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How Successful is the Mediation of Specialized Knowledge? – The Use of Thinking-aloud Protocols and Log Files of Reverbalization Processes as a Method in Comprehensibility Research

Abstract

Since the publication of Ericsson's and Simon's book *Protocol Analysis: Verbal Reports as Data* in 1984, thinking-aloud has found its way into the exploration of (interlingual) translation processes. To gain deeper insight into translation processes, the method of thinking-aloud has been combined with the use of the software TRANSLOG developed by Jakobsen and Schou. This software records (logs) all keystrokes and mouse clicks during writing processes as well as the time intervals between them without the user of this programme realizing this.

In my paper, I will describe how the method of thinking aloud combined with the use of TRANSLOG can be used to determine the comprehensibility of non-instructive texts. It focuses on an experiment in which five subjects were asked to optimize a popular science text using TRANSLOG. During this intralingual translation process, the subjects had to think aloud. The paper will focus on the method I used and present what it reveals about the comprehensibility of the popular science text.

1. The challenge: Measuring how successfully knowledge is mediated in non-instructive texts

Whereas reliable results on how successfully knowledge is mediated in instructive texts can be obtained by usability testing (cf. Rubin 1994), the comprehensibility of non-instructive texts is hard to analyze. Methods such as the use of readability formulas take into account only aspects of what makes a text comprehensible or incomprehensible. The employment of my Karlsruhe comprehensibility concept (Göpferich 2001, 2002, ^{2}2006), which represents an extended and improved ver-

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sion of the comprehensibility concepts by the Hamburg group of psychologists Langer, Schulz von Thun & Tausch ([5]1993) and by Groeben (1982), has proved a reliable instrument in pre-optimizing non-instructive texts (cf. Göpferich [2]2006: 154–188), but cannot replace target-group-centered empirical research into text comprehensibility. Methods employed so far in this type of comprehensibility research are cloze procedures, questions on the texts whose comprehensibility is to be determined, and reproductions of such texts. These methods have the disadvantage, however, that they measure either only aspects of the texts' comprehensibility (e. g., the predictability of words and phrases that fill gaps, the comprehensibility of words or passages relevant for answering the questions asked) or merely their rough overall comprehensibility. Furthermore, some of these methods lead to a confusion of the concepts of comprehensibility and retainability (cf. the research summary in Göpferich [2]2006: chapter 4).

In this paper, I will present a target-group-centered empirical method for determining the comprehensibility of texts which takes into account every detail of the texts to be analyzed, which is independent of the texts' retainability, and which does not only allow the researcher to detect where the texts are incomprehensible, but also where they are hard to understand and where they give rise to misunderstandings or a demand for further information which is not given in the texts. I call this method *optimizing reverbalization using thinking aloud and log files*.

Since the publication of Ericsson's and Simon's book *Protocol Analysis: Verbal Reports as Data* in 1984 (Ericsson/Simon [2]1999), thinking aloud has found its way into the exploration of writing processes (cf. recently Schindler 2004) and (interlingual) translation processes (cf. the special edition of *Meta* edited by Lee-Jahnke 2005). To gain deeper insight into these processes, the method of thinking aloud has been combined with the use of the software TRANSLOG developed by Jakobsen and Schou (1999). This software records (logs) all keystrokes and mouse clicks during writing processes as well as the time intervals between them without the user of this software realizing this.

I have adopted the thinking-aloud method combined with the use of TRANSLOG to investigate the comprehensibility of a popular science text on diabetes. For this purpose, five subjects, which belong to the target group of the text, were given the text and asked to optimize it us-

ing TRANSLOG. This process can be considered a type of intralingual translation. During this intralingual translation process, the subjects had to think aloud.

In my paper, I will give a detailed description of the methods employed and present what they reveal about the comprehensibility of the diabetes text. The methods can also be used to investigate the subjects' maxims and strategies in making the text more comprehensible, i. e., their writing and optimizing strategies.[1] Although I will make a few remarks on the latter, too, the focus of this paper will be on the comprehensibility of the popular science text (for results on the subjects' maxims and strategies cf. Göpferich forthcoming).

2. The methods employed

Five subjects, who belong to the target group of the popular-science text on diabetes reproduced in Appendix A, were asked to reverbalize this text in TRANSLOG in such a way that the result was optimally comprehensible for its target group. The target group is specified as follows on the website where the text to be optimized appears: "These contributions provide basic information on diabetes mellitus for which no prior knowledge is required." (Deutsches Diabetes-Zentrum 2004; my transl.). During the experiment, the subjects had to think aloud ("level 1 verbalizations" according to Ericsson and Simon 1999: 79).

2.1. The subjects

All subjects were female and either students in the degree programme "Translation and Interpreting" at the Department of Translation Studies of the University of Graz, had graduated from this programme, or were lecturers there. Their mother tongue was German; four of them were Austrians and one (YG) came from Switzerland. A short description of the subjects' educational and professional background is given in Ta-

1 By *maxims* I mean goals of action the subjects strive for at a specific point in the optimization process. The term *strategy* is used in the sense of Faerch/Kasper (1983: 36), who define strategies as "potentially conscious plans for solving what to an individual presents itself as a problem in reaching a particular communicative goal". This definition is also adopted by Krings (1986: 175). Thus *maxims* are targets, *strategies*, potentially conscious paths which are believed to lead to these targets.

ble 1. Table 2 provides information on their physical and psychological condition during the experiment as described by themselves.

