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INVESTIGATING PROCESSING FAILURE: THE CASE OF GARDEN PATH SENTENCES

Agnieszka Solska

1. INTRODUCTION

Unlike other models of utterance interpretation, the cognitively-grounded model proposed by SPERBER and WILSON (1995), known as the relevance theory, claims to offer tools which can be applied to the investigation of utterance comprehension not only at the context-sensitive pragmatic level of drawing inferences from available inputs but also at the subpragmatic level of linguistic decoding. In this paper I will report on an empirical study conducted to determine what insights the model can reveal about the nature of the cognitive processes responsible for the recovery of linguistically encoded meanings and how well it can account for the processing failure caused by linguistic rather than pragmatic factors.

2. DATA

When looking for the linguistic data that would cause the normally smooth process of linguistic decoding to be disrupted it was perhaps inevitable to settle on the so-called garden path sentences, which have long been used as test material by psychologists and psycholinguists in their attempts to gain insight into natural language processing (CHRISTIANSON et. al., 2001, FERREIRA and

HENDERSON, 1991; FRAZIER and RAYNER, 1982). Ten such sentences, listed below together with their unambiguous paraphrases, were used in the study.

- (1) *While John hunted the deer ran into the woods.*
(i.e. 'The deer ran into the woods, while John hunted'.)
- (2) *The horse raced past the barn fell.*
(i.e. 'The horse which was raced [by someone] past the barn fell [down]'.)
- (3) *I convinced her children are noisy.*
(i.e. 'I convinced her that children are noisy'.)
- (4) *Mary gave the child the dog bit a bandage.*
(i.e. 'Mary gave a bandage to the child whom the dog bit'.)
- (5) *The old man the boat.*
(i.e. 'The boat is manned by old people'.)
- (6) *Fat people eat accumulates.*
(i.e. '[The] fat [which] people eat accumulates [in their bodies]'.)
- (7) *The girl told the story cried.*
(i.e. 'The girl to whom the story was told cried'.)
- (8) *The man who whistles tunes pianos.*
(i.e. 'The man who whistles is a piano tuner'.)
- (9) *Tommy got fat spattered on his arm.*
(i.e. 'Someone spattered fat on Tommy's arm'.)
- (10) *While Anna dressed the baby sat up on the bed.*
(i.e. 'The baby sat up on the bed, while Anna dressed'.)

Despite being grammatically correct, garden path sentences entice the comprehender to consider a specific parse, hence one interpretation, only to force him to relinquish it and search for another. For instance, sentence (1) induces the reader to treat the word *hunted* as a transitive verb followed by the object noun phrase *the deer*. Such an interpretation turns out to be incorrect when he reaches the verb *ran*, which seems to lack a subject and which acts like an error signal indicating that the reader's initial assumption was mistaken. This causes the reader to backtrack and attempt to reinterpret the sentence. Only some readers will succeed in correctly reanalyzing *the deer* as the subject of the main clause preceded by a subordinate clause in which the verb *hunted* is used intransitively. As I observed elsewhere (SOLSKA, forthcoming), apart from the rare cases when the addressee does not fall into the verbal trap and correctly interprets the sentence at first pass, the stages in the on-line recovery of the linguistic meaning of a typical garden path sentence may be schematically represented in the way shown in Figure 1 below:

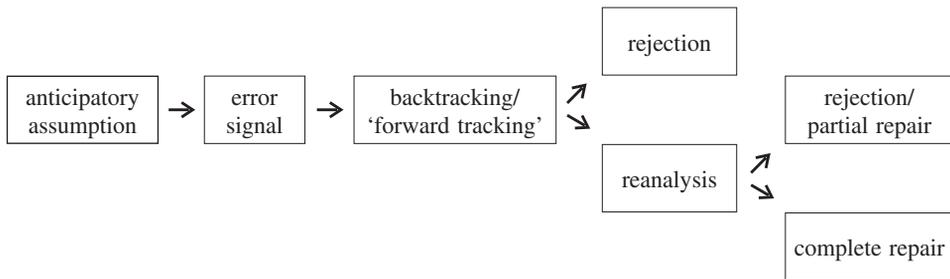


Fig. 1. Stages in the on-line recovery of the linguistic meaning of a garden path sentence

Structurally, the 10 sentences are quite diverse. Two of them, i.e. (4) and (5), are simple, the rest are complex sentences. Sentences (1) and (10) contain a fronted adverbial clause. Sentences (2) and (7) both have subjects post-modified by a non-finite passive participle relative clause. Sentences (6) and (8) both have subjects postmodified by a finite relative clause. In sentence (3) the main verb is followed by a *that*-clause complement and sentence (9) represents the so-called experiential *get* construction.

