONDING,
BACKCHANNELING) FOR
PERSON2 IN DIALOGUE
WITH 1

—

BE
SILENT

V:VOCATIVE TERM
A:ADDRESSEE

FIG. 2

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Modeling transfer of information

As hinted at above human dialogue can partly be seen as a
successive mutual updating of the databases of the partners.
But this is done in a very subtle way, where the speakers
ideally indicate their "knowledges", assumptions and attitudes.

Fig.3 shows a number of different communicative
situations and related utterances. Each partner is assumed
to have a picture of the "real" world as he sees or imagines it.
The real world which I is trying to convey information about
is the marine scene mentioned above. I's and II's pictures
may differ as indicated.When I says something he is adding
something to a verbal discourse world which is also indicated
in the figure. Similarly the partner II is assumed to have
a verbal discourse world which is being changed as he understands
I's utterances. It is important to note that the "real" worlds
and the verbal worlds are not identical. What I says is only
one out of an infinite number of comments which could be made,
and his comments do by no means give all the details of the
situation.

When the speaker I says:"A ship is approaching the
submarine" he may have a picture of the "real" world as
depicted in fig 3. His verbal world may be represented by
the logical formule APPR(S,U), where APPR is short for "is
approaching", S is the ship and U the submarine. It is clear that
he assumes that his partner II knows about the existence of the
submarine. This is indicated by the square brackets around
EXT(U),and the occurence of the same item in II's world
indicates that I's assumption is correct. The new information
is thus only EXT(S) and APPR(S,U) and one may say that only
APPR(S,U) is primary, EXT(S) may be derivable.

II may be said to have understood, when he has updated
his verbal discourse world, but that does not mean that II
has the same picture of the "real" world as I. There are many
places where the ship may be located, satisfying the conditions
imposed by approaching. The ship could approach from the North,
from the East etc. It could be close, it could go fast etc. The
listener fills in the details and he may guess wrongly (as in fig 3).

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If the answer is OK or "I see" it shows that II
has just stored the new piece of information in his memory.
But human partners often give other backchannel items,
e.g."Fine", which means that the information is favourable in
some way. One may think of a situation here where the ship
by approaching comes within reach of the torpedos of the sub-
marine. Using such emotional backchannel items requires
information of the intentions and plans of II. This is also
the case if disproving items such as "Blast" are to be used.
One may imagine a situation where the approaching of the
ship interferes with the plans of the submarine, which is
now threatened.

