Meta
Journal des traducteurs
Translators' Journal

META

Neurocognitive Aspects of Translation

Jean-Marie Annoni, Hannelore Lee-Jahnke et Annegret Sturm

Volume 57, numéro 1, mars 2012

La CIUTI, chef de file pour la promotion de l'employabilité et de la recherche
CIUTI: Leader in Advocating Employability and Research

URI : https://id.erudit.org/iderudit/1012743ar
DOI : https://doi.org/10.7202/1012743ar

Aller au sommaire du numéro

Éditeur(s)

Les Presses de l'Université de Montréal

ISSN

0026-0452 (imprimé)
1492-1421 (numérique)

Découvrir la revue

Citer cet article

Annoni, J.-M., Lee-Jahnke, H. & Sturm, A. (2012). Neurocognitive Aspects of Translation. *Meta*, *57*(1), 96–107. https://doi.org/10.7202/1012743ar

Résumé de l'article

La traduction est au centre de différents domaines cognitifs, telles la pédagogie, la linguistique, la pragmatique, les neurosciences et la cognition sociale. Les modèles actuels de la traduction reflètent ce caractère interdisciplinaire. Récemment, les neurosciences ont découvert des mécanismes cérébraux en relation avec le bilinguisme, et il serait logique de transférer ce savoir à la traductologie et à l'apprentissage de la traduction. Un champ de recherche intéressant s'ouvre sur les processus communicatifs et non linguistiques qui sont particulièrement importants en traduction. L'interprétation des intentions de l'auteur, même si elles ne sont pas explicitement mentionnées dans le texte, sont au centre de l'activité du traducteur, tout comme l'anticipation du public cible, ses attentions et attitudes envers le texte. Le traducteur doit toujours les prendre en considération pendant son travail. En neurosciences, la capacité d'interpréter et d'anticiper le comportement d'autrui est connue sous le terme de *Théorie de l'Esprit* (*Theory of Mind, ToM*). Cette capacité semble être dissociée du groupe des fonctions exécutives, bien qu'elle en dépende, et semble être organisée en large réseau individuel. Tandis que la recherche en traductologie porte largement sur le niveau microstratégique, des études qui portent sur l'aspect des macrostratégies font souvent défaut. Les résultats préliminaires des expériences neuroscientifiques sur le paradigme de la traduction montrent que la recherche interdisciplinaire n'apporte pas seulement des données sur les mécanismes linguistiques, mais également sur les mécanismes cognitifs et sociaux des stratégies de traduction.

Neurocognitive Aspects of Translation

JEAN-MARIE ANNONI
University of Fribourg and Geneva, Fribourg, Switzerland
jean-marie.annoni@unifr.ch

HANNELORE LEE-JAHNKE
University of Geneva, Geneva, Switzerland
hannelore.lee-jahnke@unige.ch

ANNEGRET STURM
University of Geneva, Geneva, Switzerland
annegret.sturm@unige.ch

RÉSUMÉ

La traduction est au centre de différents domaines cognitifs, telles la pédagogie, la linguistique, la pragmatique, les neurosciences et la cognition sociale. Les modèles actuels de la traduction reflètent ce caractère interdisciplinaire. Récemment, les neurosciences ont découvert des mécanismes cérébraux en relation avec le bilinguisme, et il serait logique de transférer ce savoir à la traductologie et à l'apprentissage de la traduction. Un champ de recherche intéressant s'ouvre sur les processus communicatifs et non linguistiques qui sont particulièrement importants en traduction. L'interprétation des intentions de l'auteur, même si elles ne sont pas explicitement mentionnées dans le texte, sont au centre de l'activité du traducteur, tout comme l'anticipation du public cible, ses attentions et attitudes envers le texte. Le traducteur doit toujours les prendre en considération pendant son travail. En neurosciences, la capacité d'interpréter et d'anticiper le comportement d'autrui est connue sous le terme de *Théorie de l'Esprit* (*Theory of Mind, ToM*). Cette capacité semble être dissociée du groupe des fonctions exécutives, bien qu'elle en dépende, et semble être organisée en large réseau individuel. Tandis que la recherche en traductologie porte largement sur le niveau microstratégique, des études qui portent sur l'aspect des macrostratégies font souvent défaut. Les résultats préliminaires des expériences neuroscientifiques sur le paradigme de la traduction montrent que la recherche interdisciplinaire n'apporte pas seulement des données sur les mécanismes linguistiques, mais également sur les mécanismes cognitifs et sociaux des stratégies de traduction.

