This is a pre-printed version of the article.

The final version of the article was published as:

Korpal, Paweł. 2015. "Eye-tracking in Translation and Interpreting Studies: The growing popularity and methodological problems", in: Łukasz Bogucki and Mikołaj Deckert (eds.), *Accessing audiovisual translation*. Łódź: Peter Lang, 199-212.

Eye-tracking in Translation and Interpreting Studies: The growing popularity and methodological problems

Paweł Korpal

Adam Mickiewicz University in Poznań

Abstract

The emerging eye-tracking technique has opened a window of opportunities not only in medical research but also in Translation and Interpreting Studies. In recent years this research method has been used to trace the processes of reading, translation and interpreting. Eye-tracking has recently become a popular technique to examine cognitive effort involved in written translation, audiovisual translation and conference interpreting. Thanks to the use of an eye-tracker one is able to investigate the whole process and not limit oneself to analysing the quality of the output. To be more precise, by means of eye-tracking experimenters may investigate moment-by-moment changes in the cognitive effort necessary to perform a given translation/interpreting task.

Useful as the eye-tracking technique may be, researchers must often face methodological and apparatus-related challenges. The present paper is intended to discuss the eye-tracking methodology and then to address the potential problems of applying this method to investigate the processes of translation and interpreting. Among the notions to be discussed are: the types of eye-trackers and their usability, accuracy vs. ecological validity, accommodation (O'Brien 2010), sampling, the use of inferential statistics for small experimental groups as well as ethics. I will also refer to my own research on the notion of language-pair specificity in sight translation (Korpal 2012) as well as a collaborative work on numerical data processing in simultaneous interpreting (Korpal and Stachowiak, manuscript in preparation).

Why eye-tracking?

At first glance, studying eye movements appears not to have anything in common with linguistic studies. While one would say that the examination of a human eye may be useful in

medical science, the applicability of the eye movement research to linguistics is probably not that straightforward. Nevertheless, the examination of eye movements has played a pivotal role in a range of psycholinguistic studies, since "eye tracking can possibly provide significant information about an observer's cognitive overload" (Goldberg and Wichansky 2003: 500). In other words, thanks to the study of eye behaviour a researcher may gain insight into the operation of the human brain (Leigh and Zee 1999: 3). It is assumed that eye movements reflect the cognitive processes taking place in the human mind (the so-called *eye-mind hypothesis*, Just and Carpenter 1980). In many linguistic empirical studies the analysis of the product is not enough to corroborate certain hypotheses. The veracity of the results may be, however, enhanced by means of investigating the process itself. The eye-tracking technique, i.e. the study of eye movements, is one of the ways to achieve it and, hence, it has gained great popularity in recent years in the field of psycho- and neurolinguistics.

Eye-tracking is only one of the psycholinguistic methods that have been eagerly adopted in recent decades to trace the cognitive processes involved in translation and interpreting. In order to make the results of an experiment more credible several different techniques are often used at the same time (cf. the notion of *triangulation*, Alves 2003). Špakov et al. (2009), while investigating cognitive processes involved in translation, proposed an integrated monitoring model. So as to have an even greater insight in the process of translation, the researchers combined eye-tracking with key-logging, electroencephalogram (EEG), electrooculogram (EOG) and electrocardiogram (ECG). Similarly, Lachaud (2011) used eye-tracking, key-logging and EEG in order to examine the cognitive mechanisms involved in written translation. The product-oriented approach limits an experimenter to formulate assumptions concerning the cognitive overload involved in certain tasks on the basis of quality assessment. However, the intricacies of the process itself are not analysed in this approach. When one takes it into consideration, it is no longer surprising that linguists working in the field of translation and interpreting have started to adopt eye-tracking as one of the process-oriented psycholinguistic methods.