The feature which they all share and which is often held to be the reason why they are difficult to parse (PRITCHETT, 1992) is the occurrence of a local ambiguity in their grammatical structure. Such an ambiguity creates a place of indeterminacy sustaining more than one interpretation, only one of which will turn out to be viable. Thus the fronted subordinate clause in sentences (1) and in (10) creates uncertainty as to whether a noun phrase should be treated as the object of the preceding subordinate clause verb or as the subject of the main clause verb. In sentences (2) and (7) the verb directly following the subject noun phrase can be interpreted as the past tense form of the main verb of the sentence or as a passive participle in a non-finite relative clause modifying the subject. In sentence (3) it is not clear what constitutes the complement of the verb *convinced* and in sentence (4), what constitutes the object or objects of the verb *give*. In (5) the garden path effect is caused by the lexical ambiguity of 2 elements, i.e. *old*, which can be treated either as an adjective or a noun, and *man*, which can be treated either as a noun or a verb. In (8) it arises due to the possible verbal or nominal reading of the word *tunes*, and in (9) it is caused by the possible adjectival or nominal reading of the word *fat*.

3. THEORETICAL BACKGROUND

On the relevance-theoretic view, utterance interpretation is primarily a cognitive phenomenon. It is regulated by the so-called Cognitive Principle of Rele-

vance (SPERBER and WILSON, 1986/1995: 260), according to which the comprehender processing any kind of input (whether visual, auditory or linguistic) attempts to derive maximum cognitive effects while exerting the lowest possible processing effort. This basic tenet of the theory predicts that structures which require the comprehender to process again already processed information in order to revise previously taken assumptions must increase the cost of achieving cognitive effects. As a result such structures are less relevant to the individual and more likely to lead to a processing failure.

Unlike other cognitive stimuli, verbal messages are believed to be intentional and the mere fact that they have been produced is supposed to signal to the addressee that they are going to yield enough cognitive effects to be worth the effort he might put into processing them. This axiom, known as the Communicative Principle of Relevance (SPERBER and WILSON, 1986/1995: 260) determines which interpretations of an utterance are likely to be accepted or rejected by the addressees.

In the process of utterance comprehension the addressee conducts two types of mental activities, namely linguistic decoding and pragmatic inference. He decodes utterances into structured sets of encoded concepts, i.e. into logical forms, which provide input to the processes of constructing the hypotheses about the explicitly and implicitly communicated assumptions making up speaker meaning. In doing so the addressee follows a procedure of taking a path of least effort in computing cognitive effects, during which he tests hypotheses as they become available to him and stops as soon as his expectations of relevance are satisfied (WILSON and SPERBER, 2003: 13).

In the case of garden path sentences it is the automatic recovery of linguistically encoded meanings that goes awry so it is at this at this level that we need to search for the factors which hamper comprehension. The relevance-theoretic view is that, while recovering the meaning of the linguistically encoded elements, hearers gain access to information about the concepts encoded by individual words and to procedural information about how to manipulate these concepts (BLAKEMORE, 2002). More specifically, on encountering a content word, the addressee gains access to three types of information:

- the so-called lexical entry of a concept makes available information about the lexical and grammatical properties of the word that encodes the concept,
- the logical entry specifies inference rules which apply to the logical forms of which that concept is a constituent,
- the encyclopedic entry of the concept contains knowledge about the objects, events or properties that instantiate the concept, including folk and specialist assumptions, cultural beliefs and personal experiences stored in the form of propositional representations, scenarios or scripts and mental images.