ABSTRACT

Translation is at the centre of many cognitive domains such as pedagogy, linguistic, pragmatic, neurosciences, and social cognition. This multi-domain aspect is reflected in the current models of translation. Recently, cognitive neurosciences have unraveled some brain mechanisms in the bilingualism domain, and it is quite logical to transfer such knowledge to the field of translation as well as the learning of translation. One interesting question is which non-linguistic cognitive and communicative processes are particularly involved in translation. Particularly, in translation, the author's intentions have to be interpreted although they may not be explicitly stated in the text. These intentions have to be considered while rendering the text for the target public, a process for which it is also important to anticipate the target public's prior knowledge of the subject and the extent to which the author's aims and intentions have to be adapted in order to be correctly communicated in the other language. In neuroscience, being able to imagine another person's mental state is known as having a *Theory of Mind* (ToM). This skill seems dissociated from the group of executive functions – though it is very dependent on the latter – and seems to rely on a large but individualized brain network. While

translation is a widely investigated phenomenon at the micro-level, there is scarcely any research about the process of interpretation going on at the macro-level of text interpretation and rendering. Preliminary neuroscience experiments on the translations paradigm suggest that neurosciences can bring interesting data not only to linguistic but also to cognitive and social mechanisms of translation strategies.

MOTS-CLÉS/KEYWORDS

Théorie de l'Esprit, recherche interdisciplinaire, bilinguisme, neurolinguistique, IRMf
Theory of Mind, interdisciplinary research, bilingualism, neurolinguistics, fMRI

1. Neurosciences, bilingualism research and their applications on translation

Linguistics and clinical research have essentially considered the brain as a monolingual organ. In the 20th century, most of the fundamental clinical experiments have focused on only one language. The reason is probably that clinical research considered patients as proficient speakers in no more than one language, and that psycholinguistic as well as purely linguistic research both followed a rigorous monolingual approach in order to test their cognitive models. However, given the current interest in the implications and consequences of globalization and the multiple conceptual and methodological innovations in neurosciences, an increasing number of researches in different fields are dedicated to bilingualism.

In neurosciences and psycholinguistics, bilingualism is defined as the regular use of two languages in everyday life (Grosjean 1992: 51-62). This definition has allowed for testing different factors that have an influence on the cerebral organization of two or more languages. We only want to mention a few, such as age of acquisition (i.e., at which age a speaker has started to learn and use the language), immersion (the percentage of time in a week that the subject is actually communicating in this language) and proficiency (his or her actual mastery in using the language).

In fact, research on bilingualism has a long history. For example, hypotheses on bilingual aphasics were already discussed in the 19th century (Pearce 2005). But during the last decade the neuroscientific approach to the bilingual brain has mainly focused on two questions. The first one is: How does the brain handle two or more languages in terms of neural organization? And secondly: How do the mechanisms of language selection and language inhibition work?

Addressing the first question, behavioral, clinical and neuroimaging studies suggest that the first and the second language (L1 and L2) share, at least partly, a common network in the bilingual brain (Perani and Abutalebi 2005). However, this network seems to depend to some extent on the level of proficiency (van Heuven and Dijkstra 2010). Less proficient L2 speakers tend to rely on larger neural networks, at least in production, and require stronger cognitive control. This appears to be particularly true for the lexico-semantic aspects of language-processing. On the opposite, grammatical aspects seem less dependent on the level of proficiency, but rather on the age of acquisition (Wartenburger, Heekeren *et al.* 2003; Abutalebi 2008). Besides these biographical factors (proficiency, immersion and age of acquisition), the structural differences between L1 and L2 also play a role in their cerebral representation.

Concerning the second question, the fact that the bilingual brain does not rely on two completely separate systems for the different languages implies that there

must be a control mechanism that allows for discriminating between them and correctly selecting the language needed in a given context. Part of this mechanism also has to account for the capacity of language switching that is typical for bilingual subjects. Clinical observations have revealed the specific role of the anterior basal ganglia in language selection. Some functional imaging studies on interpreters suggest the involvement of the left inferior frontal areas. Interestingly, these structures are also part of cerebral networks involved in control of cognitive processes, such as preventing unwanted motor reaction (such as not pressing on a button…).

In the context of language selection translating from one language into another has a particular power to allow for understanding the mechanisms, since it requires high proficiency in L1 activation and simultaneous L2 inhibition. For example, translation, but no general non-verbal switching tasks, led to increased activation in the anterior cingulate cortex and subcortical structures (implicated in selection, inhibition and cognitive control of language), while activation in temporal and parietal areas associated with the understanding of word meaning decreased (Price, Green *et al.* 1999: 2229). This classic experiment was a first demonstration of the vast brain network implied in such a complex and yet highly controlled task as translation.

