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Schema activation in translation and reading: A paradoxical effect

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In three experiments we examined the effect of schema activation on professional translators who had to read and translate or to read aloud visually presented texts. In Experiment 1, text understanding was improved by presenting a summary before reading aloud the texts. However, prior presentation of the summary reduced comprehension when participants had to translate them (sight translation). The interfering effect of prior summary was replicated in semi-consecutive translation (Experiment 2). In Experiment 3, we explored the nature of this paradoxical effect by manipulating the working memory (WM) load associated with reading. When WM load increased, the benefit associated with the presentation of the summary in reading disappeared. These results are discussed in terms of a cost/benefit hypothesis of schema activation during understanding. The implications for the training of translators are also evaluated.

Reading comprehension is a cognitively demanding task which requires use of the Working Memory system (WM). In fact, virtually all models of language comprehension assume the relevance of this system to reading (Britton, Glynn, & Smith, 1985; Caplan, 1992; Gernsbacher, 1990; Just & Carpenter, 1992; Perfetti, 1994). WM resources are needed to carry out reading processes at all levels of representation (lexical, sentence and text level processes), and WM is needed to maintain the relevant information during active reading. However, the processing capacity of WM is limited and this limitation modulates the time spent on reading texts and the accuracy of comprehension. For example, in a meta-analysis of 77 studies, Daneman and Merikle (1996) showed that performance in tasks that place simultaneous demands on processing and storage (e.g., scores on the

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Reading Span Test) correlates well with individuals' language comprehension performance (measured with SAT and Nelson-Denny Reading Test). Furthermore, the constraints of WM in language processing have been shown at several levels of language perception including lexical access of isolated words (Perfetti, 1994), resolution of lexical ambiguity (Miyake, Just, & Carpenter, 1994), parsing of syntactically complex structures (King & Just, 1991), and access to the meaning of sentences (Van Petten, Weckerly, McIsaac, & Kutas, 1997).

In addition to having a crucial role in reading, the importance of WM has been pointed out from other areas such as simultaneous interpreting and translation (Bajo, Padilla, & Padilla, 2000; Gile, 1997), bilingualism studies (Kroll, Michael, Tokowicz, & Dufuor, 2002; Kroll & Tokowicz, 2001; Ransdell & Arecco, 2001), and second language acquisition (Gathercole & Thorn, 1998; MacWhinney, 1997; Miyake & Friedman, 1998). For example, Miyake and Friedman showed a positive correlation between second language (L2) syntactic comprehension and first language (L1) reading span using a group of native speakers of Japanese who had studied English as their L2. These results indicate that WM imposes limits on language processing when readers have to perform within-language tasks (e.g., sentence reading, King & Just, 1991). These processing limits have also been shown in between-languages tasks (e.g., consecutive translation, Macizo & Bajo, 2004; Macizo & Bajo, 2006). However, some empirical and theoretical work suggests that WM demands are higher in the second type of tasks (Gernsbacher & Shlesinger, 1997; Gile, 1997; Macizo & Bajo, 2004), so that additional WM resources are needed in translation as compared to within-language understanding. In consecutive and simultaneous translation, comprehension and production processes are carried out simultaneously (Christoffels & De Groot, 2005; Lee, 1999). This simultaneity implies, (a) changes of attention between the source language (SL) and the target language (TL) (Danks & Griffin, 1997), (b) increased storage demands to keep in WM the incoming text and the translated information (Gile, 1997), (c) additional operations to coordinate perception and production processes, and (d) mechanisms to avoid phonological interference because of the dual activation of phonological words in two languages (Lambert, 1988; Padilla, Bajo, & Macizo, 2005).

Recent empirical work has supported the greater need of WM resources in translation (Macizo & Bajo, 2004). Macizo and Bajo compared the performance of professional translators in reading and translation of object relative sentences using moving window presentations. Results indicated that compared to reading, on-line comprehension was slower when the participants had to later translate the sentences, and these effects

were larger in the part of the sentence that demanded more WM resources, the relative clause ending. Hence, when participants had to translate, they engaged in processes that consumed more resources from WM than the resources needed for reading, and this slowed down their reading of the more demanding region of the sentence. These data agree with a framework model of translation based on a horizontal/parallel view of the translation task (Gerver, 1976; Macizo & Bajo, 2005). Thus, from this perspective, code-switching processes proceed in parallel to understanding of the source language, that is, reformulation from one linguistic code to another starts before full comprehension of the source language has been completed. These reformulation processes would consume WM resources that would add to the resources needed for within-language comprehension. Hence, reading processes would be harder in translation because of the added demands on WM. This experimental evidence is hard to reconcile with the vertical view of the translation task (Seleskovitch, 1976) which proposes that comprehension and reformulation occurs in a sequential manner, so that reformulation into the TL takes place only after comprehension of the SL has ended. Thus, for the vertical view, comprehension in reading and comprehension during translation involve similar demands and these comprehension processes do not overlap with production in the TL.