When working out meanings of utterances the addressee draws from the three entries of the concepts which provide the raw material for the logical form

he is trying to construct and searches for the most accessible interpretation yielding satisfactory contextual effects. As I argued elsewhere (SOLSKA, forthcoming), the linguistically encoded concepts in garden path sentences tend to activate particularly strongly the type of information that will cause the comprehender to form wrong assumptions about the content of the utterance. This means that the garden path effect is triggered by the same mechanisms which usually lead to the effortless comprehension of verbal inputs.

4. RESEARCH DESCRIPTION

Since the aim of the study was to investigate failure to process linguist inputs, it seemed advisable to use informants who might be expected not to succeed in a comprehension task, for instance people who have achieved a relatively, though not outstandingly high command of English. The informants thus selected were 87 native speakers of Polish, aged 20—25, attending the second year of their studies either at the English Department of the University of Silesia or at the Teacher Training College in Sosnowiec. Their level of proficiency in English was comparable with the requirements for the Cambridge Advanced Examination of English.

The study was conducted on four groups of students in two phases:

- in 2006 it was administered to a group of 22 university students and to a group 26 college students who had just completed the first three semesters of their studies; both of these groups consisted of high school graduates who were the last ones to take an entrance examination to either the university or the college,
- in 2008 the study was administered to a group of 18 university students and to a group of 21 college students about to complete the fourth semester of their studies; the students in these two groups were the first high school leavers not required to take entrance examinations.

Such a choice of subjects was motivated by the assumption that students who had been required to prepare for the entrance examination would have had more practice in manipulating diverse structures of English. Another assumption was that an extra semester of studies would have made the 2008 groups more likely to recognize structures occurring in the test sentences, such as clausal complements of verbs, participles used in non-finite clauses or constructions with experiential *get*.

Each subject was presented with a list of ten sentences listed above. The sentences were not accompanied by the paraphrases making their meanings clear. However, Polish equivalents of some potentially difficult words (*deer, to*

race, barn) were provided. The written instruction read: “Decide if the following sentences are grammatically correct or not. Translate the correct sentences into Polish. Mark incorrect sentences as WRONG and, if possible, try to correct them”. Asking students to translate and to rephrase sentences was believed to yield responses clearly indicating whether each subject managed to analyse the sentence correctly. The study was administered to small sets of 10 to 20 participants, which allowed the researcher to observe the subjects and make sure they did not communicate with each other.

It turned out that relatively few subjects followed the instruction and provided the translations of what they considered to be correct sentences. In quite a few cases, paraphrases were provided even for sentences believed to be correct. Quite often a subject merely inserted a disambiguating comma in the sentences printed on the test sheet. The following responses were interpreted as evidence of processing failure on the part of the subject:

- marking a sentence as wrong,
- leaving a sentence untranslated,
- providing an incorrect translation of an entire sentence, e.g. translating (3) as *Przekonałem ją, że jej dzieci są hałaśliwe*, or translating (7) as *Dziewczynka płakała, opowiadając historię*,
- providing an incorrect translation of a sentence fragment, e.g. *Grubi ludzie* in (6) or *Tomek utył* in (9),
- rephrasing a sentence in a way which left the ambiguity unresolved, e.g. changing *hunted* to *was hunting* in (1) or changing *dressed* to *was dressing* in (10),
- inserting a comma in a wrong place e.g. after the word *deer* in sentence (1) or after the word *baby* in sentence (10),
- crossing out words in the sentences, e.g. crossing out the word *fell* in sentence (2),
- rephrasing a sentence in a way that changed its meaning, e.g. rephrasing (7) as *The girl cried when she told the story*, or rephrasing (2) as *While the horse was racing, the barn collapsed*,
- adding an unnecessary word changing the meaning of the sentence, e.g. adding a verb in (5), as in *The old man had/bought a boat*, adding a relative pronoun in (7), i.e. *The girl who told the story cried*, or adding a conjunction in (2), i.e. *The horse raced past the barn and fell*.

