12. Varieties of semantic evidence

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Abstract

Meanings are the most elusive objects of linguistic research. The article summarizes the type of evidence we have for them: various types of meta-linguistic activities like paraphrasing and translating, the ability to name entities and judge sentences true or false, as well as various behavioral and physiological measures such as reaction time studies, eye tracking, and electro-magnetic brain potentials. It further-more discusses the specific type of evi-dence we have for different kinds of meanings, such as truth-conditional aspects, presuppositions, implicatures, and connotations.

Keywords

###

Introduction: Aspects of Meaning and Pos-sible Sources of Evidence

Why meaning is special

If we ask an astronomer for evidence for phosphorus on Sirius, she will point out that spectral analysis of the light from this star reveals bands that are characteristic of this element, as they also show up when phosphorus is burned in the lab. If we ask a linguist the

more pedestrian question for evidence
that a certain linguistic expression —
say, the sentence *the lazy fox jumped
over the fence* — has meaning, answers
40 are probably less straightforward and
predictable. He might point out that
speakers of English generally agree that
it has meaning, but how do they know? It
is perhaps not an accident that the
45 study of meaning is the subfield of lin-
guistics that developed only very late
in the 2500 years of history of linguis-
tics, in the 19th century (cf. article
9, *The emergence of semantics as a dis-
50 cipline*).

  The reason why it is difficult to say
what evidence for meaning could be is
that it is difficult to say what *meaning*
is. According to a common assumption,
55 communication consists in putting *mean-
ing* into a *form*, a form that is then
sent from the speaker to the addressee
(this is the conduit metaphor of commu-
nication, see Lakoff & Johnson 1980).
60 Aspects that are concerned with the form
of linguistic expressions and their ma-
terial realization as studied in syntax,
morphology, phonology and phonetics;
they are generally more tangible than
65 aspects concerned with the content of
linguistic expressions. But semanticists
in general hold that semantics, the
study of linguistic meaning, indeed has
an object to study that is related but
70 distinct from the forms in which it is

encoded, from the communicative inten-
tions of the speaker and from the re-
sulting understanding of the addressee.

75 *Aspects of Meaning*

The English noun *meaning* is multiply
ambiguous, and there are two readings
that are relevant for semantics. Grice
(1957) has pointed out that we can ask
80 what a speaker meant by uttering some-
thing, and what the utterance means that
the speaker uttered (cf. article 2,
*Meaning, Intentionality and Communica-
tion*). Take J. F. Kennedy's utterance of
85 the sentence *Ich bin ein Berliner* on
June 26, 1963. JFK meant with it that in
spite of the cold war, the USA would not
give up West Berlin, which was true. The
utterance meant that JFK is a citizen of
90 Berlin, which was false. In addition, we
can ask what the linguistic form *Ich bin
ein Berliner* means independent of any
context; this can be paraphrased by 'the
speaker of the sentence is a citizen of
95 Berlin at the time of the utterance of
the sentence'. JFK expressed what he
meant by using a particular linguistic
form that he uttered in a particular
situation.
100 Semantics studies the meaning of lin-
guistic forms — sometimes called *literal
meaning*. The ways how literal meanings
are used in acts of communication and
their effects on the participants is
105 part of pragmatics (cf. article 99: *Se-*

mantics and Pragmatics). But the use of
forms and their effects on speaker and
addressee are important pieces of data
to re-engineer the underlying meaning of
110   the forms.

Types of Access to Meaning
   Grounding meaning of linguistic ex-
pressions in communication suggests that
115   there are various kinds of empirical
evidence for meaning. First, we can ob-
serve the external behavior of the par-
ticipants in, before and after the act
of communication. Some kinds of behavior
120   can be more directly related to linguis-
tic meaning than others, and hence will
play a more central role in discovering
underlying meaning. For example, com-
mands often lead to a visible non-
125   linguistic reaction, and simple *yes/no*-
questions will lead to linguistic reac-
tions that are easily decodable. Sec-
ondly, we can measure aspects of the ex-
ternal behavior in detail, like the re-
130   action times to questions or the speed
in which passages of text are read(cf.
article 115, *Meaning in Psycholinguis-*
tics). Third, we can observe physiologi-
cal reactions of participants in commu-
135   nication, like the changing size of
their pupil or the electromagnetic field
generated by their cortex (cf. article
118, *Meaning in Neurolinguistics*).
Fourth, we can test hypotheses concern-
140   ing meaning in the output of linguistic

forms itself, using statistical tech-
niques applied to corpora (cf. article
124, *Corpus Linguistics*).

145 *Is Semantics Possible?*
     The reader should be warned that cor-
relations between meanings and observ-
able phenomena like non-linguistic pat-
terns of behavior or brain scans do not
150 guarantee that the study of meaning can
be carried out successfully. Leonard
Bloomfield, a behavioralist, considered
the observable effects so complex and
interwoven with other causal chains that
155 the science of semantics is impossible:
     We have defined the meaning of a lin-
guistic form as the situation in which
the speaker utters it and the response
which it calls forth in the hearer.
160 *[...] In order to give a scientifically*
accurate definition of meaning for every
form of a language, we should have to
have a scientifically accurate knowledge
of everything in the speakers' world.
165 *The actual extent of human knowledge is*
very small compared to this. [...]. The
statement of meanings is therefore the
weak point in language-study, and will
remain so until human knowledge advances
170 *very far beyond its present state.*
(Bloomfield 1933: 139f.)
     We could imagine similar skepticism
concerning the science of semantics from
a neuroscientist believing that meanings
175 are activation patterns of our head. The

huge number of such patterns, and their
variation across individuals that we
certainly have to expect, seems to pre-
clude that they will provide the founda-
180   tion for the study of meaning.

    Despite Bloomfield's qualms, the field
of semantics has flourished. Where he
went wrong was in believing that we have
to consider the whole world of the
185   speaker, or the speaker's whole brain.
There are ways to cut out phenomena that
stand in relation to, and bear evidence
for, meanings in much more specific
ways. For example, we can investigate
190   whether a specific sentence in a par-
ticular context and describing a par-
ticular situation is considered true or
false; and derive from that hypotheses
about the meaning of the sentence and
195   the meaning of the words involved in
that sentence. The usual methods of sci-
ence — forming hypotheses and models,
deriving predictions, making observa-
tions and constructing experiments that
200   support or falsify the hypotheses — have
turned out to be applicable to linguis-
tic semantics as well.

Native Semantic Activities
205   There are many native activities that
directly address aspects of meaning.
When Adam named the animals of paradise
he assigned expressions to meanings, as
we do today when naming things or per-
210   sons or defining technical terms. We ex-

plain the meaning of words or idioms by
paraphrasing them — that is, by offering
different expressions with the same or
at least similar meanings. We can refer
215   to aspects of meaning: We say that one
expression *means* the same as another
one, or its opposite; we say that one
expression *refers* to a subcase of an-
other. As for speaker's meanings, we can
220   elaborate on what someone meant by such-
and-such words, and can point out dif-
ferences between that and what the words
actually meant or how they were under-
stood by the addressee. Meanings are
225   firmly established in the prescientific
ways we talk about language.

We can translate, that is, rephrase an
expression in one language by an expres-
sion in another while keeping the mean-
230   ing largely constant. We can teach the
meaning of words or expressions to sec-
ond language learners or to children ac-
quiring their native language — even
though both groups, in particular chil-
235   dren in first language acquisition, will
acquire meanings to a large part implic-
itly, by contextual clues. The sheer
possibility of translation has been
enormously important for the development
240   of humankind. We find records of associ-
ated practices, like the making of dic-
tionaries, dating back to Sumerian-
Akkadian glossaries of 2300 BC.

These linguistic activities show that
245   meaning is a natural notion, not a theo-

retical concept. They also provide im-
portant source of evidence for meaning.
For example, it would be nearly impossi-
ble to construct a dictionary in lin-
250 guistic field work without being able to
ask for what a particular word means, or
how a particular object is called. As
another example, it would be foolish to
dismiss the monumental achievements of
255 the art of dictionary writing as evi-
dence for the meaning of words.

But there are problems with this kind
of evidence that one must be aware of.
Take dictionary writing. Traditional
260 dictionaries are often unsystematic and
imprecise in their description of mean-
ing. They do not distinguish systemati-
cally between contextual (or "occa-
sional") meaning and systematic meaning,
265 nor do they keep ambiguity and polysemy
apart in a rigorous way. They often do
not distinguish between linguistic as-
pects and more general cultural aspects
of the meaning and use of words. Wein-
270 reich (1964) famously criticized the 115
meanings of the verb *to turn* that can be
found in Webster's Third Dictionary.
Lexicography has greatly improved since
then, with efforts to define lexical en-
275 tries by a set of basic words and by
recognizing regularities like systematic
variations between word meanings (like
the intransitive use of transitive
verbs, or the polysemy triggered in par-
280 ticular contexts of use).

Talking about Meanings

Pre-scientific ways to address mean-
ings rely on an important feature of hu-
man language, its reflexivity — we can
use language to talk about language.
This feature is so entrenched in human
language that it went unnoticed until
logicians like Frege, Russell and Tar-
ski, working with much more restricted
languages, pointed out the importance of
the metalanguage / object language dis-
tinction. It is only quite recently that
we distinguish between regular language,
reference to expressions, and referenced
to meanings by typographical conventions
and write things like "*XXX* means 'YYY'".

The possibility to describe meanings
may be considered circular — as when
Tarski states that '*Snow is white*' *is
true if and only if snow is white.* How-
ever, it does work under certain condi-
tions. First, the meaning of an unknown
word can be described, or at least de-
limited, by an expression that uses
known words; this is the classical case
of a definition. If we had only this
procedure available as evidence for
meaning, things would be hopeless be-
cause we have to start somewhere with a
few expressions whose meanings are
known; but once we have those, they can
act as bootstraps for the whole lexicon
of a language. The theory of Natural Se-
mantic Metalanguage even claims that a

small set of concepts (around 200) and a
few modes of combining them are suffi-
cient to achieve access to the meanings
of all words of a language (Goddard
320   1998).