Table 1: The subjects' educational and professional background

Subject	Age (years)	Academic degree/ profession	Foreign languages and proficiency (self-estimation: A = excellent down to E = poor)	Additional training/ experience	Proficiency as a student (self-estimation)
JS	25	student 2nd year	English (A) Italian (A) Spanish (C) French (E) Russian (E)	Dropped out of programme in translation and interpreting; new start with different language combination 20 pages of translations; 40 hours of interpreting	excellent – good
EK	25	student 6th year	French (A) Hungarian (B) English (C)	30 pages of translations; 10 days of interpreting	excellent – good
NL	25	student 7th year	English (A) Russian (B) French (D) Latin (D) Italian (E)	4 pages of translations; 5 days of interpreting	excellent – good
YG	26	Mag. phil. (Master) employed in third-party funded research project (for 6 months)	English (A) Russian (B)	8 months student assistant 20 pages of translations per year	excellent – good
SF	58	Mag. phil. (Master) university lecturer (for 20 years)	English (A) French (B) Italian (E)	4 years secretary; 30 years of translation and interpreting	no answer

Table 2: Physical and psychological condition of the subjects during the experiment (1 = applies very much, 2 = applies to some degree, 3 = applies not at all)

Subject	Fully concentrated	Under time pressure	Nervous	Relaxed	Stressed	Tired, exhausted	Enjoying the job	Comments
JS	1	3	3	1	3	1	1	—
EK	2	2	3	2	3	2	1	Suffering from a bit of a headache; under time pressure during the retrospective interview.
NL	1	3	3	2	3	3	1	—
YG	1	3	2	2	3	3	1	—
SF	1	3	3	1	3	3	1	—

Although all subjects belong to the target group of the text to be analyzed, they are not representative of this target group. As can be seen from Table 1, their education and training is certainly above that of the average reader. This means that whatever is incomprehensible for them can also be regarded as incomprehensible for the intended readership in general. Since the subjects were asked to optimize the text for the intended readership (and not only for themselves), they may have optimized sections of the text that they have found comprehensible for themselves but considered incomprehensible for people with lower education. Their judgement on such elements of the text must be considered to be speculative. To reduce subjectivity, I have taken into account how many of the five subjects judged elements of the text to be optimized incomprehensible or hard to understand. We must not forget, however, that people with a lower educational standard might find additional things incomprehensible that were not criticized or optimized in the experiment.

Selecting subjects with higher education and with at least some experience in translation has the advantage that their meta-linguistic and meta-communicative competence allows them to give a more detailed

and precise description of their comprehension problems and optimizing maxims and strategies than persons with no education and training in this field. Thus, their meta-linguistic and meta-communicative competence makes their thinking-aloud protocols more illuminating. Although what these subjects' thinking-aloud protocols reveal about text comprehension may not be representative of the entire target group, it can at least provide questions, which can be used to find out how well subjects with lower educational standards have understood certain passages of the text.

2.2. The assignment

Each subject had to reverbalize the text in Appendix A in such a way that it would be tailored to the requirements of its intended readership. Passages that the subjects considered perfect could be copied into the target version. Prior to the actual experiment a trial run with a different text was carried out to acquaint the subjects with the functionality of TRANSLOG (editing functions and TRANSLOG dictionary). Only after all the questions on the software and the test setting had been answered was the actual experiment begun. The assignment was explained to the subjects by the supervisor and also handed out to them in writing (cf. Appendix B). The dictionary entries provided with the source text in TRANSLOG are reproduced in Appendix C. No other material could be used during the experiment.

During the experiment, each subject was sitting in a quiet room[2] together with a supervisor. The subjects wore headsets; their verbalizations were recorded with the freeware AUDACITY and exported in MP3 format. The recordings were transcribed according to the GAT conventions for basic transcripts (Stelting et al. 1998) and then proofread by at least one other person. The complete transcripts of all five subjects can be downloaded as a PDF file from Göpferich (2005). During the experiment the subjects were not put under time pressure (cf. Table 2). They were informed that what was analyzed in the experiment was not their competence but the comprehensibility of the diabetes text. After the optimization process, the subjects were asked whether they had any questions for a diabetes specialist which had cropped up during

2 Any disturbances which occurred during the experiment are transcribed in the protocols (cf. Göpferich 2005).

the experiment and which they could not answer using the information in the text and the TRANSLOG dictionary. These retrospective interviews were recorded and transcribed too. They can be found at the end of each of the transcripts in Göpferich (2005).

2.3. The data

Apart from the information given in Table 1 and Table 2, the experiment provided the following data:

1. the optimized versions of the diabetes text,
2. the log files,
3. the thinking-aloud protocols (TAPs) as well as the protocols of the retrospective interviews (RIPs; cf. Göpferich 2005).

2.4. Data analysis

The data were analyzed as follows:

1. Each subject's version was compared to the original text. Passages in which changes had been made were numbered and juxtaposed to their original version in a table. For each change the comprehensibility dimension in which this change occurred according to the Karlsruhe comprehensibility concept[3] (Göpferich 2001; 2002; [2]2006) was determined as was whether the change really improved the text, made it worse, or represented neither an improvement nor a deterioration.
2. The TAPs were analyzed for comments on why the changes had been made as well as on the maxims the subjects had and the strategies they used in optimizing the text.
3. The TAPs were analyzed for further comments on the quality of the original text which did not result in changes in their optimized versions.
4. The questions which the subjects had on the text, which they could not answer using the material available to them (i. e., the text to be

3 These comprehensibility dimensions are: simplicity, structure, perceptibility, concision, motivation, and correctness.

optimized itself and the TRANSLOG dictionary), and which they therefore would have liked to ask a specialist were collected. If we start from the assumption that an optimally comprehensible text does not give rise to questions in the reader's mind that it does not answer, these remaining questions are additional reliable indicators of deficiencies with regard to comprehensibility. This also applies to dictionary look-ups.

5. For each element of the original text that had been subject to criticism or questions in the experiment, I determined how many subjects had criticized it or had questions on it (cf. Table 3 in section 4). The more subjects commented on it, the higher the probability that it may really lead to comprehension problems.

6. An optimized version was written in which the criticism of all subjects was taken into account and which answers the questions they had. In this optimized version, only real improvements suggested by the subjects were considered. If a subject formulated a maxim for a specific section of the text without providing a solution fulfilling this maxim, I tried to provide such a solution by myself. Deteriorations and 'cosmetic' changes were ignored. Linguistic mistakes made in the source text or by the subjects were corrected in the optimized version (cf. Appendix A).

7. The subjects' maxims and strategies were analyzed and classified. For each subject the repertoire of maxims she had and strategies she used were determined. From these results, conclusions for text production didactics can be drawn. The subjects' maxims and strategies, however, are beyond the scope of this paper. I will mention some of them here; a detailed analysis of them will be provided in Göpferich (forthcoming).