The collaboration between neurosciences, translation and interpreting research being very useful for the basic understanding of bilingualism, it was until now little helpful to disentangle the different mechanisms of translation itself. Translators were considered as proficient and skilled bilinguals, and tested as such on simple word level. In neurosciences there are no studies about written translations. The main reasons for this lack of "true" translation experiments are twofold: In the first place, there was a need to understand translation and switching on the world level. And secondly, most researchers working on bilingualism have either a linguistic or neurological background, but they are not familiar with translation theory.

Translation research differs fundamentally from the research on bilingualism because it does not focus on linguistic principles but on communication principles. The aim of translation is not only to provide the content of a message in another language into which it has been correctly transferred in purely linguistic terms, but to adapt this message to the other culture. Therefore, translators have to acquire linguistic, technical, cultural and communicative competences, as discussed in Göpferich (2008).

2. Interdisciplinary research in translation: A brief outline

2.1. Past: defining and understanding process-oriented translation

The study and importance of neurocognitive aspects of translation and in particular process-oriented research (Königs 1996) with a solid empirical basis, has to be viewed through a historic looking glass in order to better understand the current endeavor of research within the neurocognitive approach in translation. We are talking here on the one hand about a timeframe of some thirty years in which different studies (Gile 2005; Kalina 2005; Krings 1986; 2005; Mizuno 2005; Rydning 2005; Séguinot 1989; Asadi and Séguinot 2005; Tirkkonen-Condit 1989; 2005; Jääskeläinen 1987; Lee-Jahnke 1998; 2005; Lörscher 2005; Zhong 2005) have been conducted, all offering some insight into what goes on in the translator's mind during the translation

process. Cui bono? The great benefit goes definitely to translation and interpreting training, since this type of research shows to the trainer whether his didactical method enhances translation capacity through better inferring abilities and the development of automatisms which can be observed in professionals.

As a matter of fact we do believe that this approach has to take into consideration the early studies made by Fillmore (1977: 55-81) which have clearly shown the need of "an integrated view of language structure, language behavior, language comprehension, language change and language acquisition," as he puts it. These studies, which have marked the cognitive turn in translation (Lee-Jahnke 2007: 367), identified three major problems:

- Is it possible to formulate the description of "meaning" in a checklist?
- How to interpret the increasing interest in scene and frame not only in linguistics but also in cognitive sciences and cognitive psychology?
- How to describe in a satisfactory way the process of the understanding of a text?

Fillmore's model of Scenes-and-frames semantics was an attempt to respond to the need of a relevant theory which so far did not exist. In his own words, his research was: "a tentative first step in seeking a solution to certain problems in semantic theory within the framework of concepts that seem to be emerging in a number of disciplines touching on human thought and behavior" (Fillmore 1977: 79).

Fillmore was not the only one to identify the importance of a Gestalt[1] principle in language matters: Lakoff (1977) also published an article in the same year on "Linguistic Gestalts" and Attila (1977) on "Dynamic fields and linguistic structure: A proposal for a Gestalt linguistics." In our training situations we greatly benefited from this knowledge in combining it with the enhancing of "mental representations" (see also Lee-Jahnke 2011) prior to the translation process.

2.2. Present: comprehending and developing competences and skills

On the other hand, we have to take into account the interdisciplinary research so far completed and still ongoing within the fields of neurocognition, bilingualism[2], research in expertise and intelligence, just to name a few, in order to have a more solid basis for a yet new approach, that of ToM and translation (Sturm 2010).

In the field of bilingualism, experimental approaches resulted in many interesting data, showing particularly that different languages have fundamentally a common representation in the brain. A representation which can be modulated by different variables, such as the age of acquisition, immersion and proficiency (van Heuven and Dijkstra 2010). Thus, particularly the semantic processing seems rather to be function of the level of proficiency of L2 and syntactic processing seems to depend especially on the age of the second language acquisition (Abutalebi, Annoni *et al*. 2008).

2.3. Future: exploring yet new research combinations for higher proficiency

With the upcoming of the interdisciplinary research in translation processes, further studies have shown that consciousness has a general tendency to give more importance to personal concepts, interpretations, memories than to an objective

perception (Schneiders 2007: 106). This aspect is of major concern in translation didactics since it indicates clearly the importance of certain aspects of expertise and, very specifically, that we have to handle very carefully the training of inferences with our students.