Second, the meanings of an ambiguous
word or expression can be paraphrased by
expressions that have only one or the
other meaning. This is common practice
325   in linguistic semantics, e.g. when de-
scribing the meaning of *He saw that
gasoline can explode* as (a) 'He saw an
explosion of a can of gasoline' and (b)
'He recognized the fact that gasoline is
330   explosive'. Speakers will generally
agree that the original sentence has the
two meanings teased apart by the para-
phrases. There are variations on this
access to meaning. For example, we might
335   consider a sentence in different lin-
guistic contexts and observe differences
in the meaning of the sentence by recog-
nizing that it has to be paraphrased
differently. For the paraphrases, we can
340   use a language that has specific devices
that help to clarify meanings, like va-
riables. For example, we can state that
a sentence like *Every man likes a woman
that likes him* has a reading 'Every man
345   x likes a woman y that likes x', but not
'There is a woman y that every man x
likes and that likes x'. The disadvan-
tage of this is that the paraphrases
cannot be easily grasped by naïve native
350   speakers. In the extreme case, we can

use a fully specified formal language to specify such meanings, such as first-order predicate logic; the existing reading of our example then could be

355 specified as $\forall x[man(x) \rightarrow \exists y[woman(y) \wedge likes(x, y) \wedge likes (y, x)]]$.

Talking about meanings is a very important source of evidence for meanings. However, it is limited not only by the

360 problem mentioned above, that it describes meanings with the help of other meanings. There are many cases where speakers cannot describe the meanings of expressions because this task is too

365 complex — think of children acquiring their first language, or aphasics loosing the capacity of language. And there are cases in which the description of meanings would be too complex for the

370 linguist. We may think of first fieldwork sessions in a research project on an unknown language. Somewhat closer to home, we may also think of the astonishingly complex meanings of natural lan-

375 guage determiners such as *a, some, a certain, a particular, a given* or indefinite *that* in *there was that man standing at the door* whose meanings had to be teased apart by careful considera-

380 tions of their acceptability in particular contexts.

Fieldwork Techniques in Semantics

In this section we will discuss vari-

385 ous techniques that have been used in

linguistic fieldwork, understood in a
wide sense as to include work on one's
own language and on language acquisi-
tion, for example. There are a variety
390 of sources that reflect on possible pro-
cedures; for example, the authors in
McDaniel e.a. (eds.) (1998) discuss
techniques for the investigation of syn-
tax in child language, many of which
395 also apply to semantic investigations,
and Matthewson (2004) is concerned with
techniques for semantic research in
American languages which, of course, are
applicable for work on other languages
400 as well (cf. also article 13, *Methods in
Cross-Linguistic Semantics*, and article
116, *Semantics in First Language Acqui-
sition*).

405 *Observation, Transcription and Transla-
tion*

   The classical linguistic fieldwork
method is to record conversations and
texts in natural settings, transcribe
410 them, and assign translations, ideally
with the help of speakers that are com-
petent in a language that they share
with the investigator. In classical
American structuralism, this has been
415 the method *de rigueur*, and it is cer-
tainly of great importance when we want
to investigate natural use of language.
   However, this technique is also se-
verely limited. First, even large text
420 collections may not provide the evidence

that distinguishes between different hypothesis. Consider superlatives in English; is *John is the tallest student* true if John and Mary both are students

425 that are of the same height and taller than any other student? Competent English speakers say no, superlatives must be unique — but it might be impossible to find out on the basis of a corpus of

430 non-elicited text.

Secondly, there is the problem of translation. Even when we grant that the translation is competent according to usual standards, it is not clear how we

435 should deal with distinctions in the object language that are not easily made in the meta language. For example, Matthewson (2004) shows that in Menominee, inalienable nouns can have a prefix *me-*

440 indicating an arbitrary owner, as contrasted with a prefix *o-* indicating a specific 3rd person owner. This difference could not be derived from simple translations of Menominee texts into

445 English, as English does not make this distinction. There is also the opposite problem of distinctions that are forced on us by the meta language; for example, pronouns in English referring to humans

450 distinguish two genders, which may not be a feature of the object language. Hence, as Matthewson puts it, translations should be seen as clues for semantic analysis, rather as its result.

455 Translations, or more generally para-

phrases, are problematic for more funda-
mental reasons as evidence for meaning,
as they explain the meaning of an ex-
pression α by way of the meaning of an
460   expression β, hence it presupposes the
existence and knowledge of meanings, and
a judgment of similarity of meaning.
However, it appears that without accept-
ing this type of hermeneutic circle the
465   study of semantics could not get off the
ground. But there are methods to test
hypotheses that have been generated
first with the help of translations and
paraphrases by independent means.
470

Pointing

Pointing is a universal non-linguistic
human behavior that aligns with aspects
of meanings of certain types of linguis-
475   tic expressions (cf. also article 101,
Deixis and Demonstratives). Actually,
pointing may be as characteristic for
humans as language, as humans appear to
be the only apes that point (cf.
480   Tomasello 2008).

Pointing is most relevant for refer-
ring expressions, with names as the pro-
totypical example (cf. article 4, *Refer-
ence*). These expressions denote a par-
485   ticular entity that is also identified
by the pointing gesture, and hence
pointing is independent evidence for the
meaning of such expressions. For exam-
ple, if in a linguistic fieldwork situa-
490   tion an informant points to a person and
utters *Max*, this might be taken to be
the name of that person. We can conclude

that *Max* denotes that person, in other words, that the meaning of *Max* is the
495   person pointed at.

    Simple as this scenario is, there are certain prerequisites for it to work. For example, the pointing gesture must be recognized as such; in different cul-
500   tures, the index finger, the stretched-out hand, or an upward movement of the chin may be used, and in some cultures there may be a taboo against pointing gestured when directed at humans. Fur-
505   thermore, there must be one most salient object in the pointing cone (cf. Kronstedt e.a. 2006) that will then be identified. This presupposes a pre-linguistic notion of objects, and of sali-
510   ency. This might work well when persons or animals are pointed at, who are cognitively highly salient. But mistakes can occur when there is more than one object in the pointing cone that are
515   equally salient. When Captain Cook on his second voyage visited an island in the New Hebrides with friendly natives and tried to communicate with them, he pointed to the ground. What he heard was
520   *tanna*, which he took as the name of the island, which is still known under this name. Yet the meaning of *tana* in all Melanesian languages is simply "earth". The native name for Tanna is reported to
525   be *parei* (Gregory 2003); it is not in use anymore.

    Pointing gestures may also help to identify the meaning of common nouns, adjectives, or verbs — expressions that
530   denote sets of entities or events. The

pointing is directed towards a specimen,
but reference is at entities of the same
type as the one pointed at. There is an
added source of ambiguity or vagueness
535 here: What is "the same type as"? On his
first voyage, Captain Cook made landfall
in Australia, and observed creatures
with rabbit-like ears hopping on their
hind legs. When naturalist Joseph Banks
540 asked the local Guugu Yimidhirr people
how they are called, presumably with the
help of some pointing gesture, he was
the first to record the word *kangaroo*.
But the word *gangurru* actually just re-
545 fers to a large species of black kanga-
roo, not to the marsupial family in gen-
eral (cf. Haviland 1974).

Quine (1960), in an argument to dis-
count the possibility of true transla-
550 tion, famously described the problems
that even a simple act like pointing and
naming might involve. Assume a linguist
points to a white rabbit, and gets the
response *gavagai*. Quine asks whether
555 this may mean 'rabbit', or perhaps 'ani-
mal', or perhaps 'white', or perhaps
even 'undetached rabbit parts'. It also
might mean 'rabbit stage', in which case
repeated pointing will identify differ-
560 ent reference objects. All these options
are theoretical possibilities under the
assumption that words can refer to arbi-
trary aspects of reality. However, it is
now commonly assumed that language is
565 build on broad cognitive commonalities
about entities and classes. There is
evidence that pre-linguistic babies and
higher animals have concepts of objects

(as contrasted to substances) and ani-
570 mals (as contrasted to lifeless beings)
that preclude a conceptualization of a
rabbit as a set of rabbit legs, a rabbit
body, a rabbit head and a pair of rabbit
ears moving in unison. Furthermore,
575 there is evidence that objects are
called with terms of a middle layer of a
taxonomic hierarchy, the so-called "ge-
neric level", avoiding terms that are
too general or too specific (cf. Berlin,
580 Breedlove & Raven 1973). Hence a rabbit
will not be called *thing* in English, or
animal, and it will not be called *Eng-
lish angora* either except perhaps by
rabbit breeders that work with a differ-
585 ent taxonomy. This was the reason for
Captain Cooks misunderstanding of *gan-
gurru*; the native Guugu Yimidhirr people
had a different, and more refined, taxo-
nomic hierarchy for Australian animals,
590 where species of kangaroo formed the ge-
neric level; for the British visitors
the family itself belonged to that
level.