In sum, theory and data clearly show the role of WM in comprehension and the higher WM demands when the goal of understanding is translation as opposed to reading. Research on within-language reading suggests some strategies and factors which reduce WM load and improve reading performance: (a) A good text structure (e.g., causal structure, Linderholm et al., 2000) leads the reader to create an integrated text representation, (b) global coherence (Graesser, Singer, & Trabasso, 1994) and local coherence (Britton & Gulgoz, 1991), together, influence readers' ability to create and connect text ideas, and (c) relevance of the information influences text processing by changing the reader's goals and purposes (e.g., Graesser, Hoffman, & Clark, 1980). Some of these ways to improve comprehension rely on the readers' capacity to activate prior knowledge schemas. Activation of background knowledge is a necessary condition to reach good text comprehension (Kinstsch & Franzke, 1995; McNamara & Kintsch, 1996; Voss & Silfies, 1996). For example, Kintsch and Franzke showed the necessity of prior knowledge for constructing a comprehensive representation of the text. Readers without that prior knowledge could not make correct elaborative inferences, resulting in poorer comprehension. Beishuizen, Asscher, Prinsen, and Elshout-Mohr (2003; see also, Beishuizen et al., 2002) found that the presence of relevant examples and main ideas of an expository text increased comprehension.

Students used the examples to construct knowledge structures or to activate their prior knowledge and this improved their understanding of the text.

At first glance, it could be hypothesised that the same strategies and procedures used to reduce WM load in reading can be successfully applied to attenuate cognitive load in translation. Thus, activation of prior knowledge should have a positive effect on translation. However, we should be cautious applying reading strategies to translation because, at least theoretically, activation of prior knowledge has a collateral negative side (Britton et al., 1985). Britton and colleagues propose that previous reading of a summary as a way to activate prior knowledge schemas about the incoming text should have a positive and a negative effect. The positive effect lies in the fact that the presence of a summary before reading a text increases the predictability of its content by activating world knowledge schemas. In other words, if the text organizational structure is known to the reader by means of the summary, the reader can retrieve a schema to make predictions about what will happen next in the text. The activation of previous knowledge will reduce computational demands because the reader will not have to activate all the possible interpretations about the incoming text. However, on the negative side, schema activation by the summary will impose both WM demands and processing time costs since the summary has to be processed and maintained in WM. As Britton et al. (p. 241) point out, there is a trade-off between the resource cost of holding and using a schema, and the benefit of using the schema to predict the incoming text.

The possible costs and benefits of schema activation are of special importance for translation. In fact, part of the interpreters' training concentrates on methods for acquiring and activating knowledge structures that facilitate comprehension of the source message. Also, in professional practice, the translators often ask for written previews of the talks that they should translate in order to activate the relevant knowledge structure to understand the discourse. However, since translation is a highly demanding task, the activation of previous knowledge may cause overload of the available WM resources and hinder comprehension.

Most of the experiments examining the role of prior knowledge over reading comprehension have shown a positive effect (e.g., Kintsch & Franzke, 1995). According to the trade-off associated with the availability of prior knowledge, these results imply a prevalence of the pros over the cons of schema activation. However, none of these studies have introduced tasks that are as highly demanding as translation. The prevalence of benefits over costs might be due to the relatively low demands of understanding during the course of reading. Although reading demands WM resources,

these demands are not excessive and readers are able to handle the cost associated with knowledge activation. However, when a more demanding comprehension task such as translation is involved, the WM load will increase and schema activation might have a negative cost/benefit ratio in text understanding.

The main goal of this study was to explore the use of strategies (knowledge activation by presenting a summary before comprehending the text) to reduce WM demands in translation and reading. In addressing this point we had the opportunity to investigate the role of schema activation in within-language and between-language tasks (reading and translation, respectively) and we were able to test empirically the cost/benefit trade-off of schema activation during the course of comprehension. Furthermore, we evaluated the consequences of using a knowledge-activation strategy for training translators and interpreters.

EXPERIMENT 1

The purpose of this experiment was to explore the effect of knowledge schema activation during the course of translation and reading. Professional translators had to read aloud and translate or to read and repeat texts in the absence of a prior summary or after reading a brief summary. As in previous experiments (Macizo & Bajo, 2004), we expected to find longer reading times (RTs) in translation than in reading. This result would let us know the relative cognitive cost associated with within-language and between-language tasks and it will be congruent with the idea of high WM demands during translation.

Predictions of a summary effect in the reading task were made based on previous results showing improved comprehension after schema activation (e.g., De Vega, Carreiras, Gutiérrez-Calvo, & Alonso, 1990). In a regression analysis, De Vega et al. explored the effect of prior reading of a summary in on-line text comprehension. In their study, the summary had a predictive value of on-line comprehension, speeding up RTs. In this experiment, we wanted to replicate the positive effect of schema activation in reading. We expected faster RTs and better comprehension accuracy after processing a summary during reading. This result would agree with the cost/benefit ratio of summary availability: Reading aloud is not so WM-demanding as to preclude maintenance of activated schemas during the course of reading; therefore, participants get the benefit from schema activation. Thus, the benefit will prevail over the cost. However, the cost/benefit hypothesis would predict a higher cost than benefit in schema

activation when the participants have to carry out a higher WM-demanding task such as translation. Hence, it was predicted that a negative effect of summary would occur when participants have to comprehend texts for later translation.