3. Results

In the following, I will give a survey of all the elements of the original text that either one or more subjects in the experiment considered hard to understand or incomprehensible as well as of the questions the text gave rise to in the subjects' mind without providing an answer. For each element, extracts from the TAPs and/or RIPs will be quoted which show that the subject(s) found it difficult and, if applicable, what

maxims and strategies they followed to improve the corresponding passage. A distinction is made between a) completely incomprehensible elements of the source text and passages giving rise to questions that are not answered in the text and b) passages which are simply hard to understand.

3.1. Incomprehensible elements and missing information

1. The text says that a distinction is made between *two* types of diabetes, but then *three* types are introduced: type 1 diabetes, type 2 diabetes, and gestational diabetes. This makes four of the five subjects wonder whether gestational diabetes is a variant of type 2 diabetes (cf. TAP YG 29–30) or a type of its own. Thinking aloud, YG says,

   ```
   wenn i jetzt wüsst, (-) ob (.) der (.) schwangerschaftsdiabetes, (.) ob de::s jetzt (.) typ drei isch ((tippt öfters auf die Tastatur ohne zu schreiben)) odersch, (--) typ=zwei (-) <<sich selbst beim Tippen diktierend> werden generell, im allgemeinen> (-) woteva (--) <<sich selbst beim Tippen diktierend> im allgemeinen zwei typen unterschieden> (TAP YG 82-88).
   ```

   She solves the problem by adding “im Allgemeinen” (*In general*, a distinction between two types of diabetes is made.) and referring to gestational diabetes as a “Spezialfall”, a special type of diabetes. The log file reveals that she first puts down “zwei Typen” (two types of diabetes), then changes this into three types, and uses “zwei Typen” again in her final version. In the retrospective interview (RIP YG 476–482), she says that she would like to ask a specialist about this because she is still not sure which one is the correct version.

   To my mind, the real problem in the text here is that the author informs us about what happens in the bodies of patients with type 1 diabetes and type 2 diabetes, but not about what happens in the bodies of women with gestational diabetes. If this information were given, it would be clear that gestational diabetes is neither a variant of type 1 nor of type 2. In contrast to type 1 diabetes, which occurs when the body produces too little or no insulin, and type 2 diabetes, which occurs when the body cannot use the insulin it

produces, gestational diabetes is caused when pregnancy hormones and hormones produced by the placenta lead to such an increase in the blood glucose level that the pregnant woman's pancreas can no longer compensate for this by an increased insulin production. Adding this information together with the coherence increasing elements *in general (im Allgemeinen)* and *a special type of diabetes (ein Spezialfall der Zuckerkrankheit)* eliminates this incomprehensibility.

2. Some of the subjects do not know the (exact) meanings of the following terms used in the text without explanations: *chronisch* (TAP SF 74–78; TAP EK 26–29), *Insulin* (TAP SF 261–289; TAP EK 224–232), *Inselzellen* (cf. TAP YG 159–161; TAP NL 129–134; TAP JS 84–106 and 177–185; TAP EK 66–67 and 265–268), *T-Lymphozyten* (cf. TAP JS 267–283 and 652–655), *Gestation* (cf. RIP SF 534–540; TAP YG 133–134; TAP EK 329–331), *Glukose* (cf. TAP SF 303–312; TAP YG 200–206; TAP NL 232–233 and 243–246; TAP EK 135–162), and *Körperzellen* (cf. TAP JS 312–320). To solve this problem, these terms must either be left away or explained. They should be retained and explained if they are used in doctor-patient conversations (cf. e. g. TAP NL 98–101), but can be deleted if this is rather unlikely and they are not needed again in the text (cf. RIP JS 609–616).

3. For YG the last sentence in the text „Dabei ist jedoch das Risiko für die spätere Entwicklung eines Typ 2 oder Typ 1 Diabetes [sic] stark erhöht." (In this case, there is a considerably higher risk of developing a type 2 or type 1 diabetes afterwards.) gives rise to the question whether this refers to the mother or the child: `"beim kind oder bei der mutter?"` (TAP YG 34). That it refers to the mother can easily be made more explicit here.

4. For JS (cf. TAP JS 493–516) the original text does not make clear whether type 1 diabetes is caused only by a combination of all three factors mentioned in the text (i. e., first, genetic predisposition, second, influences from outside such as certain virus infections, and third, a disorder of the immune system) or whether it may be caused by one or two of these factors alone.

Although the combination of all three factors seems more plausible to her, she combines the factors by *or* in her optimized version, which shows that she is still not sure. Since the factors that cause the disease are an important information for the patient, the text must be made more explicit here.

3.2. What makes the text hard to understand

1. Since *Diabetes mellitus* is a specialized term for which there is the more general and thus comprehensible expression *Zuckerkrankheit* in German, YG, SF, and EK feel that this more comprehensible designation should be added already in the title of the article (cf. TAP SF 41–44, cf. also TAP YG 40–44). This makes sure that the reader knows what the text is about from the beginning.

2. SF feels that the semantic relation between the general designation *Zuckerkrankheit* and its scientific synonym *Diabetes mellitus* might not become clear if the latter is simply put in parentheses without additional explanations, and therefore should be made explicit:

   ```
   <<sich selbst beim Tippen diktierend> krankheit, in
   der folge diabetes mellitus>, eigentlich das brauch ma
   (--) gor nix so wer ma des machen, (---) in der folge,
   nein das is keine gute idee (--) zuckerkrank (.) heit,
   des kommt a mal weg, (-) diabetes mellitus, (.) jawoll,
   na mach ma schon so, in der folge diabetes mellitus.
   (4.0) <<zustimmend> mhm> (---) nein, das müsst man auch
   besser erklären, weil ich weiß das ja was das is, aber
   jemand der nicht latein und nicht griechisch kann weiß
   das nicht, (.) in der folge (--) der ha lateinischen
   oder griechischen Bezeichnung ( ) wahrscheinlich, nein
   wissenschaftlichen <<sich selbst beim Tippen diktierend>
   wissenschaftlichen bezeichnung so, diabetes mellitus,>
   (TAP SF 55– 67)
   ```

   She follows this maxim also when introducing other alternative designations such as *juvenil*, *T-Lymphozyten*, *Alterszucker*, and *Gestationsdiabetes* (cf. TAP SF 167–169, 219–223, 381–384, 432–437). EK does not comment on this, but she too makes the relation between *Diabetes mellitus* and *Zuckerkrankheit* explicit (“Diabetes mellitus ist der Fachausdruck für Zuckerkrankheit”).