The main types of eye movements

Human eye functions with great precision. The working of the human eye is made up of a continuation of very rapid movements followed by moments of stillness when the eye focuses

its attention on a specific point of interest. Crucial to the understanding of eye movements is the distinction between *saccades* and *fixations*. Rayner and McConkie describe this relationship by saying that "the eye does not move smoothly in reading but rather executes a series of rapid movements (saccades), each followed by a relatively long period during which time the eye is relatively stationary (fixation)" (1977: 186). The velocity of saccades is so high that instead of comprehending them as a sequence of small movements we tend to perceive them as continuous. They occur in both eyes simultaneously and every single move lasts for about 25-100 ms (Goldberg and Wichansky 2003: 503). The moment of fixation, on the other hand, has the average length amounting to 200-300 ms. It is assumed that the more the eye fixates on a given element, the more attention is given to process this stimulus. For this reason, fixation count and fixations length are much more often used as eye-tracking metrics in psycholinguistic studies than saccade count or the length of individual saccades.

The number of *refixations* and *regressions* during a reading task has also been proved to be informative of the cognitive effort invested in performing a given operation. By saying that a word is *refixated* one means that it receives additional fixation(s). Refixations and regressions are believed to be of a corrective nature and in studies involving reading they often result from comprehension problems. As a reader fails to localise the most appropriate point of interest, the word has to be examined again to be understood correctly. In one of the eye-tracking studies on language-pair specificity I examined whether sight translation from German into Polish is more cognitively demanding that sight translation from English into Polish. The reason for such a presumption was that one of the common characteristics of German is the verb-final structure. An example of a pair of sentences illustrating this problem has been given by Campbell (1995: 196):

(1) Ich weiß, daß er in die Stadt **gefahren ist**.
(2) I know that he has gone to town.

It transpired in the course of the analysis of eye-tracking results that many participants had major comprehension problems with processing such sentences which was reflected by a considerable number of refixations on both the final verb and the rest of the sentence. In this way computing refixations made it possible for me to identify parts of the text which proved to be cognitively challenging for the participants.

Eye-tracking metrics

The amount of cognitive effort involved in performing a specific task can be calculated by means of eye-tracking metrics. In order to be able to operationalise such effort a researcher needs to choose a set of eye-tracking indices which would function as dependent variables in the course of a study. In this section I will discuss the most common eye-tracking indicators.

One of the most commonly used eye-tracking measures is *fixation count*, i.e. the number of fixations within a particular Area of Interest. Fixations play a very important role since their number and duration determine the cognitive effort of a person performing an experimental task. A relevant example of the use of the fixation count indicator has been given by Chieh-Ying Chang (2011: 166) who compared reading a text in one's mother tongue with translation. It has been manifested that the translation task involves a higher number of fixations since – apart from comprehension skills – the latter activity requires conversion and text production.

Fixation length, i.e. the length of fixation(s) within a given Area of Interest is also informative of the cognitive load invested in performing a particular task. Longer fixations are believed to correspond to a greater cognitive load. On a more practical note, it often happens that one eye-tracking indicator is referred to by using different names. For example, *fixation length* and *total fixation time* denote the same measure and these names are often used interchangeably. Some researchers, instead of giving the total fixation time, provide the value of *first fixation duration*, i.e. "the duration of the initial fixation in a region" (Henderson and Ferreira 2004: 37). This measure has been used in the experiment carried out by Huang (2011). She demonstrated that there is a statistically significant difference in the cognitive effort involved in the three different tasks, i.e. silent reading, reading aloud and sight translation. It turned out that the highest number of first fixation duration is attributable to reading aloud whereas the lowest – to silent reading.

As has already been suggested, *the number of refixations and regressions* may indicate processing difficulties. Returning to a previous word or a phrase to process it again may be a sign of comprehension problems. For instance, one could expect a greater number of regressions while reading a text in a foreign language than in the case of a native language

excerpt, assuming that the former task requires more cognitive energy than the latter. Moreover, regression probability measure has been used in the study on the process of the resolution of temporary ambiguity (Vasishth 2011). It appears that ambiguity forces a reader to concentrate more on the process to grasp the correct meaning from a couple of available ones.

Another cognitive effort indicator used in eye-tracking studies is the so-called *observation length* understood as a "total time a person has looked within an AOI, starting with a fixation within an AOI and ending with a fixation outside the AOI" (Chmiel and Mazur 2013: 196). Computing observation length is yet another way of verifying how long it took for a person to process a given visual stimulus. Again, one needs to be aware of terminological differences which may result from fact that researchers use various eye-tracking software to analyse the study results. The name *observation length* used in TobiiStudio corresponds to the so-called *dwell time* in EyeLink Data Viewer. Hence, it is of the utmost importance for a researcher to make sure that they are aware of what the names of eye-tracking indicators stand for before conducting an eye-tracking study.