Why interdisciplinary research in cognitive sciences is of such a great importance for translation, is certainly the fact that this type of research touches upon memory, the capacity of making an abstract reasoning and to differentiate between an analytical and an holistic outlook on a text.

On the other hand, research in cognitive sciences allows us to better understand and hence guides the cognitive learning strategies and more specifically the so-called organization strategies, which enable the learner to group information in a form which is easier for him to understand. Thus we know of five different memory systems: (i) the procedural memory, which functions through repetition of an action and is situated in the cerebellum and grey nucleus; (ii) the semantic memory, which allows us to memorize concepts, the meaning of words independently of their context, and is situated in the neocortex; (iii) the representational memory, which helps to memorize an image or a face and allows us to recognize a piece of information more easily, if we have seen it before.

Another aspect which certainly is of importance within the research of neurocognitive aspects in translation are the results obtained within the research in expertise and, especially, the research of the knowledge of specific domains. Within this framework, the works of major interest to translation studies are the ones by Kolodner (1991) who examined the so-called episodic definitions, i.e., the experience of how to best use and reorganize knowledge in specific structures (Reimann and Chi 1989; Schank 1982). Kolodner based his reflections on Episodic Memory Organization Packets (E-MOPs)[3] of experts who are able to build up their experience-based knowledge in form of these so-called E-MOPs. (iv) The episodic memory, also called autobiographic memory, is located in the prefrontal cortex, the hippocampus and the thalamus.

According to these findings, applicable knowledge is being recorded in form of E-MOPs within the so-called episodic memory. But thanks to flexible mental representations also (v) declarative knowledge,[4] procedural knowledge and conditional knowledge[5] can be likewise registered. Procedural knowledge has certainly become one of the major domains of research in translation studies in the past decades. It is characterized by its dynamic feature and concentrates on how, with a certain procedure, or a certain process a clearly defined and desired result can be achieved.

Within the framework of neurocognitive aspects of translation, the importance of intelligence cannot be neglected, especially since, according to Mack (1996) a theory of intelligence can only be formulated in relation with a global theory of cognition (Richardson 1993); cognition being defined here as the processes which handle information and which are basic to perception, thinking and acting. Sternberg (1984; 1985) was of course in the forefront trying to define a theory of intelligence with his *triarchic theory of intelligence*. In this theory (Sternberg 1985), he describes three types of components which process information and which should be taken into consideration in any didactical approach:

a) Metacomponents, which are controlling processes such as planning, monitoring, evaluation;
b) Performance components, which are considered as lower processes with the following functions: stimulus encoding, inferring relations, selective attention, elaboration;
c) Components of knowledge acquisition, which involve processes which are linked to learning and memorizing of new information such as selective encoding, selective comparison, restructuring.

Within this context an interdisciplinary research led by Lehr (2010) has clearly shown, that experts, translators with a high proficiency and important percentage of automatisms, do not only have an easier access to more knowledge because of their highly developed automated processes, but that they are also able to restructure the relevant knowledge much faster, according to the need of the moment (see also Englund-Dimitrova 2005; Lee-Jahnke 2005). Since experts are able to apply more effectively – and efficiently – their knowledge, they are able to diminish the cognitive effort necessary to access this knowledge.

Theories concerning the accumulation of knowledge such as the one defined by Staszewski (1990), the Skilled Memory Theory, explain the excellent capacity of memorizing by experts according to the following three principles:

a) Encoding of information, taking into account the existing knowledge;
b) Developing cognitive structures from which the experts takes his information and which is closely linked to the long-term memory; Staszewski (1990) describes the existence of domain specific slots which enable a quick encoding of information;
c) Repeating and exercising to help diminish the time necessary in order to access information and to operate the encoding[6].

This short overview should not omit to mention the research in mirror neurons by Rizzolatti (2003; 2005), in which is clearly defined the importance of interpersonal communication as a neuronal imitation process, and where speech recognition and empathy develop the so-called hypothesis of Shared Manifold inter-subjectivity and direct matching mechanism explained through motor representations in the brain.

3. The role of Theory of Mind in Translation: One example of interdisciplinary research

The two previous chapters showed the development, evolution and future prospects not only of neurocognitive research but most importantly of interdisciplinary research in translation studies. This chapter aims to give one example of this hybrid research that uses neurocognitive concepts and methods such as fMRI to investigate translation, and more precisely the smallest translation processing unit: the Translator.