METHOD

Participants. Sixteen Spanish/English professional translators having more than two years of experience participated in this experiment. They were specialized in a wide variety of topics (technical translations, law, social sciences, etc.). The mean years of experience in translation was 8.83 (*SD* = 2.79) and the mean hours per week that they spent on this task was 32.83 (*SD* = 13.04). They self-rated their proficiency in translation on a ten point scale (1 low proficient, 10 high proficient), and they rated themselves as highly proficient (8.17, *SD* = 0.75). Before performing the actual experiment, the participants were asked to complete a language proficiency questionnaire on reading, writing, listening, and speaking in Spanish (L1) and English (L2). The ratings ranged from 1 to 10 in which 1 was not fluent and 10 was very fluent. The mean fluency in L1 was higher (9.18, *SD* = 0.77) than mean fluency in L2 (7.21, *SD* = 1.53), $p < .01$. This difference suggests that the participants were highly fluent in English but dominant in Spanish. They also completed a Spanish version of the Reading Span Test (Daneman & Carpenter, 1980). The mean span score was 3.97 (*SD* = 0.83), and they were considered as high span readers (WM span higher than 3.5, Miyake et al., 1994).

Materials and Design. A 2 x 2 within-participant model was used in this experiment. The task (reading aloud or translation) and the summary (presence or absence) were manipulated.

Twenty texts written in Spanish were used in the experiment and one more text was introduced for practice (see Appendix for an example). Half of the texts were narratives and the rest were expository. Texts were extracted from original sources. However we omitted some sentences to reduce the text length and to increase text coherence. Number or words per text ranged from 373 to 519 (*M* = 435.75, *SD* = 44.98). The mean number of words for expository texts was 410.60 (*SD* = 35.15), and the mean length for narrative texts was 460.90 (*SD* = 40.38). One expository text was taken from Graesser, Hauft-Smith et al. (1980). The nine other expository texts were selected from *Investigación y Ciencia*, the Spanish translation of the *Scientific American Journal* (see references marked with an asterisk in the reference list). A wide diversity of scientific topics were addressed in

expository texts such as health and biology (biorhythms, muscular aging), environment (atmospheric heating), and technical texts (preservation of food, water recycling), etc. Narrative texts were selected from novels written by Spanish authors. All narrative texts were short stories which introduced persons in a narrative plot with a clear ending.

A short summary was composed in Spanish for each text. Summary length ranged from 20 to 50 words and it introduced the main topics of scientific texts in addition to the plot and main characters from the narrative texts.

In order to evaluate comprehension accuracy, we constructed a paper-and-pencil questionnaire for each text. Each questionnaire included four verification sentences about the text. Participants were asked to decide whether these sentences were true based on their previous reading of the text. Each participant received two true sentences and two false sentences. Across participants, the four verification sentences were balanced and presented in the true version and in the false version an equal number of times. These sentences were more about inferential than literal content. Thus, the sentence "*They went back to the hotel because the wife was sick*" (true sentence, see Appendix), refers to a pragmatic inference which includes connective information never presented in the text. This information is needed to obtain local coherence and to understand further information (the husband was thinking whether to call a doctor).

Procedure. Texts appeared using moving window presentations (Just, Carpenter, & Woolley, 1982). During normal reading functional words (articles, auxiliary verbs, prepositions, conjunctions, etc.) are not usually fixated (Rayner, 1998).When they are presented separately from their respective content words (verbs, adverbs, adjectives, nouns, etc.) they add artificial reading times in the moving window method. In order to avoid these artificial reading times, we used the same procedure as that described by De Vega et al. (1990). Each moving window contained one to three words. Functional words were never presented alone and most of the moving windows contained a functional word and a content word. Participants read at their own pace by pressing the space bar key every time they wanted to see new words. The time between consecutive key presses was recorded as an index of the processing time for the displayed window.

Each participant read twenty texts divided in two blocks. In one block participants were asked to read aloud each text in Spanish every time they pressed the space bar key to see more text. Thus, they were instructed to say aloud each moving window as soon as they read it. In the other block,

participants were asked to translate them into English at the time they saw the text in Spanish. In real contexts, translators do not produce their output instantaneously but they wait to produce the translation until sufficient information has been comprehended and integrated in a meaningful unit (Goldman-Eisler, 1972). Thus, in order to avoid an unnatural form of translation, participants were asked to translate at their own pace and thus, the translated unit did not necessarily correspond to a moving window unit. The instructions to read or to translate were displayed right at the beginning of each text. The order of the blocks was balanced across participants. The order of texts within each block was randomised for each participant. Half of the ten texts to read aloud and half of the ten texts to translate were preceded by a summary. The summary was presented in the middle of the computer screen and participants were told to read and understand it because it would be useful for the reading/translation task. After reading the summary, the text appeared to be read or translated. Right after finishing each text, the verification comprehension test was presented to be completed in about 2 minutes. The experiment was divided in four sessions of five texts each for all the participants. Thus, the participants were called four times in a 2 week period to complete the four experimental sessions. The twenty texts were randomly assigned to one of the four sessions. Across participants the texts were counterbalanced over conditions. The duration of each session was approximately 2h.

Data analyses. In studies of text processing it is hard to control for extraneous factors while isolating variables of interest (Graesser et al., 1980). A way to overcome this problem is to analyze reading times using a multiple regression approach (e.g., Graesser & Riha, 1984; Haberlandt & Graesser, 1985). Therefore, to explore the independent effect of summary on reading and translation after controlling many other factors we analyzed RTs using regression analyses. We controlled for the effect of lexical, sentence and text level factors as well as the effect of visual presentation of the text in the screen (i.e., layout variables) by adding them as control variables in the analyses. The controlled word-level variables included: The word length, the number of syllables, the lexical frequency of words in Spanish (Alameda & Cuetos, 1995), the polysemy or the number of meanings of a word, etc. The controlled sentence-level variables included two sentence boundary variables which specified whether a word was at the beginning or at the end of a sentence versus at other positions; the metaphoric value of the sentence by means of metaphoric ratings; the imagery value of the sentence by means of sentence imagery ratings; and the cumulative number of propositions in a sentence. The text-level

variables included the beginning or the end of a paragraph versus other positions of the paragraph; the serial position of a sentence in a text; and anaphora, which indicated whether a word made reference to other words previously presented in the text. Finally, the layout variables included the beginning of line, the end of line, the beginning of screen and the end of screen (descriptive values of these variables were reported in Macizo, 2003).