An additional feature of many eye-trackers is the possibility to compute *pupil diameter*. In one the first studies related to cognitive effort involved in the process of interpreting Tommola and Niemi (1986) used pupil dilation as an eye-tracking measure. As has been underlined by Tommola and Niemi (1986: 175), "[p]upil dilation is related to the mental effort required by cognitive tasks, and relative pupil size has been found to be useful as a measure of task difficulty in a wide variety of situations". Hence, they claim that pupil diameter is correlated with the cognitive (over)load experienced by a participant of an experiment. Pupillometry, i.e. measurement of pupil diameter, has been often used as a research method in Translation Studies. The example of such a study is that of Chieh-Ying Chang (2011). He used pupil dilation to examine the cognitive load involved in the process of translation from Mandarin Chinese into English and the other way round. The statistical analysis showed that the difference between the two directionalities is statistically significant (2011: 169).

To summarise, within the last decades the method of pupillometry and other eye-tracking metrics have been used in numerous psychological and linguistic studies in order to trace the processes of reading, translation and interpreting and to account for the cognitive (over)load

involved in them. What should be made clear is that the choice of a specific measure is dependent to a large extent on the eye-tracker device that is going to be used in a study. Many eye-trackers are able to compute only the basic formula and, hence, it is impossible to take advantage of some of the measures. It should also be remembered that the choice of particular eye-tracking measures should depend on the nature of an experimental study. For example, when studying comprehension difficulties in the processing of ambiguous sentences the analysis of refixations appears to be indispensable. Similarly, when one is interested in the total time spent on the visual processing of a given stimulus, total fixation time needs to be computed instead of a first/single fixation time.

Eye movements in Translation and Interpreting Studies

As has already been stated, eye-tracking has recently become a popular technique to examine the cognitive effort involved in the process of translation and interpreting. In the present section I will provide examples of translation and interpreting research avenues in which eye-tracking has been adopted. One of the first researchers who used the method of pupillometry to investigate cognitive effort in Translation and Interpreting Studies were Tommola and Niemi (1986). The authors of the study proposed that measuring pupil dilation proves applicable to examine the variations in cognitive load which is created during the process of simultaneous interpreting. The main purpose of the experiment was to examine the amount of mental load in simultaneous interpreting from Finnish into English. Due to the fact that languages vary syntactically, restructuring was necessary in some parts of the text. As could be predicted, the results of the study demonstrated that interpreting the clauses which needed to be restructured resulted in a greater cognitive load. The researchers pointed out that the examination of the human eye may serve as a reliable indicator of the processing effort involved in simultaneous interpreting.

Another attempt to apply eye-tracking to Interpreting Studies was made by Hyönä et al. (1995). One of their experiments was designed to compare the amount of mental load in three linguistic tasks: simultaneous interpreting, shadowing and pure listening. The results demonstrated that there existed a strong correlation between the type of the task and the mental effort reflected in the pupil size variations. Simultaneous interpreting turned out to be the most cognitively demanding, whereas listening involved the least amount of the overload.

In the second experiment, participants were supposed to perform similar tasks but this time on a single-word level. Again, the correlation between the task and the pupil size was observed (Hyönä et al. 1995).

Jakobsen and Jensen (2008) recorded participants' eye movements while performing several reading tasks: reading for comprehension, reading a text before translation, sight translation and reading while translating a text. Eye-tracking measures, such as the number of fixations and fixation duration, were used to answer the question whether task type has an effect on eye movement patterns. It transpired that the purpose of reading a text had a visible impact on the amount of processing effort (Jakobsen and Jensen 2008, as cited by Alves et al. 2011: 178f.). The complexity of the task correlated with both the number and the length of fixations.