3.1. Theory of Mind and Translation

To be able to interpret others' behavior and to predict it is known as having a Theory of Mind (ToM). In translation, the author's intentions have to be interpreted although they may not be explicitly stated in the text. And those intentions have to be considered while rendering the text for the target public, a process for which it is also important to anticipate the target public's prior knowledge of the subject and the

extent to which the author's aims and intentions have to be adapted in order to be correctly communicated in the other language. While translation is a widely investigated phenomenon on the micro-level, there is scarcely any research about the process of interpretation going on the macro-level of text interpretation and rendering. However, as work by Sturm (2009) suggests, macrostrategies seem to play a far more important role than has been assumed up to now. Wilss (1992) did already outline the importance of strategies of perception of oneself and the other. This capacity again is found in the comparative study by Sturm (2009), suggesting that these features of social cognition that can be resumed under the name of ToM are of key importance in the translation process. We therefore assume that translators acquire throughout their educational training special ToM strategies.

In order to verify this hypothesis, we tested a group of translators in an fMRI bloc design. During the whole task, a fMRI brain scan was made and students' answers or comments to the answers were recorded via a headphone. Subjects were presented two sets of German sentences in a randomized order. The task was to reformulate them so that they could be better understood.

We opted for an intralingual translation setting because in this way we could exclude any cerebral activation linked to the respective other language (see Korning Zethsen 2009). The first set consisted of 20 sentences requiring a ToM analysis (ToM condition) whereas the second set consisted of 20 purely logical sentences (non-ToM condition), e.g., sentences representing causality. One sentence of each group resembled always another sentence of the other group in spite of the last words that made the difference. In this way we could largely exclude effects of lexical processing on the results. In order to understand a ToM condition sentence, you would have to take the narrator's perspective in order to understand the message (e.g., *When I stood on the stage for the very first time, my palms became wet*). For the non-ToM condition sentences, the simple understanding of the sentence's logic was required (*When touching that used towel, my hands became wet*). The resemblance of the sentences should also make sure that there was no effect linked to any text-statistics factor that would influence the results.

We used a reading aloud task as a baseline condition for the verbal task since it involves making sense of words in form of cerebral activation, but also the motor activation caused by uttering the target sentence.

In order to make sure that any ToM activation would be due to the verbal task, we used a non-verbal control condition that consisted of the "Read the Mind in the Eyes" task developed by Baron-Cohen, Wheelwright *et al.* (1997). In this task, the subject is shown pictures of human faces where any part except the eyes is spared out. Four adjectives are noted around the frame of the picture, each one associated with one of four buttons on a button board the subject had in the fMRI tomography.

The subject was asked to choose the adjective most appropriate to describe the view depicted by pressing the corresponding button. Originally, this task was designed for autistic and Asperger patients since it requires a profound analysis of the eyes and attribution of certain emotions or attitudes to the way they are looking and therefore expressing the state of mind of the depicted person. Our non verbal non-ToM condition consisted in attributing an age to the depicted person. Four age spans were placed around the picture as the adjectives had been before, and the subject had to choose one age span by pressing the corresponding button. This task

requires again some analyzing of certain traits of human faces, but in a more logical manner: looking for wrinkles, tear sacs or make-up would be the most important factors influencing the subject's decision. As a pure baseline condition that required no analysis of the human face as such, we prepared another set of the same pictures, this time with a red dot in each of them. Subjects were asked to press the button that reflected best the situation of the dot in the face (up, down, left, right). In this case, the human face in the picture is treated as a surface only, so that the task should only make sure that the subjects are capable of picture interpretation without having to apply any analysis of any features.

The materials were presented in the fMRI via a screen and mirror system. Subjects were asked to utter any of their responses for the verbal tasks (translation and reading only) into the microphone, so that we could record it for further analysis of the translation. For the non-verbal tasks, they used a set of four buttons for responding.

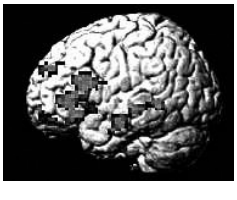
For our pilot study, we tested 3 French-German bilinguals working as translators. Any picture used in this chapter refers to this study. Participants were informed about the study's aims and methods and were asked to give their written consent prior to their participation.