The RTs which exceeded a criterion of 3 *SD* for an individual participant's mean were replaced by the cut-off value (2.81 % of the data). We averaged the readers' data in each moving window of each text (see Haberlandt & Graesser, 1985; De Vega et al., 1990; for a similar approach). A matrix was arranged computing separate means for readers in each moving window for the reading condition and a similar matrix was composed for the translation condition. All the predictor variables were included simultaneously in the analyses, in order to explore the specific impact of summary factor after controlling the effects of the other predictors (De Vega et al., 1990). To further explore differences between pairs of conditions and the direction of these differences, two-tailed *t*-test comparisons were performed. The *t* values assessed whether a specific predictor (the summary factor, in our study) made a unique contribution to the variance in RTs (Cohen & Cohen, 1975).

We also analyzed the percentage of errors in the verification task as a function of the type of task and presence/absence of a summary. Following the analyses of reading times, *t*-tests were carried out on the mean percentage of error for the twenty texts used in the study.

RESULTS AND DISCUSSION

Oral productions in the reading aloud and the translation tasks were recorded and their general quality was evaluated. In this and all other experiments in this paper, quality of task performance was measured by scoring each text for how well the participant performed the production task. Each production was rated from 1 to 5 where 1 indicated very poor production and 5 indicated very good production. The scoring system emphasized both how well the global meaning of the input was preserved and how well the lexical and syntactic constructions matched those of the target language. The mean quality in the reading aloud task was 4.26 (*SD* = 0.29) and mean quality for the translated sentences was 4.19 (*SD* = 0.27). The summary effect was not significant in either reading aloud, $t(15) = 0.71$, $p > .49$, or translation, $t(15) = 1.29$, $p > .21$. Thus, the quality of oral productions is not sensitive to manipulations related to the comprehension

process. This lack of sensitivity of production measures agrees with the result of previous studies (Macizo & Bajo, 2006; Ruiz, Paredes, Macizo, & Bajo, in press).

The mean RT in the reading aloud condition was 981 ms (*SD* = 839), whereas the mean was 1528 ms (*SD* = 1403) in the translation condition. Thus, readers in the translation condition spent significantly more time processing text than participants did in the reading aloud condition, $t(16381) = -49.04$, $p < .001$. The summary factor significantly predicted both RT variance in the reading aloud condition, $B = .04$, $t = 4.86$, $p < .001$, and RT variance in the translation condition, $B = -.04$, $t = -6.13$, $p < .001$. Changes in the positive/negative value of the regression coefficient imply an opposite effect of the summary depending on the task. In fact, *t*-test comparisons revealed that summary and RTs relation significantly varied based on the task. The availability of a summary before reading aloud the text speeded up RTs (956 ms, *SD* = 787), as compared to RTs without a prior summary (1019 ms, *SD* = 910), $t(16380) = -4.70$, $p < .001$. However, the availability of a summary before translation slowed down RTs (1575 ms, *SD* = 1467), as compared to translation without a prior summary (1458 ms, *SD* =1301), $t(16380) = 5.24$, $p < .001$ (see Figure 1).

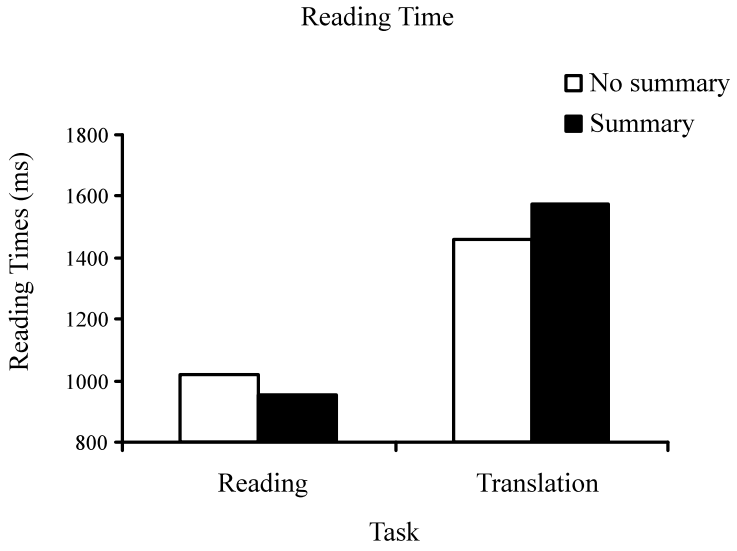

Figure 1. Mean reading times (in milliseconds) as a function of task (reading or translation) and summary (yes or no) in Experiment 1.