　　Pointing, or related gestures, have
595 been used to identify the meaning of
words. For example, in the original
study of Berlin & Kay (1969) on color
terms subjects were presented with a
two-dimensional chart of 320 colors
600 varying according to spectral color and
saturation. The task was to identify the
best specimen for a particular color
word (the focal color) and the extent to
which colors fall under a particular
605 color word. Similar techniques have been
used for other lexical fields, for exam-

ple for the classification of vessels
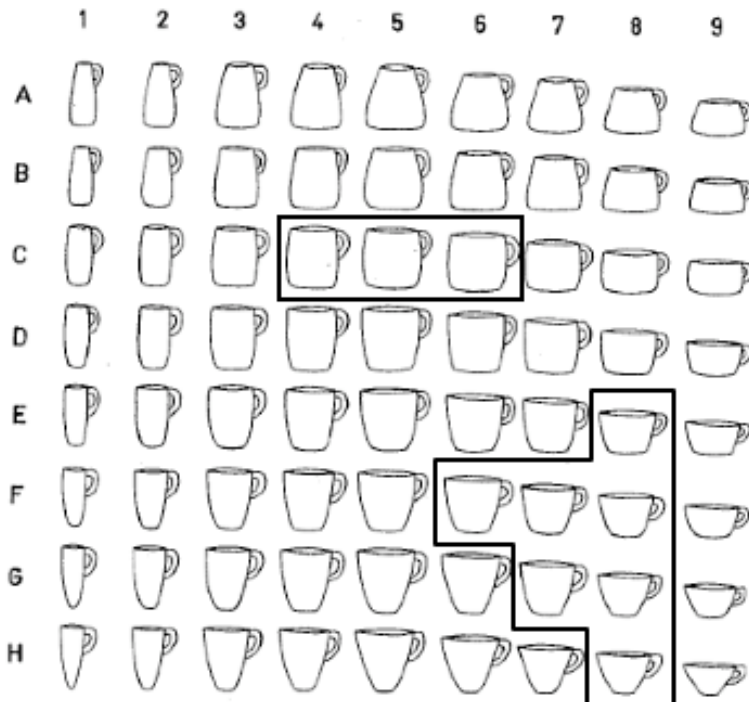using terms like *cup, mug* or *pitcher*
(cf. Kempton 1981; see Figure 1).
610

FIGURE 1: Vessel categories after Kemp-
ton (1981); identification of >80%
agreement between subjects for *mug* and
615   *coffee cup* (by the author).

Tests of this type have been carried
out in two ways: Either subjects were
presented with a field of reference ob-
620   jects ordered after certain dimensions;
e.g., Berlin & Kay (1969) presented col-
ors ordered after their wave length (the
order they present themselves in a rain-
bow) and after their saturation (with
625   white and black as the extremes). Kemp-
ton's vessels were presented as varying
in two dimensions: The relation between
the upper and lower diameters, and the
relation between height and width. When
630   judging whether certain items fall under
a term or not, the neighboring items
that already have been classified might

influence the decision. Another tech-
nique, which was carried out in the
635 World Color Survey (see Kay e.a. 2008),
presented color chips in random order to
avoid this kind of influence.

The pointing test can be used in two
ways: Either we point at an entity in
640 order to get the term that is applicable
to that entity, or we have a term and
point to various objects to find out
whether the term is applicable. The
first approach asks an onomasiological
645 question; it is concerned with the ques-
tion: How is this thing called? The sec-
ond approach asks the complementary se-
masiological question: What does this
expression mean?
650 Within a Fregean theory of meaning, a
distinction is made between reference
and sense (cf. article 3, *Sinn and Be-
deutung*). With pointing to concrete en-
tities we gain access to the reference
655 of expressions, and not to the sense,
the concept that allows us to identify
the reference. But by varying potential
reference objects we can form hypotheses
about the underlying concept, even
660 though we can never be certain that by a
variation of reference objects we will
uncover all aspects of the underlying
concept. Goodman (1955) illustrated this
with the hypothetical adjective *grue*
665 that, say, refers to green objects when
used before the year 2100 and to blue
objects when used after that time; no
pointing experiment executed before 2100
could differentiate *grue* from *green*. But
670 a meaning like the hypothetical *grue* ap-

pears as strange as a reference towards
non-detached rabbit parts. We work under
the hypothesis that meanings of lexical
items are restricted by general princi-
675 ples of uniformity over time. There are
other such principles that restrict pos-
sible meanings, for example connected-
ness and convexity (Gärdenfors 2000). In
the vessel example above, where poten-
680 tial reference objects were presented
following certain dimensions, we expect
that the areas for which *cup* and *mug* ap-
ply are not discontinuous and have the
general property that when x is an α and
685 y is an α, then everything in between x
and y is an α as well.

In spite of all its problems, pointing
is the most elementary kind of evidence
for meaning without which linguistic
690 field work, everyday communication and
language acquisition would be impossi-
ble. Yet it seems that little research
has been done on pointing and language
acquisition, be it first or second. Its
695 importance, however, was recognized as
early as in St. Augustin's *Confessions*,
where he writes about his own learning
of language:

When they [the elders] *called some*
700 *thing by name and pointed it out while*
they spoke, I saw it and realized that
the thing they wished to indicate was
called by the name they then uttered.
And what they meant was made plain by
705 *the gestures of their bodies, by a kind*
of natural language, common to all na-
tions […] (Book I:8).

Truth Value Judgments (TVJ)

710   Truth value judgments do the same job
for the meaning of sentences as pointing
does for referring expressions. In the
classical setup, a situation is pre-
sented with non-linguistic means to-
715   gether with a declarative sentence, and
the speaker has to indicate whether this
sentence is true or false with respect
to the situation. The classification as
true or false is an linguistic act by
720   itself, so it can be doubted that this
provides a way to base the study of
meaning wholly outside of language. But
arguably, agreeing or disagreeing are
more primitive linguistic acts that may
725   even rely on simple gestures, just as in
the case of pointing.

   The similarity between referential ex-
pressions — which identify objects — and
declarative sentences — which identify
730   states of affairs in which they are true
— is related to Frege's identification
of the reference of sentences with their
truth value with respect to a particular
situation (even though this was not the
735   original motivation for this identifica-
tion, cf. Frege 1892). This is reflected
in the two basic extensional types as-
sumed in sentence semantics: Type e for
entities referred to by names, and type
740   t for truth values referred to by sen-
tences. But there is an important dif-
ference here: There are many distinct
objects — D_e, the universe of discourse,

is typically large; but there are just
745 two (basic) truth values — D_t, the set
of truth values, standardly is {0, 1},
falsity and truth. Hence we can distin-
guish referring expressions more easily
by their reference than we can distin-
750 guish declarative sentences. One conse-
quence of this is that onomasiological
tests do not work. We cannot present a
"truth value" and expect a declarative
sentence that is true. Also, on present-
755 ing a situation in a picture or a little
movie we cannot expect that the linguis-
tic reactions are as uniform as when we,
say, present the picture of an apple.
But the semasiological direction works
760 fine: We can present speakers with a de-
clarative sentence and a situation or a
set of situations and ask whether the
sentence is true in those situations.

    Truth values are not just an ingenious
765 idea of language philosophers to reduce
the meaning of declarative sentences to
judgments whether a sentence is true or
false in given situations. They are of-
ten used to investigate the meaning of
770 sentences in experiments and in linguis-
tic field work. They have been particu-
larly popular in the study of language
acquisition because they require a
rather simple reaction by the child that
775 can be expected even from two-year olds.

    The TVJ task comes in two flavors. In
both, the subjects are presented with a
sentence and a situation, specified by a

picture, an acted-out scene with hand
puppets or a movie, or by the actual
world provided that the subjects have
the necessary information about it. In
the first version, the subjects should
simply state whether the sentence is
true or false. This can be done by a
linguistic reaction, by a gesture, by
pressing one of two buttons, or by tick-
ing one of two boxes. We may also record
the speed of these reactions in order to
get data about the processing of expres-
sions. In the second version, there is a
character, e.g. a hand puppet, that ut-
ters the sentence in question, and the
subjects should reward or punish the
character if the sentence is true or
false with respect to the situation pre-
sented (see e.g. Crain 1991). A reward
could be, for example, feeding the hand
puppet a cookie. Interestingly, the sec-
ond procedure taps into cognitive re-
sources of children that are otherwise
not as easily accessible.

Gordon (1998), in a description of TVJ
in language acquisition, points out that
this task is quite natural and easy.
This is presumably so because truth
value judgment is an elementary linguis-
tic activity, in contrast to, say, gram-
maticality judgments. TVJ also puts less
demands on answers than wh-questions
(e.g. *Who chased the zebra?* vs. *Did the
lion chase the zebra?*) This makes it the
test of choice for children and for lan-

guage-impaired persons.

815   But there are potential problems in carrying out TVJ tasks. For example, Crain e.a. (1998) have investigated the phenomenon that children seem to consider a sentence like *Every farmer is*

820 *feeding a donkey* false if there is a donkey that is not fed by the farmer. They argue that children are confused by the extra donkey and try to reinterpret the sentence in a way that seems to make

825 sense. A setup in which attention is not drawn to a single object might be better; even adding a second unfed donkey makes the judgments more adult-like. Also, children respond better to scenes

830 that are acted out than to static pictures. In designing TVJ experiments, one should consider the fact that positive answers are given quicker and more easily than negative ones. Furthermore, one

835 should be aware that unconscious reactions of the experimenter may provide subtle clues for the "right" answer (the "Clever Hans" effect, named after the horse that supposedly could solve arith-

840 metic problems). For example, when acting out and describing a scene, the experimenter may be more hesitant when uttering a false statement.