3.2. Preliminary results

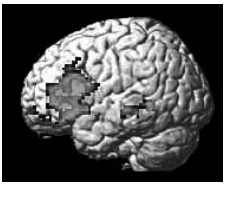
By analyzing the data obtained from our first pilot study, we can see (Figure 1) that the translation task is valid in the sense that it is associated to a dense left superior temporal, inferior and dorsolateral prefrontal activation, all areas known to play a role in language and language control. However, some differences emerge in activation according to the condition. In case of the ToM condition (left), we can see an important activation of the left lateral temporal sulcus, one area supposed to be important for ToM processing. This part shows less activation in the non-ToM condition which could be explained by the nature of interpreting the task elicited. However, we can see a strong activation in the left frontal lobe, the evolutionarily most recent part of the brain that is mostly associated to logical thinking and abstraction. Again, the large activation of an area responsible for logic processing could be explained by the purely logical settings reflected in the non-ToM condition sentences.

FIGURE 1

Verbal ToM-control (A) vs. verbal non-ToM-control activation (B)



A



B

FIGURE 2
Non Verbal ToM-control (A) vs. Non Verbal Non-ToM-control (B)

A

B

The pictures obtained from the non-verbal tests show that, again, the left lateral temporal sulcus is largely implicated in the processing of the ToM condition, although the task was held in a non-verbal setting. The non-ToM condition does not parallel the verbal non-ToM condition (Figure 2) regarding the huge activation in the frontal lobe, showing only slight activation on the upper frontal level.

4. Discussion

The field of translation, being at the centre of different domains such as language, learning, cognitive neurosciences and social cognition, has always been enriched by interdisciplinary research. Our proposal is that neurosciences and social cognition can bring interesting theoretical and experimental input in the field of translation and vice-versa. The aim of this paper is: i) to provide some information about current neuroscience research in bilingualism; ii) to discuss some domains of translation in which interaction with neuroscience could be constructive for both fields; and iii) to demonstrate the feasibility of such a paradigm. In the first pilot experiment presented above preliminary results support that some hypotheses dealing with translating competencies and translating model may be tested. In order to verify that brain mechanisms may differ depending on the macro-context, we tested three French/German translators in an fMRI bloc design where they were confronted with faces and with sentences requiring either a ToM analysis or a purely logical approach. The data suggests that, even on this very small number of subjects, translators can be tested in such paradigms. In the first control task (recognition of social emotions on faces), the subjects seemed to activate their superior temporal sulcus (here on the left side) more when they have to recognize the social emotional attributes of human faces. In contrast, the same three translators, when tasked with reformulating sentences, processing of sentences with emotional component associated with an activation of the right medial frontal gyrus (BA6). Both of these activated areas are known to be part of ToM brain networks. It would be unethical and unscientific to draw conclusions on three subjects. However these data suggest that the paradigms work and that this line of research can be continued. We plan in the next year to present solid data on this topic and to test the hypothesis that translators do use their ToM structures more intensely in empathic reformulations. Such an approach has two important consequences; it can validate cognitive models of translation, and it can point to specific skill necessary for translation, both of which can be applied in the learning programs.

NOTES

1. The concept of Gestalt describes something which is more active than "perception" and more passive than "consciousness"; in German another expression is often used: Gewahrsein which indicates that a perception is accompanied by a certain kind of self-conscious knowledge of perception (Blankertz and Doubrawa 2005).
2. Some scientific findings have shown that, for instance, dyslexia varies with language, a fact which also should interest translation studies. For further reading, see O'Connor (2004) and Marwinski (1998). O'Connor, Anahad (9 September 2004): Dyslexia varies with language. *International Herald Tribune*. 9.
3 Schank (1982) defines an E-MOP as a generalized episode which contains the general information of individual episodes, which are differentiated from the general episode.
4. In didactics this indicates factual knowledge.
5. Conditional knowledge indicates, according to Ruf (2006), under which conditions which steps to solve a problem have to be made.
6. For further reading see also Pavlenko (2005), especially Chapter 7 (*Social cognition*, p. 192-224) and Lee-Jahnke (2007).

REFERENCES

Abutalebi, Jubin (2008): Neural aspects of second language representation and language control. *Acta Psychologica*. 128(3):466-478.

Abutalebi, Jubin, Annoni, Jean-Marie, Zimine, Ivan, *et al.* (2008): Language Control and lexical competition in bilinguals: an event-related fMRI-study. *Cerebral Cortex*. 18(7):1496-1505.

Asadi, Paula and Séguinot, Candace (2005): Shortcuts, strategies and general patterns in a process study of nine professionals. *Meta*. 50(2):522-548.

Attila, Raimo (1977): Dynamic fields and linguistic structure: A proposal for a *Gestalt* linguistics. *Die Sprache*. 23(1):1-10.