The same pattern of results was found on errors in the verification task. When participants read aloud texts after a summary they produced fewer errors (5.3 %, *SD* = 5.1) than after reading aloud without a summary (10.3 %, *SD* = 7.6), $t(19) = -3.39$, $p < .003$. However, when they had to translate, the opposite pattern of summary effect was found. Texts translated after a summary produced more verification errors (8.1 %, *SD* = 6.4) than texts translated without a previous summary (4.7 %, *SD* = 4.5). This effect was close to significant, $t(19) = 1.87$, $p < .07$ (see Figure 2).

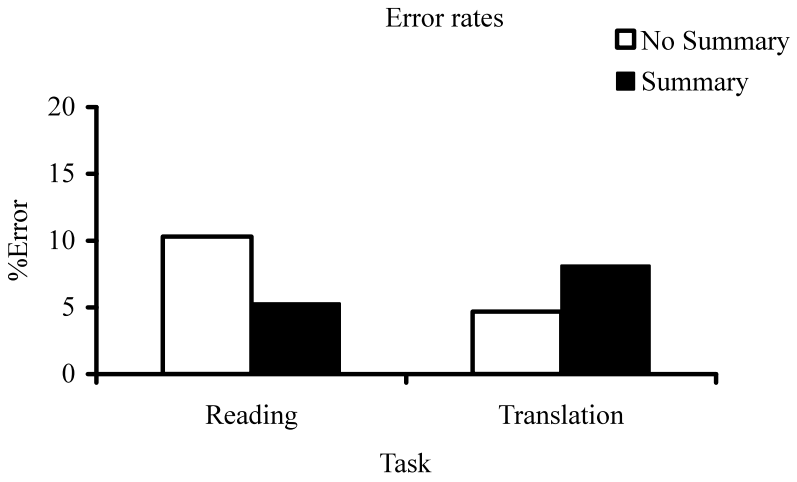

Figure 2. Error rates in sentence verification as a function of task (reading or translation) and summary (yes or no) in Experiment 1.

Hence, when translators had to read aloud, reading times and comprehension accuracy were positively affected by the presence of a summary prior to understanding. However, when participants had to translate, RTs became slower and comprehension became less accurate when the text was preceded by a summary.

It is important to note that the text materials and summaries used in the experiment were the same for the translation and reading conditions so that any difference between reading and translation in the effect of the summary might be due to the relative WM demands imposed by the task. Thus, translation demands more WM resources than the reading task. Accordingly, RTs were slower and comprehension accuracy was poorer when participants were asked to translate the sentences than when they were asked to repeat them (see Macizo & Bajo, 2004, for similar results). This

suggest that reading for translation, probably because of the additional code-switching processes involved (Grosjean, 1997), is a highly demanding task, so that participants cannot deal with the cost associated with schema activation. In contrast, readers benefited from schema activation when reading for repetition because of the low cognitive cost associated with within-language tasks as compared to between-language tasks.

In sum, schema activation by a prior summary facilitates understanding when reading aloud, but it makes it harder when reading for translation. However, before concluding that comprehension for translation is hindered by the presence of a summary, this interfering effect should be replicated and generalized to other translation tasks. Macizo & Bajo (2007) have classified the forms of translation in two dimensions: the oral or visual nature of the input SL text (interpreting and translation, respectively) and the simultaneity of the SL comprehension and TL production. The translation task used in Experiment 1 is called sight translation (or simultaneous translation, McDonald & Carpenter, 1981) in which professionals are required to read sentences at their own pace and try to translate them as they go along. Sight translation is the highest demanding form of translation since (a) the translator has to continuously produce the output in the TL under time pressure and (b) the perception-production delay is very short and, thus, the degree of overlapping between SL comprehension and TL production is very high. It could be, therefore, argued that the negative summary effect observed in Experiment 1 only apply to sight translation in which WM demands are extreme. Hence, the paradoxical influence of schema activation could be a local effect that might not be observed in other varieties of translation. Experiment 2 examines this possibility by introducing a new modality of translation while manipulating the availability of a summary before translating texts.

EXPERIMENT 2

The results of Experiment 1 indicated that the presence of a summary before reading the text influenced reading and translation in a paradoxical way. When participants had to read texts, the summary positively affected RTs and comprehension accuracy. This effect replicates previous studies demonstrating the positive influence of prior knowledge over reading comprehension (e.g., Kintsch & Franzke, 1995). However, the presence of a summary before translation slowed down reading times and made comprehension less accurate. The aim of Experiment 2 was to replicate the paradoxical interference effect of schema activation and extend it to a new

modality of translation task, semi-consecutive translation (Macizo & Bajo, 2007). In this task the written text has to be orally produced in the TL but, in contrast to the sight translation task used in Experiment 1, in which the professionals have to read and generate the SL text concurrently, in semi-consecutive translation the translators alternate between reading and speaking periods. Therefore, the presence of a summary before the task was manipulated and participants were asked to silently read each sentence of the Spanish text and, afterward, translate them into English.

METHOD

Participants. Ten professional translators participated in Experiment 2. We attempted to match them in professional experience, L1-L2 language fluency and WM capacity to the participants in Experiment 1. The mean years of experience in translation was 8.80 (*SD* = 5.29), the mean hours per week they spent working on translation was 29.80 (*SD* = 14.08), and their mean ratings on translation proficiency was 8.20 (*SD* = 0.63). The participants' mean fluency in L1 and L2 was 9.30, *SD* = 0.93, and 7.25, *SD* = 1.44, respectively. The mean reading span score for the total set of participants was 4.05 (*SD* = 0.89). A series of *t*-tests was performed to compare the experience in translation, L1-L2 language fluency and WM span of the participants in the two experiments. All of these comparisons yielded *p* values > .67. Hence, both groups of translators were similar in translation proficiency, L1 and L2 language proficiency and WM span.