Pavlović and Jensen (2009) used the eye-tracking technique to examine the notion of directionality in written translation. Four different eye-tracking indicators were incorporated in the study: gaze time, average fixation duration, pupil dilation and total task length (Pavlović and Jensen 2009: 98f.). The authors of the study manifested that "in both directions of translation, processing the TT requires more cognitive effort than processing the ST" (Pavlović and Jensen 2009: 95). There were some other hypotheses formulated by the authors which were only partially corroborated in the course of the experiment. The reason for that was that some of them were confirmed only by some eye-tracking indicators or for only one of the experimental groups. Such results are pivotal for present considerations since they show that every time an eye-tracking experiment is conducted, it is crucial to adopt a set of various eye-tracking measures so as to increase the reliability of the results. Using a limited number of such metrics (or only one) may make a researcher draw erroneous conclusions.

The process of sight translation was juxtaposed with written translation in a study conducted by Shreve et al. (2010). The peculiarity of sight translation lies in the fact that a sight translator has to produce his translation orally with constant access to the written original text. The authors of the study wanted to compare the distribution of mental efforts in both language tasks. The first aim of the study was to investigate eye movement during sight translation, as compared with bilingual reading. The second, more precise, hypothesis was to check whether "manipulation of characteristics of the sight translation text, such as lexical difficulty and syntactic complexity, could produce an effect in measures of effort, such as eye movements"

(Shreve et al. 2010: 71). A range of eye movement patterns were used in the experiment, i.e. "fixation frequency and duration, fixations in areas of interest (AOI), regression frequency and duration, and certain derived metrics (fixation/regression ratio, etc.)" (Shreve et al. 2010: 71). The results of the experiment showed that bilingual reading is not as effortful as sight translation. The effect of the AOI complexity on cognitive overload reflected in eye movement patterns turned out not to be so straightforward.

Sjørup (2011) used the eye-tracking technique to study cognitive effort involved in the translation of metaphorical language. Metaphorical expressions may be problematic for a translator since they can be translated by means of various techniques. A translator (or an interpreter) may look for the metaphorical equivalent in the target language. However, he may also decide on a functional translation, i.e. he may dispose of the metaphorical image and translate (interpret) the meaning of the metaphorical expression. In her study, Sjørup (2011) attempted to investigate whether translators invest more cognitive effort in translating metaphorical language when compared with non-metaphorical expressions (2011: 197). The author of the experiment hypothesised that the difference would be reflected in eye-tracking measures and that the translation of metaphorical expressions would be correlated with longer gaze times than in the case of non-metaphorical expressions. As concluded by Sjørup, "there seems to be a *slight* correlation between the distribution of translation strategies and in the two texts and the mean gaze times". Nevertheless, the study again proves the usability of eye-tracking methodology to examine cognitive overload involved in the process of written translation.

In recent years eye-tracking has also been eagerly applied to audiovisual translation. One of the pioneers of applying the analysis of eye movements to subtitling is D'Ydewalle with his collaborators (e.g. 1991; 2007). Szarkowska et al. (2013) conducted a series of studies in which they used the eye-tracking methodology to study audio description in art, education as well as subtitling for the deaf and hard of hearing. The authors intended to investigate the use of subtitles and the perception of the audio described works (Szarkowska et al. 2013: 179). One of the results of their research is that "children's eye movements – and thus their attention – can be positively affected by AD [audio description], which helps them to focus on relevant elements of the screen" (Szarkowska et al. 2013: 173). Although the authors acknowledge that eye-tracking may prove useful in audiovisual translation and media

accessibility, they also report on the methodological problems they have encountered. They point out that so far eye-tracking has been mostly used to analyse static images and they suggest that smooth pursuits (which allow the eyes to follow a moving object) should be included in the analysis of dynamic media (Szarkowska et al. 2013: 180). Even though there exist methodological and apparatus-related challenges of applying psycholiguistic methods in linguistics, audio description is a great of example of the growing popularity of eye movement research in Translation Studies, also in Poland. In 2013 Grucza et al. published the *Translation Studies and Eye-Tracking Analysis* volume in which they published the results of the ongoing research on eye movements in the processes of written, sight and audiovisual translation.

Methodological problems

The main purpose of the previous section was to give examples of research avenues in which eye-tracking may be (and has been) combined with Translation and Interpreting Studies. In the context of the growing popularity – almost a trend – of using eye-tracking methodology to investigate the process of translation and interpreting, a discussion of the major methodological problems that a researcher may encounter appears to be even more relevant.