3. YG wonders about the term *Definition* in the title because to her mind the text provides more information on diabetes mellitus than just a definition (cf. TAP YG 344–349), so that the term does not fit. Furthermore, one may object that the term *Definition* is a hard word for many readers, which is a second reason for taking it out. (In spite of her objections, YG takes the term over in her final version.) EK deletes the term *Definition* in her title, but does not comment on this.

4. The subjects YG and NL wonder whether "ist gekennzeichnet durch" is the correct expression in the definition of diabetes mellitus or could be replaced by a simpler verb. Both of them feel that the latter is the case (cf. TAP NL 44–82; TAP YG 568–632).

5. For YG the first sentence does not make clear whether the participle construction "verbunden mit dem Risiko für schwere Begleit- und Folgeerkrankungen" (combined with the risk for serious other diseases which accompany or follow it) describes necessary features of the term *diabetes mellitus* and thus forms part of its definition, or gives just additional information. Thinking aloud, she comments on this:

   <<sich selbst beim Tippen diktierend> erhöhung des blutzuckers, (.) verbunden mit dem risiko> (2.0) MO: MENT (3.0) oke=verbunden mit dem risiko des interess: iert mich hier eigentli net wirklich (5.0) verbunden mit dem risiko (3.0) aber die zuckerkrankheit is:t eigentlich nur eine chronische erhöhung des blutzuckers; (---) UND wenn ma erhöhtn blutzucker::, (.) wenn sich der erhöht (.) dann:: .hh können schwere beglEIT und FOLgeerkrankungen (--) FOLgen (TAP YG 45-52).

   In the retrospective interview, she comes back to this comprehension problem saying,

   beim erstn satz hab i mi a bissl gwundert, (--) weil <<den Ausgangstext lesend> zuckerkrankheit (.) ist gekennzeichnet durch chronische erhöhung des blutzuckers verbunden mit dem RIsiko.> (--) is eigentlich (--) a:: (-) <<all> ahso> .h sog ma so- (.) i persönlich versteh des anders. für mi is zucker; zuckerkrankheit

chronische erhöhung des blutzuckers (-) und danach (---) also (.) beziehungsweise (.) durch die erhöhung (--) kommen begleit- und folgeerkrankungen. aber es is net (3.0) zuckerkrankheit is net (2.5) gleich (-) begleit- (.) und folgeerkrankungen. (RIP YG 568-578)

The information in the participle construction does not form part of the definition, which should be made clear in the optimized version.

6. Four of the five subjects (SF, YG, NL, EK) are amazed that the term *Zuckerspiegel* (sugar level) is used in the plural; they have only heard of *der Zuckerspiegel* in the singular and wonder whether there are several sugar levels (cf. TAP YG 220–223; cf. also TAP SF 320–329). In fact, there is only *one* blood sugar level, so that the plural is wrong and must be changed into a singular. Even if there were several blood sugar levels, using the singular would be the option to be preferred in this context because a distinction between different sugar levels is not necessary in the text and wondering about the plural requires memory capacity which will then not be available for processing the central information on diabetes. If a differentiation were relevant, the plural should be introduced explicitly so that the reader need not wonder about it. YG opts for the plural because, as she says in the retrospective interview (RIP YG 498–507), the author of the text is an expert and should know what he is talking about. This is also the reason why SF uses the plural (cf. TAP SF 326–329). NL and EK prefer to use the more common singular (cf. TAP NL 264–268; TAP EK 209–210).

7. In the original version, information which belongs closely together such as a) the different designations of each type of diabetes, b) the age when type 2 diabetes occurs, c) the beginning and the end of gestational diabetes, and d) the first mentioning of the destruction of the insulin producing cells and the detailed explanation of how they are destroyed and why are given at different places in the text. YG brings some of them together (a and c), however, without commenting on it in her TAP (‘information clustering maxim’). EK brings the information under a) together (TAP EK 69–71). NL explicitly states that she wants to bring the information when type 2 diabetes occurs together (cf. TAP NL 345–354). SJ comments on d) saying,

```
<<sich selbst beim Tippen diktierend> beruht .hh auf
einem (.) mangel an insu .hhh hh (--) infolge (-) einer
zerstörung> .hhh hh (2.0) der sogenannten bet (2.0) ah
das klingt glaub i komisch, wenn das da hinten so (.)
.h der insulin produzierenden zellen (2.0) .hh ja aber
wodurch werden die zerstört? (2.0) <<den Ausgangstext
lesend> diese zellen gehören zur bauchspeicheldrüse und
sind ein bestimmter typ der sogenannten inselzellen. am
höchsten ist die neuerkrankungsrate bei kindern,> (2.0)
ah=so (.) do unten steht des erst (.) ha? (TAP JS 58-
68)
```

This comment, too, shows that information belonging closely together should be provided together.

8. Without mentioning this explicitly, YG seems to follow a parallelism maxim. This can be seen in her optimized version, where she tries to structure the sections on the three types of diabetes in parallel (age groups and designations, disease itself, causes, effects).[4] NL follows the parallelism maxim explicitly stating twice that she wants to structure the information on type 2 diabetes in the same way as that on type 1 diabetes (cf. TAP NL 318–323 and 332–341, cf. also 381–382).

   Parallelism has been propagated by stylistics for a long time. For the reader, it increases the predictability of what comes next in a text and therefore is important for text comprehensibility.