Materials and Design. The presence of a summary before presenting the text to be translated (presence or absence) was manipulated within participants. In order to make easier the experimental task, we selected five narrative texts from Experiment 1[1] (see Experiment 1, *Method* section, for more details). The summaries and verification sentences were also those corresponding to narrative texts of Experiment 1.

[1] We decided to only use narrative texts in Experiments 2 and 3. Limiting the type of text to only narratives should not change the effects obtained in Experiments 2 and 3, since the effect of summary and type of task in Experiment 1 was similar for narrative and expository texts. New analyses indicated that narrative texts were read faster than expository texts (263 ms difference, $p < .001$). However, the Summary x Task interaction was significant in both narrative and expository texts ($ps < .001$). Facilitation effects were obtained by the summary in reading aloud while interference effects were obtained by the summary in translation.

Procedure. Each participant received two texts using moving window presentations (Just et al., 1982). Participants were asked to understand each sentence and to say its English translation after finishing reading it. One text was preceded by a summary; the other text was presented without a summary. When the summary was presented, participants were told to read and understand it because it will be useful for the translation task. The order of the summary (presence or absence) was balanced across participants.

The selected five texts were randomly assigned to the ten participants of this experiment. Across participants each text was presented four times (two times preceded by a summary). A participant never received the same text twice. As in the previous experiment, at the end of each text a verification task was presented to be completed in about 2 minutes. The duration of the experiment was approximately 90 minutes, including breaks after each text. All other details of the procedure were identical to those in Experiment 1.

Data analyses. Reaction times were analysed using the same regression approach as that reported in Experiment 1. The latencies that exceeded a criterion of 3 *SD* for an individual participant's mean were replaced by the filter value (1.82 % of the data). Comprehension accuracy of the sentences was analysed by looking at the error rates of the responses in the verification task. As in Experiment 1, for the analyses of both RTs and error rates on the verification task *t*-test comparisons were carried out.

RESULTS AND DISCUSSION

As in Experiment 1, oral productions were rated using a five point scale (1 = very poor quality, 5 = very good quality). The scoring procedure was identical to that used in the previous experiment. The mean quality of translations without a summary was 4.41 (SD = 0.64), and the mean quality of translations with a summary was 4.33 (SD = 0.63). The effect of summary was not significant, $t(9) = 0.26$, $p > .80$.

The mean RT in the translation conditions was 682 ms (SD = 326). The summary factor significantly predicted RT variance, $B = -.13$, $t = -6.85$, $p < .0001$. Further *t*-test comparisons revealed that the presence of a summary increased RTs (724 ms, SD = 376) relative to the condition in which the summary was absent (641 ms, SD = 259.42), $t(1316) = -7.69$, $p < .0001$ (see Figure 3).

The mean percentage of errors in the verification task was 20.0 % (see Figure 4). The presence of a summary marginally affected comprehension

accuracy for translation, $t(4) = 2.45$, $p > .07$. When a summary was available before translating, comprehension was poorer (26.0 %, *SD* = 20.7, of errors) than when there was no summary before the task (14.0 %, *SD* = 13.4, of errors).

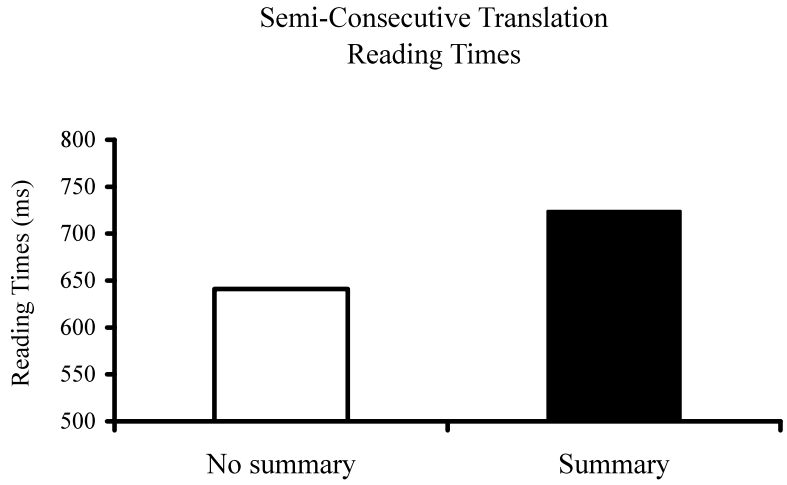

Figure 3. Mean reading times in semi-consecutive translation (in milliseconds) as a function of summary (yes or no) in Experiment 2.

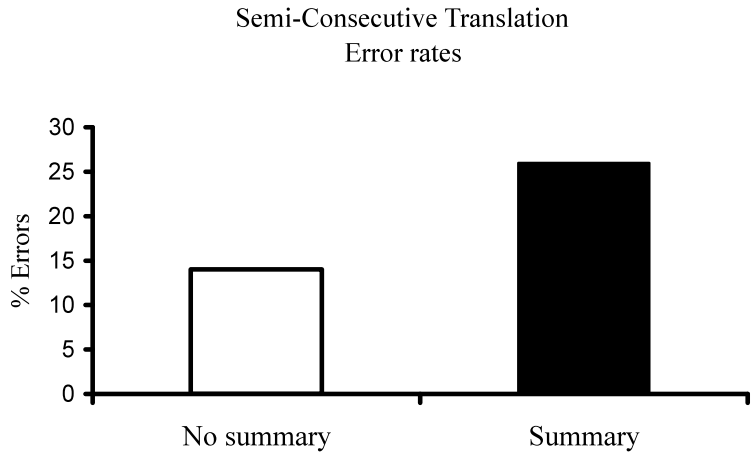

Figure 4. Error rates in sentence verification as a function of summary (yes or no) in semi-consecutive translation of Experiment 2.