845 *TVJ and presuppositions / implicatures*
    There are different aspects of meaning beyond the literal meaning, such as presuppositions, conventional implicatures,

conversational implicatures and the
850   like, and it would be interesting to
know how such meaning components fare in
TVJ tasks. Take presuppositions (cf.
also article 102, *Presuppositions*).
Theories such as Stalnaker (1974) that
855   treat them as preconditions of interpre-
tation predict that sentences cannot be
interpreted with respect to situations
that violate their presuppositions. The
TVJ test does not seem to support this
860   view. The sentence *The dog is eating the
bone* will most likely be judged true
with respect to a picture showing two
dogs, where one of the dogs is eating a
bone. This may be considered evidence
865   for the ease of accommodation, which
consists of restricting the context to
the one dog that is eating a bone. In-
cluding a third option or truth value
like "don't know" might reveal the spe-
870   cific meaning contribution of presuppo-
sitions

    As for conversational implicature (cf.
article 103, *Implicature*) we appear to
get the opposite picture. TVJ tests have
875   been used to check the relevance of sca-
lar implicatures. For example, Noveck
(2001), building on work of Smith
(1980), argued that children are "more
logical" than adults because they can
880   dissociate literal meanings from scalar
implicatures. Children up to 11 years
react to statements like *some giraffes
have long necks* (where the picture shows

that all giraffes have long necks) with
885 an affirmative answer, while most adults
find them inappropriate.

TVJ Variants: Picture Selection and Act-
ing Out
890   The picture selection task has been
applied for a variety of purposes beyond
truth values (cf. Gerken & Shady 1998).
But for the purpose of investigating
sentence meanings, it can be seen as a
895 variant to the TVJ task: The subject is
exposed to a declarative sentence and
two or more pictures and has to identify
the picture for which the sentence is
true. It is good to include irrelevant
900 pictures as filler items, which can test
the attention of the subjects. The task
can be used to identify situations that
fit best to a sentence. For example, for
sentences with presuppositions it is ex-
905 pected that a picture will be chosen
that does not only satisfy the asser-
tion, but also the presupposition. So,
if the sentence is *The dog is eating a*
bone, and if a picture with one or two
910 dogs is shown, then presumably the pic-
ture with one dog will be preferred.
Also, sentences whose scalar implicature
is satisfied will be preferred over
those for which this is not the case.
915 For example, if the sentence is *some gi-*
raffes have long necks, a picture in
which some but not all giraffes have
long necks will be preferred over a pic-

ture in which all giraffes are long-
920 necked.

   Another relative of the TVJ task is
the Act Out task in which the subject
has to "act out" a sentence with a scene
such that the sentence is true. Again,
925 we should expect that sentences are
acted out in a way as to satisfy all
meaning components of a sentence.

Restrictions of the TVJ Methodology
930   One restriction of the various TVJ
methodologies appears to be that they
just target expressions that have a
truth value, that is, sentences. How-
ever, they allow to investigate the
935 meaning of subsentential expressions,
under the assumption that the meaning of
sentences is computed in a compositional
way from the meanings of their syntactic
parts (cf. article 6, *Compositionality*).
940 For example, the meaning of spatial pre-
suppositions like *on*, *on top of, above*
or *over* can be investigated with scenes
in which objects are arranged in par-
ticular ways.
945   Another potential restriction of TVJ
as discussed so far is that we assumed
that the situations are presented by
pictures. Language is not restricted to
encoding information that can be repre-
950 sented by visual stimuli. But we can
also present sounds, movie scenes or
comic strips that represent temporal de-
velopments, or even olfactory and tac-

tile stimuli to judge the range of mean-
955   ings of words (cf. e.g. Majid (ed.) 2006
for verbs of cutting and breaking).

TVJ is also difficult to apply when
deictic expressions are involved, as
they often require reference to the
960   speaker, who is typically not part of
the picture. For example, in English the
sentence *The ball is in front of the*
tree means that the ball is in between
the speaker that faces the tree and the
965   tree; the superficially corresponding
sentence in Hausa means that the ball is
behind the tree (cf. Hill 1982). In Eng-
lish, the tree is seen as facing the
speaker, whereas in Hausa the speaker
970   aligns with the tree (cf. article 110,
Expression of Space). Such differences
are not normally represented in pic-
tures, but it can be done. One could ei-
ther represent the picture from a par-
975   ticular angle, or represent a speaker
with a particular position and orienta-
tion in the picture itself and ask the
subject to identify with that figure.

The TVJ technique is systematically
980   limited for sentences that do not have
truth values, such as questions, com-
mands, or exclamatives. But we can gen-
eralize it to a judgment of appropriate-
ness of sentences given a situation,
985   which sometimes is done to investigate
politeness phenomena and the like. There
are also subtypes of declarative sen-
tences that are difficult to investigate

with TVJ, namely modal statements, e.g.
990 *Mary must be at home*, or habituals and
generics that allow for exceptions, like
Delmer walks to school, or *Birds fly*
(cf. article 49, *Genericity*). This is
arguably so because those sentences re-
995 quire to consider different possible
worlds, which cannot be easily repre-
sented graphically.

TVJ with Linguistic Presentation of
1000 *Situation*

The TVJ technique can be applied for
modal or generic statements if we pre-
sent the situation linguistically, by
describing it. For example, we could ask
1005 whether *Delmer walks to school* is true
if Delmer walks every day except Fri-
days, when his father gives him a ride.
Of course, this kind of linguistic eli-
citation technique can be used in nearly
1010 all the cases described so far. It has
clear advantages: Linguistic descrip-
tions are easy and cheap to produce and
can focus the attention of the subject
to aspects that are of particular rele-
1015 vance for the task. For this reason it
is very popular for quick elicitations
whether a sentence can mean such-and-
such.

Matthewson (2004) argues that elicita-
1020 tion is virtually the only way to get to
more subtle semantic phenomena. She also
argues that it can be combined with
other techniques, like TVJ and grammati-

cality judgments. For example, in inves-
tigating aspect marking in St'át'imcets
Salish, the sentence *Have you been to
Seattle?* is translated using an adverb
lán that otherwise occurs with the mean-
ing 'already'; a follow-up question
could be whether it is possible to drop
lán in this context, retaining roughly
the same meaning.

The linguistic presentation of scenes
comes with its own limitations. There is
the foundational problem that we get at
the meaning of an expression α by way of
the meaning of an expression β. It can-
not be applied in case of insufficient
linguistic competence, as with young
children or language-impaired persons.

Acceptability Tests

In this type of test, speakers are
given an expression and a linguistic
context and/or an description of an ex-
tralinguistic situation, and are asked
whether the expression is acceptable
with respect to this context or the
situation. With it, we can explore the
felicity conditions of an expression,
which often are closely related to cer-
tain aspects of its meaning.

Acceptability tests are the natural
way to investigate presuppositions and
conventional implicatures of expres-
sions. For example, additive focus par-
ticles like *also* presuppose that the
predication holds for an alternative to

the focus item. Hence in a context like
1060 *John went to Paris*, the sentence *John
also went to PRAGUE* is felicitous, but
the sentence *Mary also went to PRAGUE* is
not. Acceptability tests can also be
used to investigate information-struc-
1065 tural distinctions. For example, in Eng-
lish, different accent patterns indicate
different focus structures; this can be
seen when judging sentences like *JOHN
went to Paris* vs. *John went to PARIS* in
1070 the context of questions like *Who went
to Paris?* and *John went where?* (cf. ar-
ticle 74 on questions). As another exam-
ple, Portner & Yabushita (1998) dis-
cussed the acceptability of sentences
1075 with a topic-comment structure in Japa-
nese where the topic was identified by a
noun phrase with a restrictive relative
clause and found that such structures
are better if the relative clause corre-
1080 sponds to a comment on the topic in the
preceding discourse. Acceptability tests
can also be used to test the appropri-
ateness of terms with honorific meaning,
or various shades of expressive meaning,
1085 which have been analyzed as conventional
implicatures by Potts (2005).

When applying acceptability judgments,
it is natural to present the context
first, to preclude that the subject
1090 first comes up with other contexts which
may influence the interpretation. An-
other issue is whether the contexts
should be specified in the object lan-

guage, or can also be given in the meta-
language that is used to carry out the
investigation. Matthewson (2004) dis-
cusses the various advantages and disad-
vantages — especially if the investiga-
tor has a less-than-perfect command over
the object language — and argues that
using a meta-language is acceptable, as
language informants generally can resist
the possible influence of the metalan-
guage on their responses.

Elicited Production

We can turn the TVJ test on its head
and ask subjects to describe given
situations with their own words. In lan-
guage acquisition research, this tech-
nique is known as "elicited production",
and encompasses all linguistic reactions
to planned stimuli (cf. Thornton 1998).
In this technique the presumed meaning
is fixed, and controls the linguistic
production; we can hypothesize about how
this meaning can be represented in lan-
guage. The best known example of proba-
bly is the retelling of a little movie
called the Pear Story, which has un-
earthed interesting differences in the
use of tense and aspect distinctions in
different languages (cf. Chafe 1980 for
the original publication).

The main problem of elicited produc-
tion is that the number of possible re-
actions by speakers is, in principle,
unlimited. It might well be that the

type of utterances one expects do not

1130 occur at all. For example, we could set
up a situation in which person A thinks
that person B thinks that person C
thinks that it is raining, to test the
recursivity of propositional attitude

1135 expressions, but we will have to wait
long till such utterances are actually
produced. So it is crucial to select
cues that constrain the linguistic pro-
duction in a way that ensures that the

1140 expected utterances will indeed occur.

From Sentence Meanings to Word Meanings
The TVJ technique and its variants

1145 test the meaning of sentences, not of
words or subsentential expressions.
Also, with elicitation techniques, often
we will get sentence-like reactions.
With elicited translations, it is also

1150 advisable to use whole sentences instead
of single words or simpler expressions,
as Matthewson (2004) argues. It is pos-
sible to elicit the basic meaning of
nouns or certain verbs directly, but

1155 this is impossible for many other words.
The first ten most frequent words in
English are often cited as being *the,*
of, and, a, to, in, is, you, that; it
would be impossible to ask a naïve

1160 speaker of English what they mean or
discover there meanings in other more
direct ways, with the possible exception
of *you.*

We can derive hypotheses about the
meaning of such words by using them in
sentences and judging the truth value of
the sentences with respect to certain
situations, and their acceptability in
certain contexts. For example, we can
unearth the basic uses of the definite
article by presenting pictures contain-
ing one or two barking dogs, and ask to
pick out the best picture for *the dog is
barking*. The underlying idea is that the
assignment of meanings to expressions is
compositional, that is, that the meaning
of the complex expression is a result of
the meaning of its parts and the way
they are combined.