As has already been mentioned, the choice of eye-tracking measures should not be haphazard but ought to result from the nature of an experimental study. *The choice of a particular eye-tracker* is also subject to the purpose of the experiment. There is a major distinction between remote eye-trackers and head-mounted eye-trackers. Remote eye-trackers do not support the head of a participant and it is believed that the use of such equipment enhances the *ecological validity* of a study. A text to translate or sight-translate may be displayed on a computer screen and the eye movements on the screen are then recorded by an eye-tracking machine. Using a head-mounted eye-tracker could mean forcing a participant not to move his head while (sight-)translating a text which would not imitate the natural translation context. However, there is one downside to using remote eye-trackers, i.e. it is generally believed that the results are slightly less accurate when compared with head-supported eye-trackers. Jensen discussed *eye-tracking accuracy* in translation studies and managed to conclude that "an error rate of 20% or more (sometimes much more) must be expected" (2008: 173). This shows that

eye movement accuracy is one of the most central problems and major limitations of the eye-tracking research. Even if one chooses the most modern head-mounted eye-tracker available on the market, this person should not expect 100% eye-tracking accuracy.

Before choosing a particular eye-tracker, it is suggested to consider whether the ecological validity is crucial to obtain reliable data from the study. In the experiment on language-pair specificity in sight translation I used a remote eye-tracker to cater for the natural context of the experiment but I also complied with Gerganov's (2007) recommendations regarding the choice of the font, the number of characters per line and lines per slide. In this way I attempted to reach a compromise between the problem of data accuracy and the validity of the experiment. In the study on numerical data processing in simultaneous interpreting, the use of the SMI head-mounted eye-tracker transpired not to be the best idea. Together with my collaborator we noticed that some participants were preoccupied with the unnatural procedure of the experiment which distracted them from performing an interpreting task (Korpal and Stachowiak, manuscript in preparation).

Another important problem related to the use of psycholinguistic methods is *ethics*. One of the rules listed in the *Ethical Principles Underlying Human Research Participant Protections* published by the American Psychological Association states that: "individuals should not be exposed to harm or unnecessary risk, and any benefits should be maximized" (http://www.apa.org/science/leadership/research/ethical-conduct-humans.aspx?item=2). Eye-tracking is generally believed not to be an invasive research method. On the other hand, infrared light is emitted during eye-tracking experiments which, in extreme cases, might be detrimental to participants' health. O'Brien (2010: 259) suggests that not informing the participants that their eyes are being tracked could also be considered unethical by many researchers. One of the ways to minimise the problem is to notify the participants of the experimental procedure and to inform them how an eye-tracker works, i.e. that the infrared light is emitted by the machine so as to record their eye movements. Collecting participants' written consents to take part in an eye-tracking study is not only a good idea but an obligation of every researcher. According to the American Psychological Association: "[t]he principle of respect for persons requires voluntary informed consent be obtained from potential participants" (http://www.apa.org/science/leadership/research/ethical-conduct-humans.aspx).

It seems to me that one of the greatest problems of studies involving professional translators and interpreters is collecting a sufficient *number of participants*. In the case of eye-tracking experiments this problem may be magnified since some people are not willing to take part in psycholinguistic studies which they find invasive. Many statisticians would argue that at least 25 participants are needed in each experimental group to be able to draw reliable conclusions from inferential statistics. However, O'Brien (2010: 255) pinpoints the advantages of small-scale studies in Translation Studies by saying that such experiments "are pioneering in their use of eye-tracking in translation studies. Researchers are testing equipment, research designs, and methodologies". Hence, even if it is impossible to make valid generalisations, small-scale eye-tracking studies may prove useful in Translation and Interpreting Studies.

In eye-tracking experiments consideration must also be given to *accommodation* which may be regarded as a limitation of this research method. There is a range of variables which need to be controlled in the course of the experiment. Since pupil dilation is analysed in many studies concerning the cognitive overload involved in performing a translation task, an experimenter should control the amount of light in a room. O'Brien (2010: 253) gives examples of some other potentially confounding variables which may skew the results of the experiment, for example caffeine level and eye make-up. The former has an impact on the organism's activation level which, in turn, may be reflected in pupil dilation. Heavy make-up (or even long eyelashes), on the other hand, may distort the correct recording of eye movements. The questions is whether it is possible to control all these factors and dispose of all the potential confounding variables. While conducting a study on number processing, together with my collaborator we asked female participants not to wear heavy make-up. We also asked the interpreters not to drink any coffee right before the experiment but this, of course, was impossible to be verified as the experiment started (Korpal and Stachowiak, manuscript in preparation).