In sum, the results of this experiment replicated the paradoxical interference effect of summary in translation. The translators slowed down reading times when they had to translate texts after a summary. Therefore, we replicated the negative effect of knowledge activation by the presence of a summary observed in sight translation (Experiment 1) and we also extended this result to semi-consecutive translation. Although the summary had the same effect in Experiment 1 and 2, the participants were faster in the last experiment. This could be due to the experimental task since, in Experiment 1, participants had to understand the SL at the time they were producing the TL (simultaneous translation), while in Experiment 2 oral productions were delayed at the end of each sentence (semi-consecutive translation). In addition, faster reading times in Experiment 2 could be due to the fact that participants were reading only narrative texts as compared to the narrative and expository texts read in Experiment 1 (see footnote 1).

The cost associated with presenting a summary before translating texts might be due to the overload imposed on working memory by having to access lexical and syntactic entries in the TL while maintaining the information provided by the summary. Previous work has demonstrated that even in the semi-consecutive translation task used in Experiment 2, in which the overlap between SL perception and TL production is low, the translators retrieve TL properties before finishing the SL understanding (Macizo & Bajo, 2006). This early access to TL might increase WM demand during the course of SL reading. We will discuss this point later. On the contrary, reading a text is not highly demanding; therefore, participants can handle the activation of prior knowledge which benefit their text understanding (Experiment 1). The purpose of Experiment 3 was to directly test that the low demands on WM imposed by the reading task allow participants to benefit from schema activation. In the next experiment WM load was added to the presence of a summary while participants read texts. According to the cost/benefit ratio of processing a summary (Britton et al., 1985), participants might not be able to manage the cost associated with schema activation under this overloaded reading situation.

EXPERIMENT 3

The purpose of this experiment was to find more direct evidence to support the WM load interpretation of the schema activation effect. In order to equate the timing of the reading condition to that used in the semi-consecutive translation task of Experiment 2, in this experiment participants had to read each sentence and repeat it once they finished reading. The

reading and repeating condition (without a summary) was compared to a critical condition in which a summary was presented and a WM load was added. In doing this, we followed Baddeley and Hitch's (1974) classic study which demonstrated that the concurrent performance of a memory task interfered with prose comprehension. Thus, in Experiment 3 translators were presented a text after a summary and they had to read it while maintaining three digits in their WM. If participants can benefit from the presence of a summary before reading a text so long as they have enough resources to handle schema activation, this benefit from the summary should not be present or even revert to interference when a WM load is introduced and the WM demands are increased.

METHOD

Participants. The same ten professional translators that participated in Experiment 2 were called again to participate in Experiment 3.

Materials and Design. Two levels were manipulated within participants: (a) reading without a summary and without WM load, (b) reading with summary and WM load. The texts, summaries and verification sentences were the same as those used in Experiment 2.

Procedure. The selected five texts were randomly assigned to the ten participants of this experiment. Across participants each text was presented four times (two times preceded by a summary under WM load). A participant never received the same text twice. In addition, the texts presented to a participant were different to those she/he received in Experiment 2.

Each participant received two texts using moving window presentations (Just et al., 1982). Participants were asked to understand each sentence of the texts and to say it aloud at the end of the current sentence. One text was presented without a summary; the other text was presented with a summary under WM load. When the summary was presented, participants were told to read and understand it because it will be useful for the reading task. The order of these two conditions was balanced across participants. In the reading after summary under WM load condition, a digit recall task was included (Baddeley & Hitch, 1974): Before each sentence to be read, three numbers were presented in the middle of the computer screen for 3s. They were randomly presented (single digit numbers that ranged from 1 to 9). Participants were instructed to maintain these numbers and to

recall them at the end of reading the current sentence. As in the previous experiment, at the end of each text a verification task was presented to be completed in about 2 minutes. The duration of the experiment was approximately 90 minutes, including breaks after each text. All other details of the procedure were identical to those in Experiment 2.

Data analyses. Reaction times were analysed using the same regression approach as that reported in previous experiments. The latencies that exceeded a criterion of 3 *SD* for an individual participant's mean were replaced by the filter value (1.92 % of the data). Comprehension accuracy of the sentences was analysed by looking at the error rates of the responses in the verification task. As in previous experiments, for the analyses of both RTs and error rates on the verification task *t*-test comparisons were carried out.

RESULTS AND DISCUSSION

Oral production quality was evaluated with the same five point scale used in previous experiments (1 = very poor, 5 = very good). The mean quality of oral repetitions in the reading without a summary and without WM load (4.31, $SD = 0.70$), was similar to the mean quality in the reading with a summary and WM load (4.26, $SD = 0.59$), $t(9) = 0.15$, $p > .88$.