The following answers were interpreted as evidence that the participant succeeded in achieving a successful repair or maybe even managed to successfully interpret the sentence on the first attempt:

- providing a correct translation, e.g. translating sentence (4) as *Mary dała bandaż dziecku ugryzionemu przez psa*,
- rephrasing a sentence in a way that unambiguously brought out its meaning, e.g. rephrasing (4) as *Mary gave a bandage to the child bitten by the dog*,

- disambiguating a sentence by inserting a comma, e.g. after *hunted* in sentence (1) or after *dressed* in sentence (10),
- adding a subordinating conjunction or a relative pronoun, e.g. inserting *that* after the word *convinced* in (3) or adding either *which* or *that* after *fat* in (6),
- providing a translation with the key word given a somewhat inaccurate yet close enough sense, e.g. translating (5) as *Starzy ludzie zaludniają łódź*.

The results of the study are given in Table 1 below, with the sentences listed according to their relative degree of difficulty:

Table 1

Failures to conduct successful repairs of garden path sentences

Sentences \ Failures to repair [%]	University students 2006	College students 2006	University students 2008	College students 2008	Average for each sentence
Sentence (2) <i>The horse raced past the barn fell</i>	100.00	100.00	100.00	100.00	100.00
Sentence (5) <i>The old man the boat</i>	90.91	100.00	100.00	96.67	96.88
Sentence (7) <i>The girl told the story cried</i>	95.45	92.31	94.44	100.00	95.83
Sentence (6) <i>Fat people eat accumulates</i>	95.45	92.31	83.33	96.67	92.71
Sentence (4) <i>Mary gave the child the dog bit a bandage</i>	95.45	100.00	66.67	76.67	85.42
Sentence (10) <i>While Anna dressed the baby sat up on the bed</i>	90.91	92.31	72.22	76.67	83.33
Sentence (1) <i>While John hunted the deer ran into the woods</i>	68.18	65.38	77.78	66.67	68.75
Sentence (3) <i>I convinced her children are noisy</i>	68.18	80.77	61.11	60.00	67.71
Sentence (9) <i>Tommy got fat spattered on his arm</i>	59.09	76.92	11.11	43.33	50.00
Sentence (8) <i>The man who whistles tunes pianos</i>	13.64	61.54	16.67	63.33	42.71
Average for each group	77.73	86.15	68.33	78.00	78.23
Number of exclusively wrong responses	0	10	1	5	16

5. DISCUSSION

The following tools offered by Sperber and Wilson's framework proved particularly applicable to the interpretation or misinterpretation of garden path sentences:

- the balance of processing cost and cognitive gain,
- the presumption of relevance of verbal inputs,
- the so-called relevance-theoretic comprehension procedure,
- the nature of conceptual meanings.

5.1. THE BALANCE OF PROCESSING COST AND COGNITIVE GAIN

As could be expected, subjects found the task inordinately difficult, with the average rate of failures exceeding 78%. It might be interesting to note that in all groups participants exhibited signs of being puzzled by the sentences they were presented with. In all cases a few minutes elapsed before the participants started to write on their sheets. In each group some participants were completely unable to provide an answer. Such a result was to be expected in a situation where the prohibitively high processing cost of the linguistic material was not offset by any kind of gain except perhaps satisfaction a subject may have felt at having been able to solve a linguistic puzzle.

Predictably, a better command of English was the main factor compensating for the unusually great effort required to parse each sentence. The results achieved by students who completed an additional semester of their studies were higher by almost 10%. The difference in the contents of the syllabi followed at the college and the university can explain why results for sentence (9) differed so drastically. Causative constructions are part of the syllabus for the practical grammar at the university but not at the college. As can be seen in the table of results, university students generally scored better than college students, typically recruited from candidates not admitted to the university because their English was not good enough at the time of admissions. Moreover, as shown in the bottom line in the table, more college students returned responses with all sentences marked as wrong.

Interestingly, the two groups that participated in the test in the year 2008 achieved better results than the groups which participated in the year 2006. It would be inappropriate to draw far reaching conclusions from this fact but it might serve as an argument against a wide-spread view about falling standards brought about by abolishing entrance exams.