Communicative Behavior

Perhaps the most important function of
language is to communicate, that is, to
transfer meanings from one mind to an-
other. So we should be able to find evi-
dence for meaning by investigating com-
municative acts. This is obvious in a
trivial sense: If A tells B something, B
will often act in certain ways that be-
tray that B understood what A meant.
More specifically, we can investigate
particular aspects of communication and
relate them to particular aspects of
meaning. We will look at three examples
here: Presuppositions, conversational
implicatures and focus-induced alterna-

tives.

1200   Presuppositions (cf. article 102, *Pre-supposition*) are meaning components that are taken for granted, and hence appear to be downtoned. This shows up in possible communicative reactions. For exam-

1205 ple, consider the following dialogues:

    A: *Unfortunately, it is raining.*

    B: *No, it isn't.*

    Here, B denies that it is raining; the meaning component of *unfortunate* ex-

1210 pressing regret by the speaker is presupposed or conventionally implicated.

    A: *It is unfortunate that it is raining.*

    B: *No, it isn't.*

    Here, B presupposes that it is rain-

1215 ing, and states that this is unfortunate. In order to deny the presupposed part, other conversational reactions are necessary, like *But that's not unfortunate*, or *But it doesn't rain.* Simple and

1220 more elaborate denials are a fairly consistent test to distinguish between presupposed and proffered content (cf. van der Sandt 1988).

    For conversational implicatures (cf.

1225 article 103, *Implicature*) the most distinctive property is that they are cancelable without leading to contradiction. For example, *John has three children* triggers the scalar implicature

1230 that John has exactly three children. But this meaning component can be explicitly suspended: *John has three children, if not more*. It can be explicitly

cancelled: *John has three children, in* *fact he has four.* And it does not arise in particular contexts, e.g. in the context of *People get a tax reduction if* *they have three children.* This distinguishes conversational implicatures from presuppositions and semantic entailments: *John has three children, {if not* *two / in fact, two}* is judged contradictory.

Our last example concerns the introduction of alternatives that are indicated by focus, which in turn can be marked in various ways, e.g. by sentence accent. A typical procedure to investigate the role of focus is the question-answer test (cf. article 74, *Questions*). In the following four potential question-answer pairs (A1–B1) and (A2–B2) are well-formed, but (A1–B2) and (A2–B!) are odd.

A1: *Who ate the cake?*
A2: *What did Mary eat?*
B1: *MARY ate the cake.*
B2: *Mary ate the CAKE.*

This has been interpreted as saying that the alternatives of the answer have to correspond to the alternatives of the question.

To sum up, using communicative behavior as evidence for meaning consists in evaluating the appropriateness of certain conversational interactions. Competent speakers generally agree on such judgments. The technique has been used

in particular to identify, and differen-
1270   tiate, between different meaning compo-
nents having to do with the presentation
of meanings, in particular with informa-
tion structure.

1275

Behavioral Effects of Semantic Processing

When discussing evidence for the mean-
ing of expressions we have focused so
1280   far on the meaning themselves. We can
also investigate how semantic informa-
tion is processed, and get a handle on
how the human mind computes meanings. To
get information on semantic processing,
1285   judgment tasks are often not helpful,
and might even be deceiving. We need
other types of evidence that arguably
stand in a more direct relation to se-
mantic processing. It is customary to
1290   distinguish between behavioral data on
the one hand, and neurophysiologic data
that directly investigates brain phenom-
ena on the other. In this section we
will focus on behavioral approaches (cf.
1295   also article 15, *Experimental Methods*).

Reaction times
The judgment tasks for meanings de-
scribed so far can also tap into the
1300   processing of semantic information if
the timing of judgments is considered.
The basic assumption is that longer re-
action times, everything else being

equal, are a sign for semantic process-
1305   ing load.

    For example, Clark & Lucy (1975) have
shown that indirect speech acts take
longer for processing than direct ones,
and attribute this to the additional in-
1310   ferences that they require. Noveck
(2004) has shown that the computation of
scalar implicature takes time; people
that reacted to sentences like *Some ele-
phants are mammals* with a denial (be-
1315   cause all elephants and not just some
do) took considerably longer. Kim (2008)
has investigated the processing of *only*-
sentences, showing that the affirmative
content is evaluated first, and the pre-
1320   supposition is taken into account only
after.

    Reaction times are relevant for many
other psycholinguistic paradigms, beyond
tasks like TVJ, and can provide hints
1325   for semantic processing. One notable ex-
ample is the semantic phenomenon of co-
ercion, changes of meanings that are
triggered by the particular context in
which meaning-bearing expressions occur
1330   (cf. article 25, *Mismatches and coer-
cion*). One well-known example is aspec-
tual coercion: Temporal adverbials of
the type *until dawn* select for atelic
verbal predicates, hence *The horse slept
1335   until dawn* is fine. But *The horse jumped
until dawn* is acceptable as well, under
an iterative interpretation of *jump* that
is not reflected overtly. This adapta-

tion of the basic meaning to fit the re-
1340   quirements of the context should be cog-
nitively costly, and there is indeed
evidence for the additional semantic
processing involved. Piñango e.a. (2006)
report on various studies and their own
1345   experiments that made use of the dual
task interference paradigm: Subjects
listen to sentences and, at particular
points, deal with an unrelated written
lexical decision task. They were sig-
1350   nificantly slower in deciding this task
just after an expression that triggered
coercion (e.g. *until* in the second exam-
ple, as compared to the first). This can
be taken as evidence for the cognitive
1355   effort involved in coercion; notice that
there is not syntactic difference be-
tween the sentences to which such reac-
tion time difference could be attrib-
uted.
1360

*Reading process: Self-paced reading and
eye tracking*
   Another window into semantic process-
ing is the observation of the reading
1365   process. There are two techniques that
have been used: (i) Self-paced reading,
where subjects are presented with a text
in a word-by-word or phrase-by-phrase
fashion; the subject has control over
1370   the speed of presentation, which is re-
corded. (ii) Eye tracking, where the
reading movements of the subject are re-
corded by cameras and matched with the

text being read. While self-paced read-
1375 ing is easier to handle as a research
paradigm, it has the disadvantage that
it might not give fine-grained data, as
subjects tend to get into a rhythmical
tapping habit.

1380   Investigations of reading have been
provided many insights into semantic
processing; however, it should be kept
in mind that by their nature they only
help to investigate one particular as-
1385 pect of language use that lacks many
features of spoken language.

  For example, reading speed has been
used to determine how speakers deal with
semantic ambiguity: Do they try to re-
1390 solve it early on, which would mean that
they slow down when reading triggers of
ambiguity, or do they entertain an un-
derspecified interpretation? Frazier &
Rayner (1990) have shown that reading
1395 slows down after ambiguous words, as
e.g. in *The records were carefully*
guarded {after they were scratched / af-
ter the political takeover}, showing
evidence for an early commitment for a
1400 particular reading. However, with
polysemous words, no such slowing could
be detected; an example is *Unfortunately*
the newspaper was destroyed, {lying in
the rain / managing advertising so
1405 *poorly}.*

  The *newspaper* example is a case of co-
ercion, which shows effects for semantic
processing under the dual task paradigm

(see discussion of Piñango e.a. 2006
above). Indeed, Pickering e.a. (2006)
have shown that the aspectual coercion
cases do not result in increased reading
times; thus different kinds of tests
seem to differ in their sensitivity.

Another area for which reading behav-
ior has been investigated is the time
course of pronoun resolution: Are pro-
nouns resolved as early as possible, at
the place where they occur, or is the
semantic processor procrastinating this
decision? According to Ehrlich & Rayner
(1983), the latter is the case. They ma-
nipulated the distance between an ante-
cedent and its pronoun and showed that
distance had an effect on reading times,
but only well after the pronoun itself
was encountered.

Preferential Looking and the Visual
World Paradigm

Visual gaze and eye movement can be
used in other ways as windows to meaning
and semantic processing.

One technique to investigate language
understanding is the preferential look-
ing paradigm, a version of the picture
selection task that can be administered
to young infants. Preferential looking
has been used for the investigation of
stimulus discrimination, as infants look
at new stimuli longer than at stimuli
that they are already accustomed to. For
the investigation of semantic abilities,

so-called "Intermodal Preferential Look-
1445 ing" is used: Infants hear an expression
and are presented at the same time with
two pictures or movie scenes side by
side; they preferentially look at the
one that fits the description best.
1450 Hirsh-Pasek & Golinkoff (1996) have used
this technique to investigate the under-
standing of sentences by young children
that produce only single-word utter-
ances.
1455   A second procedure that uses eye gaze
is known as "Visual World Paradigm". The
general setup is as follows: Subjects
are presented with a scene and a sen-
tence or text, and have to judge whether
1460 the sentence is true with respect to the
scene. In order to perform this verifi-
cation, subjects have to glance at par-
ticular aspects of the scene, which
yields clues about the way how the sen-
1465 tence is verified or falsified, that is,
how it is semantically processed.
   In an early study, Eberhard e.a.
(1995) have shown that eye gaze tracks
semantic interpretation quite closely.
1470 Listeners use information on a word-by-
word basis to reduce the set of possible
visual referents to the intended one.
For example, when instructed to *Touch*
the starred yellow square, subjects were
1475 quick to look at the target in the left-
hand situation, slower in the middle
situation, and slowest in the right-hand
situation. Sedivy e.a. (1999) have shown

that there are similar effects of incre-
1480 mental interpretation even with non-
intersective adjectives, like *tall*.
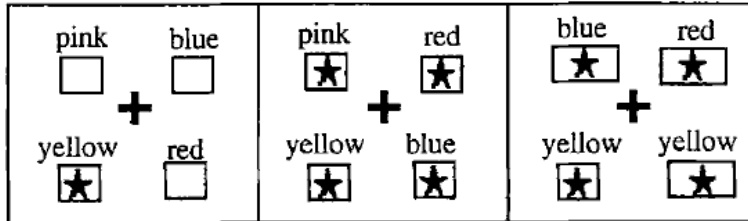
From Eberhard e.a. (1995)
1485

Altman & Kamide (1999) have shown that
eye gaze is not just cotemporaneous with
interpretation, but may jump ahead; sub-
jects listening to *The boy will eat the…*
1490 looked preferentially at the picture of
a cake than at the picture of something
non-edible. In a number of studies, in-
cluding Weber e.a. (2006), the effect of
contrastive accent has been studied.
1495 When listeners had already fixated one
object — say, the purple scissors — and
now are asked to touch *the RED scissors*
(where there is a competing red vase),
they gaze at the red scissors more
1500 quickly, presumably because the square
property is given. This effect is also
present, though weaker, without contras-
tive accent, presumably because the use
of modifying adjectives is inherently
1505 contrastive.