9. In the original text, *Beta-Zellen* (beta cells) is introduced as the specialized term for *Insulin produzierende Zellen* (insulin producing cells). YG decides not to eliminate this alternative designation from the text because it might be used in doctor-patient conversations (cf. TAP YG 152–156), but she introduces it only once and then – in contrast to the author of the original text – goes on using the more telling expression *Insulin produzierende Zellen*, which I consider a good decision.

10. Several of the subjects (SF, YG, NL) wonder about the noun *Untergang* (decline). YG laughs when she reads it (TAP YG e. g. 186–

4 If certain types of information are not given in the original text, she cannot provide this information in her optimized version, of course.

187); SF says: "sagt man wirklich den untergang?" (TAP SF 244–245), "untergang gefällt mir überhaupt nicht" (TAP SF 254). NL comments:

> in folge davon kommt es zu einem unter <<f> untergang der insulin produzierenden zellen> (3.5) also des kann i ma a net gut vorstellen (.) untergang der (---) zellen (3.0) da hab ich gleich diese assoziation dass (.) diese zellen ausschauen wie schiffe und irgendwie attakiert werden und dann .hh sinken; und untergehen. was kann damit gemeint sein?=is da irgendwas im wörterbuch? ((schlägt im Wörterbuch nach)) natürlich nicht. (TAP NL 174-182)

This unintentional foregrounding of linguistic elements takes away memory capacity necessary for processing the content on diabetes and therefore should be avoided and, as NL's TAP shows, be replaced by a semantically more precise formulation. NL says,

> also untergang des klingt für mich komisch. das führt zu einem verlust an, .h dadurch werden die insulin produzierenden zellen (2.0) geschädigt, oder beschädigt, oder werden sie wirklich zerstört? .hh das würd ich jetz gern noch an fachmann fragen (-) was dann wirklich mit diesen zellen passiert. (3.5) ob einfach die anzahl reduziert wird, oder ob sie beschädigt und daher funktionsunfähig sin, (---) oder ob sie wirklich völlig zerstört werden. das müsste man noch mal fragen. (TAP NL 195-203)

11. The original text says that type 2 diabetes, also called *Altersdiabetes (old-age diabetes)*, occurs after age 40 in most cases, which is the reason for its designation. In recent years, however, people have been affected by this type of diabetes at an ever earlier age. For YG age 40 is not really old: "<<len> vierzge isch jo (.) no net (.) speziell: (-) alt.>" (TAP YG 404–405). Therefore she feels that the designation is not motivated semantically and wonders whether type 2 diabetes occurred later than age 40 in the past and the age has gone down to 40 only in recent times (cf. TAP YG 252–260). Since YG is the only of the five subjects who had

this problem, this is not taken into account in the optimized version.

12. The expression “nach Beendigung der Schwangerschaft” causes YG to laugh when she first reads it (cf. TAP YG 32); later on she reads it with a disgusted undertone (TAP YG 429–446). She does not comment, however, on what is wrong with it. NL comments on it explicitly:

    beendigung des klingt mir aber viel zu aktiv (--) natürlich die geburt is das logische ende der schwangerschaft aber (.) einfach so beendigen? beenden kamma schwangerschaft ja, das ende der schwangerschaft. (4.0) <<sich selbst beim Tippen diktierend> in der regel verschwindet diese form des diabetes (2.5)> nach beendigung nein, (.) nach ende ((tippt)) (4.0) oder einfach nach der schwangerschaft (1.5) oder nach der geburt (10.0) nja ende der schwangerschaft kann auch a tragischeres (-) resultat sein als geburt (--) wemma des kind verliert (5.0) also kamma nicht einfach (.) also wär das vielleicht nicht ganz eindeutig (.) das was damit gemeint is wenn ich geburt schreibe (6.5) <<den optimierten Text lesend> in der regel verschwindet diese form des diabetes> (-) nach ende der schwangerschaft (-) oder nach der schwangerschaft (5.0) oder eben nach der geburt aber des is (-) nicht ganz optimal. (3.0) [...] diese form des (2.0) diabetes .h verschwi:ndet ((klickt)) in der (2.0) in der regel (.) nach ende (1.5) nja schreib ma nach ende der schwangerschaft ((tippt)) (.) <<sich selbst beim Tippen diktierend> ( )ngerschaft> schwangerschaft, (1.5) hh oder mit dem ende der schwangerschaft (--) nein, verschwindet in der regel nach ende der schwangerschaft, (TAP NL 414-443)

    Her criticism is justified because the German verb *beenden* possesses the semantic features <controlled by one’s will>, <intentionally>, which may lead to the wrong interpretation that the author does not (also) refer to the end of a pregnancy marked by the birth of the child but only to an end caused by abortion. Both ends are meant. To make this clear a more general formulation is needed such as *nach der Schwangerschaft* (after the pregnancy).

13. The author of the original text has a strong tendency to use nominal style, which the subjects seem to find hard to understand. They transform several nominal formulations into verbal ones: „chronische Erhöhung des Blutzuckers“ (NL), „Neuerkrankungsrate“ (YG), „Untergang der insulinproduzierenden Zellen“ (SF, YG, NL, EK), „das Ansprechen der Körperzellen auf Insulin“ (SF, NL, EK), „das Alter beim Auftreten des Diabetes“ (SF, YG), and „das Risiko für die spätere Entwicklung eines Typ 2 oder Typ 1 Diabetes [sic]“ (YG, NL, EK). SF transforms „infolge einer Zerstörung der insulinproduzierenden Zellen“ into verbal style saying,

    <<den Ausgangstext lesend> infolge einer zerstörung der insulin produzierenden zellen> ich würde des auflösen mit einem nebensatz. (TAP EF 107-9)

    SF and NL also feel that „Neuerkrankungsrate“ is a hard word for somebody who does not know it and also try to transform it into a verbal expression, but do not succeed (cf. e. g. NL TAP 140–149). SF therefore decides to split it up into “Rate von Neuerkrankungen” (cf. TAP SF 143–153).