Baron-Cohen, Simon, Wheelwright, Sally and Jolliffe, Therese (1997): Is there a "language of the eyes"? Evidence from normal adults and adults with autism or Asperger syndrome. *Visual Cognition*. 4(3):311-331.

Blankertz, Stefan and Doubrawa, Erhard (2005): *Lexikon der Gestalttherapie*. Wuppertal: Peter Hammer Verlag.

Englund-Dimitrova, Birgitta (2005): *Expertise and Explicitation in the Translation Process*. Amsterdam/Philadelphia: John Benjamins.

Fillmore, Charles (1977): Scenes-and-frames Semantics. *In*: Antonio Zampolli, ed. *Linguistic Structures Processing*. Amsterdam: North Holland, 55-81.

Gile, Daniel (2005): La recherche sur les processus traductionnels et la formation en interprétation de conférence. *Meta*. 50(2):713-726.

Göpferich, Susanne (2008): *Translationsprozessforschung. Stand – Methoden – Perspektiven*. Tübingen: Gunther Narr.

Grosjean, François (1992): Another View of Bilingualism. *In*: Richard J. Harris, ed. *Cognitive Processing in Bilinguals*. Amsterdam: North-Holland, 51-62.

Jääskeläinen, Riita (1987): *What happens in a Translation Process: Think-aloud Protocols of Translation*. Master thesis, unpublished. Savonlinna: University of Joensuu.

Kalina, Sylvia (2005): Quality Assurance for Interpreting Processes. *Meta*. 50(2):768-784.

Kolodner, Janet L. (1991): Improving Human Decision Making through Case-Based Decision Aiding. *AI Magazine*. 12(2):52-68.

Königs, Frank, ed. (1996): Les processus de la traduction. *Meta*. 41(1):5-184.

Korning Zethsen, Karen (2009): Intralingual Translation: An Attempt at Description. *Meta*. 54(4):795-812.

Krings, Hans-Peter (1986): *Was in den Köpfen von Übersetzern vorgeht: Eine empirische Untersuchung zur Struktur des Übersetzungsprozesses an fortgeschrittenen Französischlernern*. Tübingen: Narr Verlag.

Krings, Hans-Peter (2005): Wege ins Labyrinth – Fragestellungen und Methoden der Übersetzungsprozessforschung im Überblick. *Meta*. 50(2):342-358.

Lakoff, George (1977): Linguistic Gestalts. *In*: Woodford Beach, Samuel E. Fox and Shulamith Philosoph, eds. *Papers from the Thirteens Regional meeting, Chicago Linguistic Society*. Chicago: University of Chicago, 236-287.

Lee-Jahnke, Hannelore (1998): L'introspection à haute voix: recherche appliquée. *In*: Jean Delisle and Hannelore Lee-Jahnke, eds. *Enseignement de la traduction et traduction dans l'enseignement*. Ottawa: Les Presses de l'Université d'Ottawa, 155-183.

Lee-Jahnke, Hannelore (2005): New Cognitive Approaches in Process-oriented Translation Training. *Meta*. 50(2):359-377.

Lee-Jahnke, Hannelore (2007): Kognition und Qualität. Überlegungen zu kognitiven Prozessen in der Translationsdidaktik. *In*: Peter A. Schmitt and Heike Jüngst, eds. *Translationsqualität*. Frankfurt am Main: Peter Lang, 364-386.

Lee-Jahnke, Hannelore (2011): Trendsetters & Milestones in Interdisciplinary Process-oriented Translation: Cognition, Emotion, Motivation. *CIUTI FORUM 2010 Global Governance and Intercultural Dialogue: Translation and Interpreting in a new Geopolitical Setting*. Bern: Peter Lang, 109-153.

Lehr, Caroline (2010): Psycholinguistik, Übersetzungswissenschaft und Expertiseforschung im Rahmen der interdisziplinären Forschung. *In*: Daniel Gile, Gyde Hansen and Nike K. Pokorn, eds. *Why Translation Studies Matters*. Amsterdam/Philadelphia: John Benjamins, 211-222.

Lörscher, Wolfgang (2005): The Translation Process: Methods and Problems of its Investigation. *Meta*. 50(2):597-608.

Mack, Wolfgang (1996): Expertise und Intelligenz. *In*: Hans Gruber and Albert Ziegler, eds. *Expertiseforschung. Theoretische und methodische Grundlagen*. Opladen: Westdeutscher Verlag, 92-114.

Marwinski, David (1998): *Übertragungsstrategien und –Fehler bei Anfängern und Fortgeschrittenen Lernern*. Diploma thesis, unpublished. Geneva: University of Geneva.