**Physiological effects of semantic process-
ing**

1510

There is no clear-cut way to distin-
guishing physiological effects from be-
havioral effects. With the physiological
phenomena discussed in this section it

1515 is evident that they are truly beyond
conscious control, and thus may provide
more immediate access to semantic proc-
essing.

Physiological evidence can be gained

1520 in a number of ways: From lesions of the
brain and how they affect linguistic
performance, from excitations of brain
areas during surgery, from the observ-
able metabolic processes related to

1525 brain activities, and from the electro-
magnetic brain potentials that accompany
the firing of bundles of neurons. There
are other techniques that have been used
occasionally, such as pupillary dila-

1530 tion, which correlates with cognitive
load. For example, Krüger e.a. (2001)
show with this measure that representa-
tions of event sequences following their
natural order are cognitively less de-

1535 manding than when not following the time
line.

Brain Lesions and Stimulations
Since the early discoveries of Broca

1540 and Wernicke, it has been assumed that
specific brain lesions affect the rela-
tion between expressions to meanings.

The classical picture of Broca's area
responsible for production and Wer-
1545   nicke's area responsible for comprehen-
sion is now known to be incomplete (cf.
Damasio 2004), but it is still assumed
that Broca's aphasia impedes the ability
to use complex syntactic forms to encode
1550   and also to decode meanings. From lesion
studies it became clear that areas out-
side the classical Broca/Wernicke re-
gions and the connecting area assumed by
Geschwind are relevant for language pro-
1555   duction and understanding. Brain regions
have been identified where lesions lead
to semantic dementia (also known as
anomic aphasia) that selectively affects
the recognition of names of persons,
1560   nouns for manipulable objects such as
tools, or nouns of natural objects such
as animals. These regions are typically
situated in the left temporal lobe, but
the studies reported by Damasio e.a.
1565   (2004) also indicate that regions of the
right hemisphere play an important role.

It remains unclear, however, whether
these lesions affect particular linguis-
tic abilities or more general problems
1570   with the pre-linguistic categorization
of objects. A serious problem with the
use of brain lesions as source of evi-
dence is that they are often not suffi-
ciently locally constrained as to allow
1575   for specific inferences.

Stimulation techniques allow for more
directed manipulations, and hence for

more specific testing of hypothesis.
There are deep stimulation techniques
1580 that can be applied during brain sur-
gery. There is also a new technique,
Transcranial Magnetic Stimulation (TMS),
which affects the functioning of par-
ticular brain regions by electromagnetic
1585 fields applied from outside of the
skull.

Brain Imaging of Metabolic Effects
The last decades have seen a lively
1590 development of methods that help to lo-
cate brain activity by identifying cor-
related metabolic effects. Neuronal ac-
tivity in certain brain regions stimu-
late the flow of oxygen-rich blood,
1595 which in turn can be localized by vari-
ous means. While early methods like PET
(Positron-Electron Tomography) required
the use of radioactive markers, the
method of fMRI (functional Magnetic-
1600 Resonance Imaging) is less invasive; it
is based on measuring the electromag-
netic fields of water molecules excited
by strong magnetic fields. A more recent
method, NIRS (Near Infrared Spectros-
1605 copy), applies low-frequency laser light
from outside the skull; it is currently
the least invasive technique. All the
procedures mentioned have a low temporal
resolution, as metabolic changes are
1610 slow, within the range of a second or
so. However, their spatial resolution is
quite acute, especially for fMRI using

strong magnetic fields.

Results of metabolic brain-image tech-
1615 niques often support and refine findings
derived from brain lesions (cf. Damasio
e.a. 2004). As an example of a recent
study, Tyler e.a. (2008) challenge the
view that nouns and verbs are repre-
1620 sented in different brain regions; they
rather argue that inflected nouns and
verbs and minimal noun phrases and mini-
mal verb phrases, that is, specific syn-
tactic uses of nouns and verbs, are spa-
1625 tially differentiated. An ongoing dis-
cussion is how general the findings
about localizations of brain activities
are, given the enormous plasticity of
the brain.
1630

Event-Related Potentials

This family of procedures investigates
the electromagnetic fields generated by
the cortical activity. They are observed
1635 by sensors placed on the scalp that ei-
ther track minute variations of the
electric field (EEG) or the magnetic
field (MEG). The limitations of this
technique are that only fields generated
1640 by the neocortex directly under the cra-
nium can be detected. As the neocortex
is deeply folded, this applies only to a
small part of it. Furthermore, the num-
ber of electrodes that can be applied on
1645 the scalp is limited (typically 16 to
64, sometimes up to 256), hence the spa-
tial resolution is weak even for the ac-

cessible parts of the cortex. Spatial
resolution is better for MEG, but the
1650 required techniques are considerably
more complex and expensive. On the posi-
tive side, the temporal resolution of
the technique is very high, as it does
not measure slow metabolic effects of
1655 brain activity, but the electric fields
generated by the neurons themselves
(more specifically, the action poten-
tials that cause neurotransmitter re-
lease at the synapses). EEG electrodes
1660 can record these fields if generated by
a large number of neurons in the pyrami-
dal bundles of neurons in which the cor-
tex is organized, in the magnitude of at
least 1000 neurons.

1665   ERP has been used for thirty years
in psycholinguistic research, and spe-
cifically for semantic processing since
the discovery by Kutas & Hillyard (1980)
of a specific brain potential, the N400.
1670 This is a frequently observed change in
the potential leading to higher negativ-
ity roughly 400ms after the onset of a
relevant stimulus. See Kutas e.a. (2006)
for a review of the vast literature, and
1675 Lau e.a. (2008) for a partially critical
view of standard interpretations.

The N400 effect is seen when subjects
are presented in an incremental way with
sentences like *I like my coffee with*
1680 *cream and {sugar / socks}*, and the EEG
signals of the first and the second
variant is compared. In the second vari-

ant, with a semantically incongruous
word, a negativity around 400ms after
1685   the onset of the anomalous word (here:
socks) appears when the brain potential
development is averaged over a number of
trials.
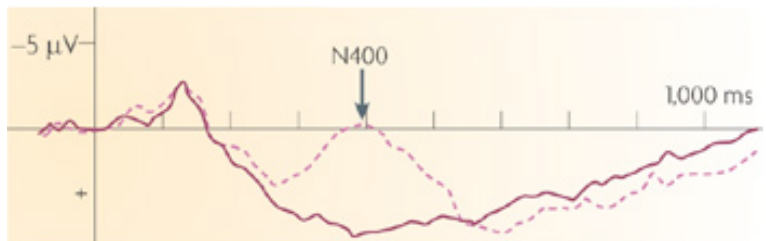
1690

    Figure: Averaged EEG over sentences
with no semantic violation (solid line)
and with semantic violation (dotted
line); vertical axis at the onset of the
1695   anomalous word. (after Lau e.a. 2008).

    There are at least two interpretations
of the N400 effect: Most researchers see
it as a reflex of the attempt to inte-
1700   grate the meaning of a subexpression
into the meaning of the larger expres-
sion, as constructed so far. With incon-
gruous words, this task is hard or even
fails, which is reflected by a stronger
1705   N400. The alternative view is that the
N400 reflects the effort of lexical ac-
cess. This is facilitated when the word
is predictable by the context, but also
when the word is frequent in general.
1710   There is evidence that highly frequent
words lead to a smaller N400 effect.
Also, N400 can be triggered by simple
word priming tasks; e.g. in *coffee* —

{*tea / chair*}, the non-primed word *chair*
1715 leads to an N400. See Lau e.a. (2008)
for consequences of the integration view
and the lexical access view of the N400.

The spatial location of the N400 is
also a matter of dispute. While Kutas
1720 e.a. (2006) claim that its origins are
in the left temporal lobe and hence can
be related to established language ar-
eas, the main electromagnetic field can
be observed rather in the centroparietal
1725 region, and often on the right hemi-
sphere. Lau e.a. (2008) discuss various
possible interpretations of these find-
ings.

There are a number of other reproduci-
1730 ble electrophysiological effects that
point at additional aspects of language
processing. In particular, Early Left
Anterior Negativity (ELAN) has been im-
plicated in phrase structure violations
1735 (150ms), Left Anterior Negativity (LAN)
appears with morphosyntactic agreement
violations (300-500ms), and P600, a
positivity after 600ms, has been seen as
evidence for difficulties of syntactic
1740 integration, perhaps as evidence for at-
tempts at syntactic restructuring. It is
being discussed how specific N400 is for
semantics; while it is triggered by phe-
nomena that are clearly related to the
1745 meaning aspects of language, it can be
also found when subjects perform certain
non-linguistic tasks, as in melody rec-
ognition. Interestingly, N400 can be

masked by syntactic inappropriateness,

1750   as Hahne & Friederici (2002) have shown. This can be explained by the plausible assumption that structures first have to make syntactic sense before semantic integration can even start to take place.