    SF and NL explicitly mention their avoid-nominal-style strategy, saying,

    ein vermindertes ansprechen auf körperzellen das müsst ich sicherlich auch anders auflösen weil das is vielleicht doch ein bisschen zu schwierig zu verstehn (.) .hhh (4.0) beim typ zwei diabetes (3.0) .h würd ich nicht (.) nominalisieren sondern vielleicht (.) eher verbalisieren (TAP SF 345-350)

    na ma könnt nominalstil noch auflösen (TAP NL 452-453)

14. SF and NL feel that the original text does not make clear that the sentence following the expression “Fehlsteuerung des Immunsystems” explains what is meant by it. Thinking aloud, SF says,

    <<sich selbst beim Tippen diktierend> fehlsteuerung des immunsystems> (21.0) .hhh <<ff>> das passt mir nicht.> <<den optimierten Text lesend> <<pp>> als ursache des typ eins diabetes sieht heute die wissenschaft das zusammenwirken (3.0) des immunsystems> (.) doch (.) punkt. (9.0) hm immunsystems (.) <<den Ausgangstext

lesend> bestimmte weiße blutkörperchen richten sich speziell gegen die betazellen> (5.0) .hh das würd ich auf jeden fall noch amal wiederholen (--) immunsystems, ich werde da hier auch einen doppelpunkt machen damit man weiß das hängt damit zusammen (TAP SF 209-219)

Text coherence should be improved here. Both SF and NL use the strategy of inserting coherence increasing elements (e. g., a colon after "Fehlsteuerung" in the case of SF and *dabei* in the case of NL) in other places also (cf. TAP SF 296–298, 323–324; TAP NL 182–189).

NL also feels that the logical relation between the two sentences "Die Zuckerspiegel im Blut steigen an" (The sugar levels in the blood increase) and "der Körper muss als Energiequelle sein Fettgewebe aufzehren" (the body must fall back on its fatty tissues as a source of power) does not become clear. Thinking aloud, she says,

das versteh ich jetz nicht ganz <<den Ausgangstext lesend> ohne insulin kann jedoch glukose nicht mehr aus dem blut in die körperzellen (1.5) aufgenommen (--) und verwertet werden. die blutzuckerspiegel im (2.5) die zuckerspiegel im blut steigen an (.) und der körper muss als energiequelle> (5.0) ach so hh anstatt dass die energie aus dem blut gewonnen wird, (4.0) muss der körper sein fettgewebe aufzehren. (TAP NL 233-240; cf. also TAP NL 269-314).

She solves the problem by making explicit that the body cannot use the glucose in the increased blood sugar level and therefore has to fall back on its fatty tissue (and protein reserves, which is not mentioned in the original text) *instead*, which, to my mind, is an excellent solution.

15. For EK the explanation of type 2 diabetes is not clear. She wonders "was bedeutet ein vermindertes ansprechen"? (TAP EK 307). In the retrospective interview she wants to ask an expert about this:

unter der frage was versteht man unter dem .h typ zwei diabetes genau und wodurch wird er hervorgerufen ist jetzt als vage; also das müsst ma noch einen experten

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fragen und (--) .hh klären; hh was genau der typ zwei
diabetes ist. (RIP EK 470-474)
```

16. NL wonders why type 1 and type 2 diabetes are not mentioned in the usual order in the last sentence:

```
<<sich selbst beim Tippen diktierend> dIabetes (---)
typ> (--) warum is des (1.5) zuerst des typ zwei und dann
des typ eins (2.0) warum steht da des (.) zuerst? (3.0)
na ja wahrscheinlich weil (-) sobald eine frau im (1.5)
gebärfähigen alter is, ist es wahrscheinlicher dass sie
erst später an diesem altersdiabetes erkrankt (6.0)
größer (4.0) ah, trotzdem find ichs irgendwie seltsam
zuerst zwei und dann eins zu schreiben (4.0) ((tippt))
(4.0) ((tippt)) so. (2.0) ah (-) das risiko später an
typ eins oder zwei diabetes zu erkrANken gehört da
natürlich noch rein (TAP NL 456-465)
```

The unusual order leads to a foregrounding of this information as can been seen from NL's reflections. If there is a reason for the unusual order, this reason should be given explicitly. In fact, there is a reason: The risk of being affected by type 2 diabetes after a pregnancy is higher than being affected by type 1. If no reason is given, the usual order should be used (cf. the solution in the optimized version in Appendix A).

4. Summary and conclusions

Table 3 gives an overview of the problematic elements in the source text, of how many subjects had problems with them, and of a few maxims and strategies used by the subjects to solve these problems.

Table 3: Deficiencies of the original diabetes text with regard to comprehensibility

No.	Problem in the diabetes text	Subjects who found the item problematic	Maxims and strategies followed in optimizing the text[5]
	Incomprehensible elements and missing information		
1	Is gestational diabetes a third type of diabetes or a variant of type 1 or type 2?	SF, YG, JS, EK	coherence increasing maxim insert-coherence-increasing-element strategy
2	Unknown terms: chronisch Insulin Inselzellen T-Lymphozyten Gestation Glukose Körperzellen	 SF, EK SF, EK YG, NL, JS, EK JS SF, YG, (JS)[6], EK SF, YG, NL, EK JS	terminology explanation maxim
3	After gestational diabetes, is there a higher risk of developing type 1 or type 2 diabetes for the mother or the child?	YG	correctness, clarity and optimality maxim
4	Is type 1 diabetes caused only by a combination of all three factors mentioned or may it also be caused by one or two of these factors alone?	JS	correctness, clarity and optimality maxim

5 These maxims and strategies are only a selection of the complete repertoire used by the subjects. They can only be mentioned here. A detailed discussion of them is provided in Göpferich (forthcoming).

6 (XY) means that XY's TAP does not contain any explicit comment on this problem, but that she also replaces or adapts the element in question.

	What makes the text hard to understand?		
1	Unexplained terminology *(Diabetes mellitus)* in the title for which there is a common designation *(Zuckerkrankheit)*	SF, YG, (EK)	terminology explanation maxim add-general-designation strategy
2	Semantic relation between designations and their synonyms in parentheses unclear	SF, (EK)	explain-semantic-relation maxim
3	Title does not fit *(Definition)*	YG, (EK)	correctness, clarity and optimality maxim
4	Is "is gekennzeichnet durch" in the definition of diabetes mellitus correct?	YG, NL, (JS)	correctness, clarity and optimality maxim
5	Unprecise definition of diabetes mellitus	YG	correctness, clarity and optimality maxim
6	Unusual plural form of *Zuckerspiegel*	SF, YG, NL, EK	take-over strategy (believe-authority strategy)
7	Information which belongs together given in different places	YG, NL, SJ, EK	information clustering maxim
8	Paragraphs on comparable phenomena do not have a parallel structure	YG, NL	parallelism maxim
9	Abstract designations (*Betazellen* instead of *Insulin produzierende Zellen*)	YG	replace-by-general-designation strategy (after introducing the less telling synonyms if necessary)
10	Use of designations which lead to unintentional foregrounding *(Untergang)*	SF, YG, NL	correctness, clarity and optimality maxim
11	Semantic motivation of the designation *Altersdiabetes* (old-age diabetes)	YG	correctness, clarity and optimality maxim
12	Misleading designations (*Beendigung*)	YG, NL	correctness, clarity and optimality maxim

13	Tendency to use nominal style: chronische Erhöhung des Blutzuckers infolge einer Zerstörung der insulinpropduzierenden Zellen Neuerkrankungsrate Untergang Auftreten des Diabetes Ansprechen der Körperzellen auf Insulin Risiko für die Entwicklung	 NL, (JS) SF, NL SF, YG, NL SF, YG, NL, (EK) SF, YG, NL, (JS) SF, NL, EK YG, NL, (EK)	avoid-nominal-style strategy split-up-long-designation strategy
14	Intersentencial text coherence is not clear between: – "Fehlsteuerung des Immunsystems" and its explanation in the sentence following it – "Die Zuckerspiegel im Blut steigen an" and "und der Körper muss als Energiequelle sein Fettgewebe aufzehren"	 SF, NL NL	coherence increasing maxim insert-coherence-increasing-element strategy
15	What does "vermindertes Ansprechen" mean (explanation of type-2 diabetes unclear)?	EK	correctness, clarity and optimality maxim
16	Why is type-2 diabetes mentioned before type-1 diabetes in the last sentence?	NL	correctness, clarity and optimality maxim

The criticism summarized in Table 3 can be used to produce a version optimized on an empirical basis. Such a version is juxtaposed to the original version in Appendix A. In this optimized version, all elements criticized have been changed except for three items which were criticized by only one subject and in an unconvincing manner: *T-Lymphozyten*, *Körperzellen*, and the semantic motivation of *Alterdiabetes*. Ideally, this optimized version should again become the object of optimizing reverbalization, which is an iterative method, until no further deficiencies can be recognized.

If we compare the insight into text comprehensibility the method of optimizing reverbalization described here gives us with the results obtainable with readability formulas, cloze procedures, questions on texts whose comprehensibility is to be assessed, or text reproductions (cf.

section 1), it becomes obvious that the method described here provides much more differentiated and reliable results. At the same time, however, it is also much more time-consuming.

The subjects' criticism of the diabetes text and their maxims and strategies, of which only a few could be mentioned here, reveal what the 'ingredients' of comprehensibility are to their mind. A comparison of these 'ingredients' of comprehensibility with the six dimensions of the Karlsruhe comprehensibility model reveals that there were no items of criticism that could not be attributed to one of the dimensions of the Karlsruhe model. This shows that the comprehensibility concept underlying the Karlsruhe model seems to match the intuitive comprehensibility concepts of the subjects in the experiment.