Mizuno, Akira (2005): Process Model for simultaneous interpreting and working memory. *In*: Hannelore Lee-Jahnke, ed. *Processus et cheminements en traduction et interprétation. Meta*. 50(2):739-753.

Pavlenko, Aneta (2005): *Emotions and Multilingualism*. Cambridge: Cambridge University Press.

Pearce, Janet M. (2005): A note on aphasia in bilingual patients: Pitres' and Ribot's laws. *European Neurology*. 54(3):127-131.

Perani, Daniela and Abutalebi, Jubin (2005): The neural basis of first and second language processing. *Current Opinion in Neurobiology*. 15(2):202-206.

Price, Cathy J., Green, David W. and von Studnitz, Roswitha (1999): Functional imaging study of translation and language switching. *Brain*. 122(12):2221-2235.

Reimann, Peter and Chi, Michelene T. (1989): Human Expertise. *In*: Kenneth J. Gilhooly, ed. *Human and Machine Problem Solving*. New York: Plenum, 161-191.

Richardson, Ken (1993): *Understanding Intelligence*. Philadelphia: Open University Press.

Rizzolatti, Giacomo (2003): The mirror system in humans. *In*: Maxim Stamenov and Vittorio Gallese, eds. *Mirror Neurons and the Evolution of Brain and Language*. Amsterdam/Philadelphia: John Benjamins, 37-59.

Rizzolatti, Giacomo (2005): The mirror neuron system and its function in humans. *Anatomy and Embryology*. 210(5-6):419-421.

Ruf, Michael (2006): Praxisphasen als Beitrag zur Employability. *Das Hochschulwesen*. 54(4):135-139.

Rydning, Antin Fougner (2005): The return of sense on the scene of translation studies in the light of the cognitive blending theory. *Meta*. 50(2):392-404.

Schank, Roger C. (1982): *Dynamic Memory*. Cambridge: Cambridge University Press.

Schneiders, Hans-Wolfgang (2007): *Allgemeine Übersetzungstheorie. Verstehen und Wiedergeben*. Bonn: Romanistischer Verlag.

Séguinot, Candace (1989): The translation process: An experimental study. *In*: Candace Séguinot, ed. *The Translation Process*. Toronto: H.G. Publications, 21-53.

Staszewski, James J. (1990): Exceptional Memory: The influence of practice and knowledge on the development of elaborative encoding strategies. *In*: Wolfgang Schneider and Franz Emanuel Weinert, eds. *Interactions Among Aptitudes, Strategies, and Knowledge in Cognitive Performance*. New York: Springer, 252-285.

Sternberg, Robert J. (1984): Toward a triarchic theory of human intelligence. *The Behavioral and Brain Science*. 7(2):269-287.

Sternberg, Robert J. (1985): *Beyond IQ: A Triarchic Theory of Human Intelligence*. New York: Cambridge University Press.

Sturm, Annegret (2009): *Übersetzungsfähigkeit bei zweisprachigen Patienten mit chronischer Aphasie*. Master thesis, unpublished. Geneva: École de traduction et d'interprétation.

Sturm, Annegret (2010): What aphasics can tell us about translation: The role of interdisciplinary research in translation studies. *In*: Martin Forstner and Hannelore Lee-Jahnke, eds. *CIUTI FORUM New Needs, Translators & Programs*. Bern: Peter Lang, 145-157.

Tirkkonen-Condit, Sonja (1989): Professional versus non-professional Translation: A think-aloud protocol study. *In*: Candace Séguinot, ed. *The Translation Process*. Toronto: H.G. Publications, 73-84.

Tirkkonen-Condit, Sonja (2005): The monitor model revisited: Evidence from process research. *Meta*. 50(2):405-414.

van Heuven, Walter. J. and Dijkstra, Ton (2010): Language comprehension in the bilingual brain: fMRI and ERP support for psycholinguistic models. *Brain Research Reviews*. 64(1):104-122.

Wartenburger, Isabell, Heekeren, Hauke R., Abutalebi, Jubin, *et al.* (2003): Early setting of grammatical processing in the bilingual brain. *Neuron*. 37(1):159-170.

Wilss, Wolfram (1992): *Übersetzungsfertigkeit: Annäherungen an einen komplexen übersetzungspraktischen Begriff*. Tübingen: G. Narr.

Zhong, Yong (2005): A matter of principles: Empirical treatments of translation principles: A case study. *Meta*. 50(2):495-510.