1755   There are a number of interesting specific finding around N400 or related brain potentials (cf. Kutas e.a. (2006) for an overview). Closed-class words generally trigger smaller N400 effects

1760   than open-class words, and the shape of their negativity is different as well — it is more drawn out up to about 700ms. As already mentioned, low-frequency words trigger greater N400 effects,

1765   which may be seen as a point in favor for the lexical access theory; however, we can also assume that low frequency is a general factor that impedes semantic integration. It has been observed that

1770   N400 is greater for inappropriate concrete nouns than for inappropriate abstract nouns. With auditory presentations of linguistic structures, it was surprising to learn that N400 effects

1775   can appear already before the end of the triggering word; this is evidence that word recognition and semantic integration sets in very early, after the first phonemes of a word.

1780   The larger context of an expression can modulate the N400 effect, that is, the preceding text of a sentence can determine whether a particular word fits

and is easy to integrate, or does not

1785 fit and leads to integration problems. For example, in a context in which piercing was mentioned, *earring* triggers a smaller N400 than *necklace*. This has been seen as evidence that semantic in-

1790 tegration does not differentiate between lexical access, the local syntactic fit and the more global semantic plausibil- ity; rather, all factors play a role at roughly the same time.

1795 N400 has been used as evidence for se- mantic features. For example, in the triple *The pizza was too hot to {eat / drink / kill}*, the item *drink* elicits a smaller N400 than *kill*, which can be in-

1800 terpreted as showing that the expected item *eat* and the test item *drink* have semantic features in common (ingestion), in contrast to *eat* and *kill*.

Brain potentials have also been used

1805 to investigate the semantic processing of negative polarity items (cf. article 71, *Polarity items*). Saddy e.a. (2004) and Drenhaus e.a. (2006) observe that negative polarity items in inappropriate

1810 contexts trigger an N400 effect (as in *{A / no} man was ever happy}*. With NPIs and with positive polarity items, a P600 could be observed as well, which is in- dicative for an attempt to achieve a

1815 syntactic structure in which there is a suitable licensing operator in the right syntactic configuration. Incidentally, these findings favor the semantic inte-

gration view of the N400 over the lexi-
cal access view.

There are text types that require spe-
cial efforts for semantic integration —
riddles and jokes. With jokes based on
the reinterpretation of words, it has
been found that better comprehenders of
jokes show a slightly higher N400 effect
on critical words, and a larger P600 ef-
fect for overall integration. Additional
effort for semantic integration has also
been shown for metaphorical interpreta-
tions.

A negativity around 320ms has been
identified by Fischler e.a. (1985) for
statements known to the subjects to be
false, even if they were not asked to
judge the truth value. But semantic
anomaly clearly overrides false state-
ments; as Kounious & Holcomb (1992) have
showed, in the examples like *No dogs are
{animals / fruits}*, the latter triggers
an N400 effect.

More recent experiments using MEG have
discovered a brain potential called AMF
(Anterior Midline Field) situated in the
frontal lobe, an area that is not nor-
mally implied in language understanding.
The effect shows up with coercion phe-
nomena (cf. article 25, *Mismatches and
coercion*). Coercion does not lead to an
N400 effect; there is no anomaly with
John began the book (which has to be co-
erced to *read* or *write* the book). But
Pylkkänen & McElree (2007) found an AMF

effect about 350ms after onset. This ef-
1855   fect is absent with semantically incon-
gruous words, as well with words that do
not require coercion. Interestingly, the
same brain area has been implied for the
understanding of sarcastic and ironic
1860   language in lesion studies (Shamay-
Tsoory e.a. 2005).

Corpus-linguistic Methods

Linguistic corpora, the record of past
1865   linguistic production, is a valuable
source of evidence for linguistic phe-
nomena in general, and in case of ex-
tinct languages, the only kind of source
(cf. article 124, *Corpus linguistics*).
1870   This includes the study of semantic phe-
nomena. For the case of extinct lan-
guages we would like to mention, in par-
ticular, the task of deciphering, which
consists in finding a mapping between
1875   expressions and meanings.

Linguistic corpora can provide for
evidence of meaning in many different
ways. An important philosophical re-
search tradition is hermeneutics, origi-
1880   nally the art of understanding of sacred
texts. Perhaps the most important con-
cept in the modern hermeneutic tradition
is the explication of the so-called her-
meneutic circle (cf. Gadamer 1960): The
1885   interpreter necessarily approaches the
text with a certain kind of knowledge
that is necessary for an initial under-
standing, but the understanding of the

text in a first reading will influence

1890 and deepen the understanding in subse-
quent readings.

With large corpora that are available
electronically, new statistical tech-
niques have been developed that can tap
1895 into aspects of meaning that might oth-
erwise be difficult to recognize. In
linguistic corpora, the analysis of word
co-occurrences and in particular collo-
cations can yield evidence for meaning
1900 relations between words.

For example, large corpora have been
investigated for verb-NP collocations
using the so-called Expectation Maxima-
tion (EM) algorithm (Rooth e.a. 1999).
1905 This algorithms leads to the classifica-
tion of verbs and nouns into clusters
such that verbs of class X frequently
occur with nouns of class Y. The initial
part of one such cluster, developed from
1910 the British National Corpus, looks as in
the following table. The verbs can be
characterized as verbs that involve sca-
lar changes, and the nouns as denoting
entities that can move along such
1915 scales.

	number	rate	price	cost	level	amount	sale	value	interest	demand
increase.as:s	•	•	•	•	•	•	•	•	•	•
increase.aso:o		•	•	•	•	•	•	•	•	•
fall.as:s	•	•	•	•	•	•	•	•		•
pay.aso:o	•	•	•		•	•		•	•	•
reduce.aso:o	•	•	•	•	•	•	•	•	•	•
rise.as:s	•	•	•	•	•	•	•	•		•
exceed.aso:o	•	•	•	•	•	•		•	•	•
exceed.aso:s	•	•	•	•	•	•	•	•	•	•
affect.aso:o	•	•	•	•	•	•	•	•	•	•
grow.as:s	•						•	•	•	•

From Rooth e.a. (1999): Clustering analysis of nouns and verbs; dots represent pairs that occur in the corpus. "as:s" stands for subjects of intransitive verbs, "aso:s" and "aso:o" for subjects and objects of transitive verbs, respectively.

We can also look at the frequency of particular collocations within this cluster, as illustrated in the following table for the verb *increase*.

increase 17	0.923698		
number	134.147	proportion	23.8699
demand	30.7322	size	22.8108
pressure	30.5844	rate	20.9593
temperature	25.9691	level	20.7651
cost	23.9431	price	17.9996

From Rooth e.a. (1999): Frequency of nouns occurring with *increase*.

While pure statistical approaches as Rooth (1999) are of considerable interest, most applications of large-scale corpus-based research are based on a mix between hand-coding and automated procedures. The best-known project that has

turned into an important application is
1940   WordNet (Fellbaum (ed.) 1998). A good
example for the mixed procedure is
Gildea & Juravsky (2002), a project that
attempted semi-automatic assignment of
thematic roles. In a first step, the-
1945   matic roles were hand-coded for a large
number of verbs, where a large corpus
provided for a wide variety of examples.
These initial examples, together with
the coding, were used to train an auto-
1950   matic syntactic parser, which then was
able to assign thematic roles to new in-
stances of known predicates and even to
new, unseen predicates with reasonable
accuracy.
1955   Yet another application of corpus-
linguistic methods involves parallel
corpora, collections of texts and their
translations into one or more other lan-
guages. It is presupposed that the mean-
1960   ings of the texts are reasonably similar
(but recall the problems with transla-
tions mentioned above). Refined statis-
tical methods can be used to train auto-
matic translation devices on a certain
1965   corpus, which then can be extended to
new texts that then are translated auto-
matically, a method known as example
based machine translation.
        For linguistic research, parallel cor-
1970   pora have been used in other ways as
well. If a language α marks a certain
distinction overtly and regularly,
whereas language β marks that distinc-

tion only rarely and in irregular ways,
1975 good translations pairs of texts from α
into β can be used to investigate the
ways and frequency in which the distinc-
tion in β is marked. This method is
used, for example, in von Heusinger
1980 (2002) for specificity, using Umberto
Eco's *Il nome della rosa*, and Behrens
(2005) for genericity, using Sait-
Exupéry's *Le petit prince*. The articles
in Cysouw & Wälchli (2007) discuss the
1985 potential of the technique, and its
problems, for typological research.

Conclusion

1990   This article, hopefully, has shown
that the elusive concept of meaning has
many reflexes that we can observe, and
that semantics actually stands on as
firm grounds as other disciplines of
1995 linguistics. The kinds of evidence for
semantic phenomena are very diverse, and
not always as convergent as semanticists
might wish them to be. But they provide
for a very rich and interconnected area
2000 of study that has shown considerable de-
velopment since the first edition of the
Handbook Semantics in 1991. In particu-
lar, a wide variety of experimental evi-
dence has been adduced to argue for
2005 processing of meaning. It is to be hoped
that the next edition will show an even
richer and, hopefully, more convergent
picture.

2010

References

Altmann, Gerry & Yuki Kamide (1999),
"Incremental interpretation at verbs:
2015   Restricting the domain of subsequent
reference.", *Cognition* 73, 247–264.

Berlin, B., D.E. Breedlove & P.H. Ra-
ven (1973), "General principles of clas-
sification and nomenclature in folk bi-
2020   ology", *American Anthropologist* 75, 214–
242.