Summary

The main purpose of the present paper was to discuss the main eye-tracking research avenues and the major methodological challenges of using eye-tracking in Translation and Interpreting Studies, such as the choice of an eye-tracker, eye-tracking accuracy, ecological validity,

ethics, sampling and accommodation. Since psycholinguistic methods are more and more eagerly adopted to trace the processes of translation and interpreting, such knowledge appears to be indispensable. The article began with the discussion of the advantages of the eye-tracking technique over the analysis of the translation product. Then I described the main eye movements and eye-tracking measures used to operationalise the cognitive effort invested in performing an experimental task. I discussed the examples of eye-tracking experiments conducted in Translation and Interpreting Studies with an attempt to manifest that the examination of eye movements has gained great popularity in research on translation and interpreting in recent decades. I aimed at showing that there exist numerous methodological problems which a researcher must face when conducting an eye-tracking experiment. Even if it is impossible to design and conduct a perfect eye-tracking study, I strongly believe that methodological awareness makes it possible to obtain more reliable data and, in turn, it may boost the quality of eye-tracking research.

References:

Alves, Fabio (ed.). 2003. *Triangulating Translation: Perspectives in Process Oriented Research*. Amsterdam: John Benjamins.

Alves, Fabio, Adriana Pagano and Igor da Silva. 2011. "Towards an investigation of reading modalities in/for translation: An exploratory study using eye tracking data", in: Sharon O'Brien (ed.), *Cognitive explorations of translation*. London: Continuum, 175-196.

American Psychological Association. *Ethical Principles Underlying Human Research Participant Protections* (http://www.apa.org/science/leadership/research/ethical-conduct-humans.aspx?item=2) (date of access: 9 Sep 2014).

Campbell, George L. 1995. *Concise compendium of the world's languages*. London: Routledge.

Chieh-Ying Chang, Vincent. 2011. "Translation directionality and the revised hierarchical model: An eye-tracking study", in: Sharon O'Brien (ed.), *Cognitive explorations of translation*. London: Continuum, 154-174.

Chmiel, Agnieszka and Iwona Mazur. 2013. "Eye tracking sight translation performed by trainee interpreters", in: Catherine Way, Sonia Vandepitte, Reine Meylaerts and Magdalena Bartłomiejczyk (eds.), *Tracks and Treks in Translation Studies: Selected papers from the EST Congress, Leuven 2010*. Amsterdam: John Benjamins, 189-205.

D'Ydewalle, Géry, Caroline Praet, Karl Verfaillie and Johan van Rensbergen. 1991. "Watching subtitled television: Automatic reading behaviour", in: *Communication Research* 18(5), 650-666.

D'Ydewalle, Géry and Wim de Bruycker. 2007. "Eye movements of children and adults while reading television subtitles", in: *European Psychologist* 12(3): 196-205.

Gerganov, Alexander. (2007). "Appendix A: Eye tracking studies with Tobii 1750 – recommended settings and tests", in: *Appendix A to D1.2 of the Consortium EYE-to-IT* (http://cogs.nbu.bg/eye-to-it/?deliverables) (date of access: 26 April 2013).

Grucza, Sambor, Monika Płużyczka and Justyna Zając (eds.). 2013. *Translation Studies and eye-tracking analysis*. Frankfurt am Mein: Peter Lang.

Goldberg, Joseph H. and Anna M. Wichansky. 2003. "Eye tracking usability evaluation: A practitioner's guide", in: Jukka Hyönä, Ralph Radach and Heiner Deubel (eds.), *The mind's eye: cognitive and applied aspects of eye movement research*. Amsterdam: Elsevier Science, 493-516.

Henderson, John M. and Fernanda Ferreira. 2004. "Scene perception for psycholinguistics", in: John M. Henderson and Fernanda Ferreira (eds.), *The interface of language, vision and action: Eye movement and the visual world*. New York: Psychology Press, 1-58.