The method described in this article, however, may also be used to refine the Karlsruhe model in the following way: First of all, a larger number of texts has to be analyzed by means of the method described here. Then the items which make the texts incomprehensible or hard to understand have to be classified. Each category of this classification must then be subsumed under one of the six dimensions of the Karlsruhe model, which will then represent the factors which determine text comprehensibility in much more detail. Such a refined Karlsruhe model would then be an even better framework of orientation for producing more comprehensible texts and at the same time provide the criteria for comprehensibility assessments which are less time-consuming than the method described here, but provide more detailed results than the methods employed in the past.

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Appendix A:
The popular science text and its optimized version

Original version	Optimized version
Definition des Diabetes mellitus Diabetes mellitus (Zuckerkrankheit) ist gekennzeichnet durch eine chronische Erhöhung des Blutzuckers, verbunden mit dem Risiko für schwere Begleit- und Folgeerkrankungen. Es werden zwei Typen unterschieden. Der Typ 1 Diabetes beruht auf einem Mangel an Insulin infolge einer Zerstörung der insulinproduzierenden Zellen (Beta-Zellen). Diese Zellen gehören zur Bauchspeicheldrüse und sind ein bestimmter Typ der sogenannten Inselzellen. Am höchsten ist die Neuerkrankungsrate bei Kindern zwischen 11 und 13 Jahren. Deshalb wurde der Typ 1 Diabetes früher auch als jugendlicher oder juveniler Diabetes bezeichnet. Als Ursache des Typ 1 Diabetes gilt heute das Zusammenwirken von erblicher Veranlagung und äußeren Faktoren (z.B. bestimmte Virusinfektionen) und einer Fehlsteuerung des Immunsystems. Bestimmte weiße Blutkörperchen (T-Lymphozyten) richten sich speziell gegen die Beta-Zellen. In Folge davon kommt es zum Untergang der insulinproduzierenden Zellen und zum absoluten Insulinmangel. Ohne Insulin kann jedoch Glukose nicht mehr aus dem Blut in die Körperzellen aufgenommen und verwertet werden. Die Zuckerspiegel im Blut steigen an und der Körper muss als Energiequelle sein Fettgewebe aufzehren. Der Typ 2 Diabetes beruht auf einem verminderten Ansprechen der Körperzellen auf Insulin. Er macht sich meist nach dem 40. Lebensjahr erstmals bemerkbar und wurde deshalb früher auch als Altersdiabetes oder Alterszucker bezeichnet. Auslösende Faktoren sind fettreiche Kost, Übergewicht und Bewegungsmangel. In den letzten Jahren hat sich das Alter beim ersten Auftreten des Diabetes zunehmend nach unten verlagert. Ein erstmals während der Schwangerschaft auftretender Diabetes wird als Schwangerschafts- oder Gestationsdiabetes bezeichnet. In der Regel verschwindet diese Form des Diabetes nach Beendigung der Schwangerschaft. Dabei ist jedoch das Risiko für die spätere Entwicklung eines Typ 2 oder Typ 1 Diabetes stark erhöht. Prof. Dr. med. Werner Scherbaum, Deutsches Diabetes-Forschungsinstitut Düsseldorf (Scherbaum 2004)	**Was ist Diabetes mellitus (Zuckerkrankheit)?** Unter *Diabetes mellitus* (im Volksmund auch *Zuckerkrankheit* genannt) versteht man eine Stoffwechselkrankheit, die unbehandelt zu einer chronischen (dauerhaften) Erhöhung des Blutzuckers führt. Hiermit können schwere Begleit- und Folgeerkrankungen einhergehen. Man unterscheidet zwei Grundtypen von Diabetes: Der Typ-1-Diabetes wurde früher auch als *jugendlicher* (oder *juveniler*) *Diabetes* bezeichnet, weil an diesem Diabetes-Typ am häufigsten Kinder zwischen 11 und 13 Jahren neu erkranken. Er beruht auf einem Mangel an dem Blutzucker senkenden Hormon Insulin. Er entsteht, wenn die Insulin produzierenden Betazellen in der Bauchspeicheldrüse zerstört werden. Dies kann durch eine Fehlsteuerung des Immunsystems geschehen, bei der die Insulin produzierenden Zellen durch bestimmte weiße Blutkörperchen, die T-Lymphozyten, angegriffen werden, was zu deren völligen Zerstörung und damit zum absoluten Insulinmangel führen kann. Eine solche Fehlsteuerung kann erblich bedingt sein, aber auch von äußeren Faktoren (wie z. B. bestimmten Virusinfektionen) ausgelöst werden. Ohne Insulin kann Traubenzucker (Glukose) nicht mehr aus dem Blut in die Körperzellen zur Energieversorgung aufgenommen und verwertet werden. Der Zuckerspiegel im Blut steigt daher an, während der Körper als Energiequelle u. a. sein Fettgewebe aufzehren muss. Der Typ-2-Diabetes wurde früher auch als *Alterzucker* (oder *Altersdiabetes*) bezeichnet, weil er sich meist erst nach dem 40. Lebensjahr erstmals bemerkbar macht. In den letzten Jahren hat sich das Alter beim ersten Auftreten dieses Diabetes aber zunehmend nach unten verlagert. Bei diesem Diabetes-Typ können die Körperzellen Insulin nur noch vermindert nutzen. Auslöser können sein: fettreiche Kost, Übergewicht und Bewegungsmangel. Ein Sondertyp ist der Gestationsdiabetes (Gestation = Schwangerschaft), der erstmals während einer Schwangerschaft auftritt und danach meist wieder verschwindet. Er entsteht dadurch, dass Schwangerschaftshormone und Hormone, die der Mutterkuchen (Plazenta) bildet, Blutzucker erhöhend wirken, so dass die Bauchspeicheldrüse der Schwangeren zum Ausgleich immer größere Mengen an Insulin produzieren muss. Reicht die erhöhte Insulinproduktion zum Ausgleich nicht mehr aus, entsteht der Schwangerschaftsdiabetes. Für die betroffenen Schwangeren ist das Risiko, später an Diabetes Typ 1 (seltener) oder Typ 2 (häufiger) zu erkranken, stark erhöht.

Appendix B: The assignment

Aufgabenstellung zur Bearbeitung des Textes „Definition des Diabetes mellitus“

Quelle und Funktion des Textes

Der von Ihnen zu bearbeitende Text stammt von der Website www.diabetes-deutschland.de, die vom Deutschen Diabetes Forschungsinstitut (DDFI) an der Heinrich-Heine-Universität Düsseldorf herausgegeben wird.

Der Adressatenkreis der Beiträge, zu denen auch der von Ihnen zu bearbeitende Text gehört, wird vom Herausgeber wie folgt definiert:

„Diese Beiträge geben Ihnen grundlegende Informationen zum Diabetes mellitus, ohne dass Sie eigenes Vorwissen benötigen.“

Bearbeitungsaufgabe

Bearbeiten Sie den Text so, dass er Ihrer Ansicht nach den Anforderungen des o. g. Adressatenkreises optimal entspricht. Stellen, die Sie für optimal halten, können Sie übernehmen. Alles, was Ihnen optimierungsbedürftig erscheint, optimieren Sie bitte. Achten Sie dabei auch auf Rechtschreibung und die Absatzbildung. Verzichten Sie aber programmbedingt auf Hervorhebungen durch andere Schriftgrößen, -farben, Fettdruck, Kursivierungen und Unterstreichungen.

Zum Text steht Ihnen ein kleines **Wörterbuch** zur Verfügung. Zum Aufrufen der Einträge in diesem Wörterbuch gehen Sie wie folgt vor:

1. Wörterbuchsymbol anklicken.
2. Auf das zu klärende Wort klicken.

Das Programm TRANSLOG, mit dem Sie arbeiten, weist nur einen beschränkten Umfang an **Editiermöglichkeiten** auf. Folgende Funktionen stehen Ihnen zur Verfügung:

- Pfeiltasten
- Backspace-Taste
- Delete-Taste
- Return-Taste
- Tabulator-Taste
- Cut, Copy und Paste über die Menüleiste
- Home (Pos 1), End (Ende) (an den Anfang bzw. das Ende der Zeile springen)
- Control Home (Strg Pos 1), Control End (Strg Ende) (an den Anfang bzw. das Ende des Textes springen)
- Page Up (Bild ↑), Page Down (Bild ↓)
- Maus

Bitte denken Sie bei der Bearbeitung des Textes laut.

Appendix C: The TRANSLOG dictionary