Berlin, Brent & Paul Kay (1969), *Basic
color terms. Their universality and evo-
lution*, University of California Press,
2025   Berkeley.

Chafe, Wallace (ed.) (1980), The Pear
Stories: Cognitive, Cultural, and Lin-
guistic Aspects of Narrative Production,
Ablex, Norwood, N.J.
2030   Clark, Herbert H. & Peter Lucy (1975),
"Understanding what is meant from what
is said: A study in conversationally
conveyed requests", *Journal of Verbal
Learning and Verbal Behavior* 14.

2035   Crain, Stephen et al. (1998), "Quanti-
fication without quantification", Lan-
guage Acquisition 5, 83–153.

Cysouw, Michael & Bernhard Wälchli
(2007), "Parallel texts: Using transla-
2040   tional equivalents in linguistic typol-
ogy. (Theme issue).", *Sprachtypologie
und Universalienforschung* 60,

Drenhaus, Heiner et al. (2006), "Diag-

nosis and repair of negative polarity constructions in the light of symbolic resonance analysis.", *Brain and Language* 96, 255–268.

Eberhard, Kathleen et al. (1995), "Eye movement as a window into real -time spoken language comprehension in a natu-ral context", *Journal of Psycholinguis-tic Research* 24(6), 409–436.

Ehrlich, Kate & Keith Rayner (1983), "Pronoun assignment and semantic inte-gration during reading: Eye movement and immediacy of processing", *Journal of Verbal Learning and Verbal Behavior* 22, 75–87.

Fellbaum, Christiane (ed.) (1998), *WordNet: An electronic lexical database*, MIT Press, Cambridge, Mass.

Frazier, Lyn & Keith Rayner (1990), "Taking on semantic commitments: Proc-essing multiple meanings vs. multiple senses", *Journal of Memory and Language* 29, 181–200.

Frege, Gottlob (1892), "Über Sinn und Bedeutung", *Zeitschrift für Philosophie und philosophische Kritik, NF* 100, 25–50.

Gadamer, Hans Georg (1960), *Wahrheit und Methode. Grundzüge einer philoso-phischen Hermeneutig*, Tübingen.

Gärdenfors, Peter (2000), *Conceptual spaces - The geometry of thought*, The MIT Press, Cambridge, Mass., London.

Gerken, LouAnn & Michele E. Shady (1998), "The picture selection task", in

Dana McDaniel, Cecile McKdee & Helen Smith Cairns, Methods for assessing children's syntax, Cambridge, Mass, MIT Press, 125–146.

Gildea, Daniel & Daniel Jurafsky (2002), "Automatic labeling of semantic roles", *Computational Linguistics* 28, 245–288.

Goddard, Cliff (1998), *Semantic analysis. A practical introduction*, Oxford University Press, Oxford.

Goodman, Nelson (1955). Fact, Fiction, and Forecast. Cambridge, MA: Harvard UP,

Gordon, Peter (1998), "The truth-value judgment task.", in Cecil McKee & Helen Smith Carins, Methods for assessing children's syntax, Cambridge, MIT Press, 211–235.

Gregory, Robert J. (2003), "An early history of land on Tanna, Vanuatu", *The Anthropologist* 5, 67–74.

Grice, H. Paul (1975), "Logic and conversation", in Peter Cole & Jerry L. Morgan, *Syntax and Semantics 3: Speech Acts*, New York, Academic Press, 41–58.

Grice, Paul (1957), "Meaning", *The Philosophical Review* 66, 377–388.

Hahne, Anja & Angela D. Friederici (2002), "Differential task effectson semantic and syntactic processes are revealed by ERPs", *Cognitive Brain Research.* 13, 339–356.

Haviland, John B. (1974), "A last look at Cook's Guugu-Yimidhirr wordlist", *Oceania* 44, 216–232.

Hill, C. (1982), "Up/down, front/back, left/right: A contrastive study of Hausa and English", in Jürgen Weissenborn & Wolfgang Klein, Here and there: Cross-linguistic studies on deixis and demonstration, Amsterdam, Benjamins, 11-42.

Hirsh-Pasek, Kathryn & Roberta M. Golinkoff (1996), *The origin of grammar: Evidence from early language comprehension*, MIT Press, Cambridge, Mass.

Kay, Paul et al. (2008), The world color survey, Center for the Study of Language and Information, Stanford.

Kempton, William. 1981. The folk classification of ceramics. New York: Academic Press.

Kim, Christina (2008), "Processing presupposition: Verifying sentences with only", Proceedings of the 31 st Penn Linguistics Colloquium, University of Pennsylvania.

Krüger, Frank, Antje Nuthmann & Elke Van Der Meer (2001), "Pupillometric indices of the temporal order representation in semantic memory", *Zeitschrift für Psychologie* 209, 402-415.

Kutas, Marta & Steven A. Hillyard (1980), "Reading senseless sentences: Brain potentials reflect semantic incongruity", *Science* 207, 203-205.

Kutas, Marta, Cyma K. Van Petten & Robert Kluender (2006), "Psycholinguistics Electrified II (1994-2005)", in M.A. Gernsbacher & M. Traxler, *Handbook of psycholinguistics*, New York,

Eslevier,

2150   Kutas, Marta, Cyma K. Van Petten &
Robert Kluender (2006), "Psycholinguis-
tics Electrified II (1994-2005)", in
M.A. Gernsbacher & M. Traxler, *Handbook
of psycholinguistics*, New York,
2155   Eslevier.

Lakoff, George, Johnson, Mark (1980),
Metaphors we live by, University of Chi-
cago Press, Chicago.

Lau, Ellen F., Colin Phillips & David
2160   Poeppel (2008), "A cortical network for
semantics: (de)constructing the N400.",
Nature reviews neuroscience 9, 920-933.

Majid, A. et al. (2006), "The semantic
categories of cutting and breaking
2165   events: A crosslinguistic perspective.",
Cognitive Linguistics 18, 133-152.

Matthewson, Lisa (2004), "On the meth-
odology of semantic fieldwork", IJAL 70,
369-415.

2170   Noveck, Ira (2001), "When children are
more logical than adults: Experimental
investigations of scalar implicatures",
Cognition 78, 165-188.

Noveck, Ira (2004), "Pragmatic infer-
2175   ences linked to logical terms", in Ira
Noveck & Dan Sperber, *Experimental prag-
matics*, Basingstoke, Palgrave Macmillan,
301-321.

Pickering, Martin J., Brian Mcelree &
2180   Steven Frisson (2006), "Underspecifica-
tion and aspectual coercion", *Discourse
Processes* 42, 131-155.

Piñango, Maria Mercedes et al. (2006),

"Time course of semantic composition:
2185 The case of aspectual coercion", *Journal of Psycholinguistic Research* 35, 233–244.

Portner, Paul & Katsuhiko Yabushita
(1998), "The semantics and pragmatics of
2190 topic phrases", *Linguistics and Philosophy* 21, 117–157.

Potts, Christopher (2005), *The logic of conventional implicature*, Oxford University Press, Oxford.

2195 Pylkkänen, Liina & Brian McElree
(2007), "An MEG study of silent meaning", *Journal of Cognitive Neuroscience*
19, 1905–1921.

Quine, W. V. O. (1960), "Translation
2200 and meaning.", in *Word and object*, Cambridge, Mass, MIT Press, 26–79.

Rayner, Keith (1998), "Eye movements
in reading and information processing:
20 years of research.", *Psychological*
2205 *Bulletin* 124, 372–422.

Rooth, Mats et al. (1999), "Inducing a
semantically annotated lexicon via EM-
based clustering", *37th Annual Meeting
of the ACL,* 104–111.

2210 Saddy, Douglas, Heiner Drenhaus &
Stefan Frisch (2004), "Processing polarity items: Contrastive licensing costs",
Brain and Language 90, 495–502.

Sedivy, Julie C. et al. (1999),
2215 "Achieving incremental semantic interpretation through contextual representation", *Cognition* 71, 109–147.

Shamay-Tsoory, S.G., R. Tomer & J.

Aharon-Peretz (2005), "The neuroanatomi-
cal basis of understanding sarcasm and
its relationship to social cognition",
Neuropsychology 19, 288–300.

Smith, C. L. (1980). Quantifiers and
question answering in young children.
Journal of Experimental Child Psychol-
ogy, 30, 191–205.

Stalnaker, Robert (1974), "Pragmatic
presuppositions", in Milton K. Munitz &
Peter K. Unger, Semantics and Philoso-
phy, New York, New York University
Press, 197–214.

Thornton, Rosalind (1998), "Elicited
production", in Dana McDaniel, Cecil
McKee & Helen Smith Carins, *Methods for
assessing children's syntax*, Cam-
bridge,Mass, MIT Press, 77–95.

Tomasello, Michael (2008), "Why don't
apes point?", in Regine Eckardt, Gerhard
Jäger & Tonjes Veenstra, *Variation, se-
lection, development. Probing the evolu-
tionary model of language change*, Ber-
lin, Mouton de Gruyter, 375–394.

Tyler, L. K., B. Randall & E.A. Stama-
takis (2008), "Cortical differentiation
for nouns and verbs depends on grammati-
cal markers", *Journal of Cognitive Neu-
roscience* 20, 1381–1389.

van der Sandt, Rob A. (1988), *Context
and presupposition*, Croom Helm, London.

Von Heusinger, Klaus (2002), "Speci-
ficity and definiteness in sentence and
discourse structure", *Journal of Seman-
tics* 19, 245–274.

2255   Weber, Andrea, Bettina Braun & Matthew
       W. Crocker (2006), "Finding referents in
       time: Eye-tracking evidence for the role
       of contrastive accents", *Language and
       Speech* 49, 367-392.

2260