Huang, Chih-Chieh. 2011. *Tracking eye movements in sight translation: The comprehension process in interpreting*. [Unpublished thesis.]

Hyönä, Jukka, Jorma Tommola and Anna-Mari Alaja. 1995. "Pupil dilation as a measure of processing load in simultaneous interpreting and other language tasks", *The Quarterly Journal of Experimental Psychology* 48A: 598–612.

Jakobsen, Arnt Lykke and Kristian T.H. Jensen. 2008. "Eye movement behaviour across four different types of reading tasks", in: Susanne Göpferich, Arnt Lykke Jakobsen and Inger M. Mees (eds.), *Copenhagen Studies of Language* 36: 103-124.

Jensen, Christian. 2008. "Assessing eye-tracking accuracy in translation studies", *Copenhagen Studies in Language* 38: 157-174.

Just, Marcel Adam and Patricia A. Carpenter. 1980. "A theory of reading: From eye fixations to comprehension", *Psychological Review* 87 :329-354.

Korpal, Paweł. 2012. "On language-pair specificity in sight translation: An eye-tracking study", in: Wolfram Baur et al. (eds.), *Übersetzen in die Zukunft*. Berlin: BDÜ Fachverlag: 522-530.

Korpal, Paweł and Katarzyna Stachowiak. “Numerical data processing in simultaneous interpreting: An eye-tracking study” (Manuscript in preparation).

Lachaud, Christian M. 2011. “EEG, EYE and Key: Three simultaneous streams of data for investigating the cognitive mechanisms of translation”, in: Sharon O’Brien (ed.), *Cognitive explorations of translation*. London: Continuum, 131-153.

Leigh, R. John and David S. Zee. 1999. *The neurology of eye movements*. Oxford: Oxford University Press.

O'Brien, Sharon. 2010. “Eye tracking in translation process research: Methodological challenges and solutions”, *Copenhagen Studies in Language* 38, p. 251-266.

Pavlović, Nataša and Kristian T.H. Jensen. 2009. “Eye tracking translation directionality”, in: Anthony Pym and Alexander Perekrestenko (eds.), *Translation research project 2*. Tarragona: Intercultural Studies Group, 93-109.

Rayner, Keith and George W. McConkie. 1977. “Perceptual processes in reading: The perceptual spans”, in: Arthur S. Reber and Don L. Scarborough (eds.), *Toward a psychology of reading: The proceedings of the CUNY conferences*. Hillsdale, NJ: Lawrence Erlbaum. 183-206.

Shreve, Gregory M., Isabel Lacruz and Erik Angelone. 2010. “Cognitive effort, syntactic disruption, and visual interference in a sight translation task”, in: Gregory M. Shreve and Erik Angelone (eds.), *Translation and cognition*. Amsterdam: John Benjamins, 63-84.

Sjørup, Annette C. 2011. “Cognitive effort in metaphor translation: An eye-tracking study”, in: Sharon O’Brien (ed.), *Cognitive explorations of translation*. London: Continuum, 197-214.

Špakov, Oleg, Clemens Brunner, Lasse Schou and Alexander Gerganov. 2009. “Combining eye tracking, key logging, and electroencephalographic data: Towards an integrated tool for translators”. (Poster presented at Eye-to-IT conference on translation processes, Copenhagen 28-29 April 2009.).

Szarkowska, Agnieszka, Izabela Krejtz, Krzysztof Krejtz and Andrew Duchowski. 2013. “Harnessing the potential of eye-tracking for media accessibility”, in: Sambor Grucza, Monika Płużyczka and Justyna Zając (eds.), *Translation Studies and eye-tracking analysis*. Frankfurt am Mein: Peter Lang, 153-183.

Tommola, Jorma and Pekka Niemi. 1986. “Mental load in simultaneous interpreting: An on-line pilot study”, in: Lars S. Evensen (ed.), *Nordic research in text linguistics and*

discourse analysis: Papers from the first NORDTEXT Symposium, Trondheim, August 15-18, 1985. Oslo: Tapir, 171-184.

Vasishth, Shravan. 2011. "What kind of linguistic questions can be investigated through reading studies?" (Lecture given at FSK Workshop 9, Stuttgart, 17 January 2011.).