A common situation occurs when the partner already knows
and this situation is depicted below the line. In such a case
the databases of the partners I and II are identical as is shown.
II could just indicate this by saying "I know". Often the
partner gives comments which indicate how well he thinks
his parter describes the situation,i.e. how well the verbal
world agrees with the real world. Such comments may be
called metacomments and they may indicate that the wording
is perfect in which case backchannel items such as "Quite,Precisely"
Swedish"Precis, Just det" are used. These are in fact very
frequent   words. The   speaker II   may comment by saying
"Yes, to say the least", which indicates that he does not think
the wording fits the situation, in this case maybe because the
ship is rushing towards the submarine at great speed, in which
case approaching seems to weak (almost euphemistic).In other
cases the partner may agree on the situation but think that the
· wording is to strong. Types of metacomments are given in Sigurd(1986).
If the partner knows that the situation is different he
may give the backchannel"No"or he me say"Really?" This situation
is depicted by the last pictures where the verbal world
includes contradictory information : The ship is going away from
the submarine: DIST(S,U).
However the different worlds are depicted or represented,
it is clear that dialogue utterances are not just automatic
readings of facts in databases, as some designers of expert
systems seem to believe. Simulating the richness of human dialogue
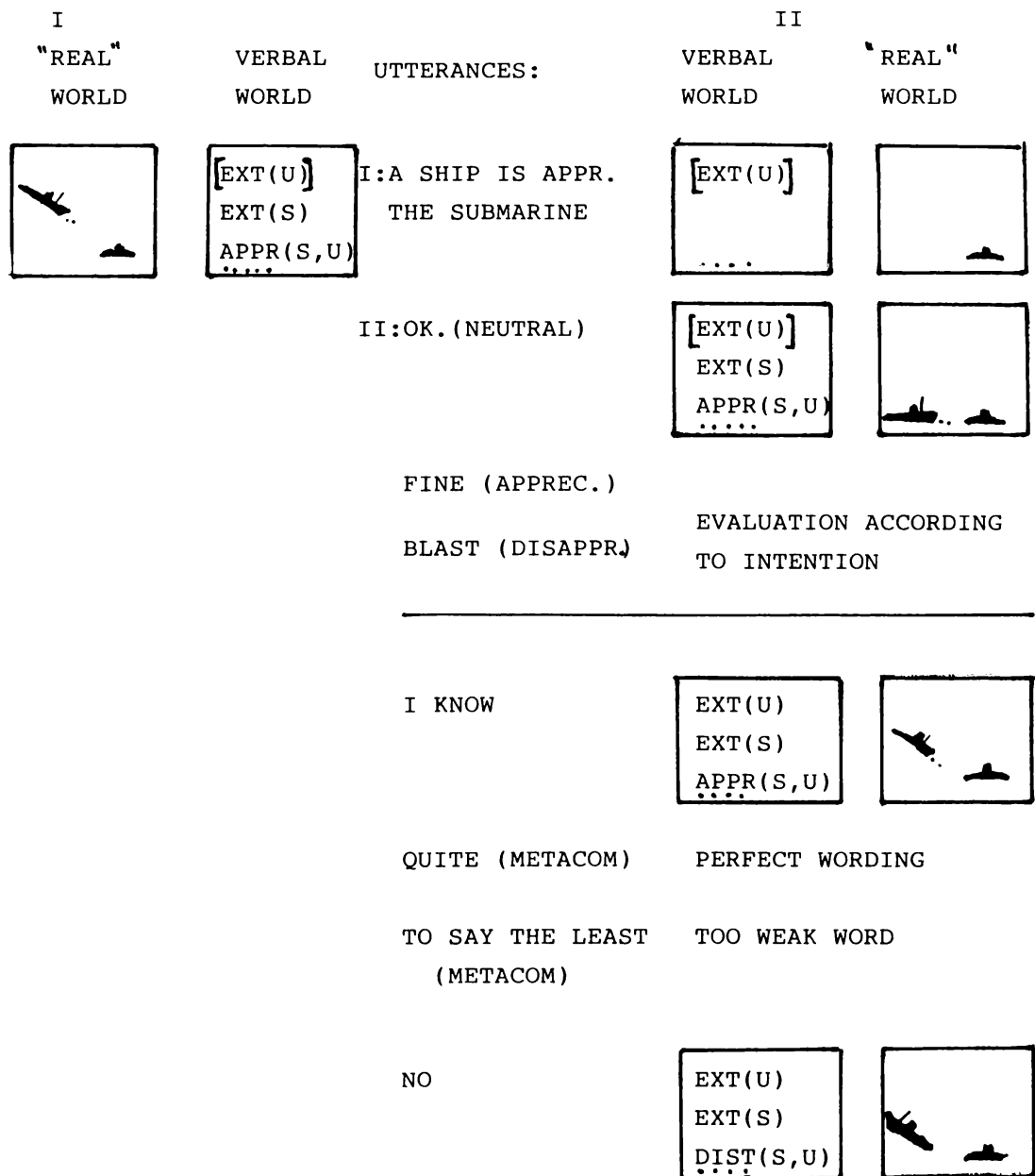is a great challenge.

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Fig.3
STATES OF THE REAL AND VERBAL WORLDS OF PARTNERS I,II
AND SAMPLE UTTERANCES. NOTE THAT THE METACOMMENTS
COMMENT ON THE DISCREPANCIES BETWEEN THE REAL AND THE
VERBAL WORLD.

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References

Brady,M.& R.C.Berwick (eds)1983.Computational models of
                    discourse. Cambridge:MIT Press

Chomsky,N.1957. Syntactic structures. The Hague:Mouton

    "   1965. Aspects of the theory of syntax.Cambridge:MIT Press

    "   1975. Reflections on language. New York:Pantheon

Oreström,B.1983.Turn-taking in English conversation.Lund:Liber

Sigurd,B.1982.COMMENTATOR.A computer model of verbal production.
                  Linguistics 1982,20

        1984."Om Jaså, Bra, Precis och andra returord".Språkvård
                  1984:3

        1985.Dialog på dator (CONVERSATOR).In:Praktisk Lingvistik
                  11.Lund:Dep. of linguistics

        1986."Ärligt talat, s.m.s. och andra metakommentarer".
                  Språkvård 1986 (to appear)

Stenström,A-B.1984.Questions and responses.Lund:Liber

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