5.2. PRESUMPTION OF RELEVANCE

One of the tenets of the relevance theory is that part of what is communicated by verbal inputs is the guarantee of the utterance's relevance to the addressee. Such presumption of relevance might explain why participants did not abandon the frustrating task as soon as possible but kept working at it. In fact in all participating groups the subjects asked the supervisor to extend the allotted time (10 minutes).

5.3. THE NATURE OF LINGUISTICALLY ENCODED MEANINGS

On the relevance-theoretic view, the relative level of difficulty of the sentences, reflected in the differing instances of failures, would depend on the nature the meanings encoded by the specific lexical items in each sentence, i.e. on what lexical, logical and encyclopedic knowledge was made available to the participants by the concepts encoded by these items.

As shown in the table of results, sentence (2), the most often quoted example of a garden path sentence, turned out particularly confusing, thwarting everybody's attempt to parse it. Incidentally, an admittedly controversial decision was made not to accept the only response that marked the sentence as correct, namely *Koń, który gnał obok stodoły upadł* on the grounds that it treated the subject as the agent of the activity. The reason why (2) should be so hard to parse might be that the phrase *past the barn* can hardly be expected to give access to information connected with a horse-racing event at which horses do not merely race but are raced against each other. In addition, for most second year students the lexical entry of the word *race* does not contain information about its potential status as a transitive verb.

In sentence (5), the second most baffling sentence, the string *the old man* was interpreted as a verb phrase due to the fact that it can form a tenable concept corresponding to a particularly frequently occurring expression. On the other hand, the collocation *man the boat* is relatively unknown to Polish students of English.

In sentence (7), the encyclopedic entry for the verb *tell* includes information about the kind of things that can be told, such as *stories, lies, the truth* or *jokes*. The verb was indeed followed by one such word causing almost all subjects to make a justified, though wrong assumption about the girl telling the story.

In (6) the subjects encountered the string *fat people*, highly likely to form a complex concept, which led them to interpret the two words as a phrase.

In sentence (4) the garden path effect arose because the string *the child* and the string *the dog* make highly likely candidates for the kind of phrases that might function as the goal and the patient of the verb *give*.

The conceptual address for the verb *dress* in (10) contains an inference rule yielding the information 'put clothes on someone', which would invite the language user to search for the possible recipient of the action. Information about being dressed is indeed contained in the encyclopedic entry for the word *baby*, making the subjects believe that the baby was being dressed.

Similarly, the verb *hunt* in sentence (1) activates the inference 'When a person hunts he or she engages in the pursuit, capture or killing of a prey.' This is why the reader of (1) is likely to make a wrong assumption about the deer being hunted. Interestingly, sentence (1), whose syntactic structure was identical with that of sentence (10), yielded fewer incorrect responses. The possible explanation might be that for most Polish speakers of English *dressing a baby* evokes a more obvious scenario than *hunting a deer*.

The string *her children* in sentence (3) was mistakenly interpreted as the object of the verb *convinced* since it constitutes a very likely candidate for being the patient of this verb. Moreover, the feminine pronoun *she* gives access to the concept WOMAN and women having children is part of our encyclopaedic knowledge of the word.

In sentence (9) the string *got fat* was interpreted as a phrase since the collocation *get fat* has a particularly high frequency of occurrence in the English language. However, the relatively long remaining part of the sentence must have counteracted the garden path effect, which is why the ambiguity remained unresolved only in about half the cases.

Sentence (8) was understood correctly by most subjects. Those who remained unable to parse it correctly probably did so because the encyclopaedic entry for *whistle* includes information about the kind of things that can be whistled, for example, *tunes*. Moreover, for many Polish learners of English the lexical entry for word *tune* does not contain information about its possible nominal status.

To sum up, the sentences which turned out to be particularly confusing contained words whose full lexical and encyclopaedic entries were not sufficiently obvious to the subjects. Identifying the intended subcategorization frame of such verbs as *race*, *hunt* and *dress* proved especially difficult.

6. CONCLUSIONS

The study reported in this paper demonstrated the usefulness of the theoretical instruments of Sperber and Wilson's model of utterance comprehension. The theory correctly identified linguistic and cognitive factors which can hamper the correct understanding of utterances and predicted cases in which processing failure is inevitable.

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