The mean RT was 602 ms, $SD = 205$, $t(2633) = -12.03$, $p < .0001$. The summary factor did not predict RT variance in the reading and repeating condition, $B = -.0002$, $t = -0.01$, $p > .99$. When WM load was added to the reading after a summary, no differences were found between reading with summary (602 ms, $SD = 209$) and reading without it (602 ms, $SD = 202$), $t(1316) = -0.11$, $p > .91$ (see Figure 5).

The mean percentage of errors in the verification task was 19.0 % (see Figure 6). The inclusion of a WM load in the reading plus summary condition reduced comprehension accuracy (24.0 %, $SD = 11.4$, of errors), as opposed to reading without a summary (14.0 %, $SD = 11.4$ of errors), $t(4) = -3.16$, $p < .03$.

The results obtained in this experiment support a WM load interpretation of the summary effect. In contrast to the facilitation effect obtained by the summary in the reading aloud condition of Experiment 1, this effect was not reliable when a WM memory load was added to the reading and repeating task. This result suggests that when the cognitive load in reading increases, participants cannot get benefit from the activation of knowledge schemas. In fact, comprehension accuracy was impaired when

the cognitive load was added to reading and a summary was presented before reading the text.

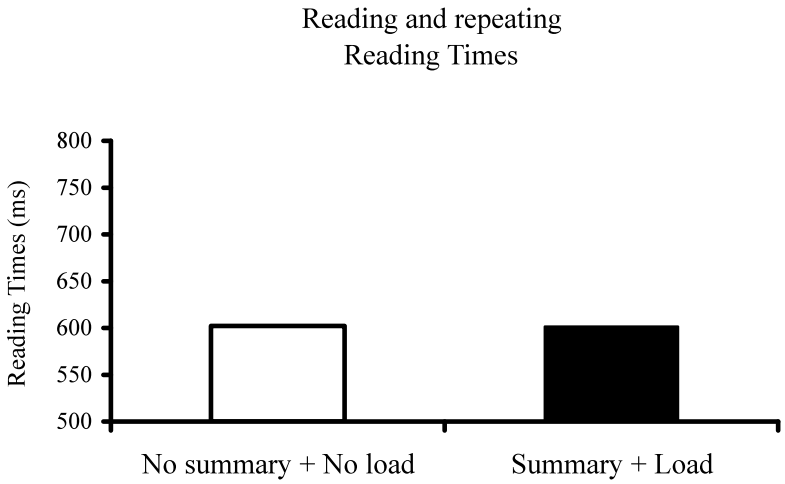

Figure 5. Mean reading times in reading (in milliseconds) as a function of the condition (no summary + no load vs. summary + load) in Experiment 3.

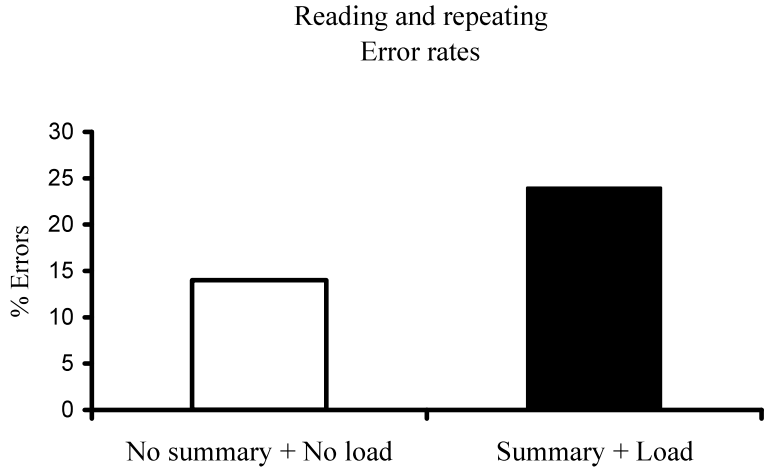

Figure 6. Error rates in sentence verification in reading as a function of the condition (no summary + no load vs. summary + load) in Experiment 3.

When comparing the overall reading times in the reading conditions of Experiments 1 and 3, we observed that participants took longer to read texts in the Experiment 1. These longer RTs seem to suggest that reading times in Experiment 1 were an index of both the time needed to comprehend the texts and the time required to say them aloud. The faster overall RT in Experiment 3 might indicate that reading times in this experiment corresponded with the time participants spent comprehending texts without the implication of any additional production processes since oral productions were carried out right after sentence comprehension was finished. Therefore, the methodology used in Experiment 3 seems to be more appropriate to directly obtain a measure of on-line comprehension when reading texts.

GENERAL DISCUSSION

In three experiments, we examined the effect of knowledge schema activation when professional translators had to read and translate and to read and repeat texts. Schema activation is assumed to be the mechanism underlying some strategies that facilitate reading, including the presentation of a summary, the presence of external pictorial and verbal cues, and good text structures (Britton & Gulgoz, 1991; Graesser et al., 1994; Linderholm et al., 2000; Plass, Chun, Mayer, & Leutner, 2003). Studies in reading have shown that these strategies reduce RTs and improve comprehension. They have been successfully applied in children's language learning (Yeung, Jin, & Sweller, 1998; Experiment 1), and they have been shown to be useful for children with reading comprehension difficulties (Cain, 2003). Most of these strategies rely on knowledge activation. Prior knowledge schema activation leads readers to create a mental representation which guides the understanding of incoming information (e.g., Kintsch & Franzke, 1995). Consistent with previous findings, results obtained in Experiment 1 showed the positive effect of knowledge activation in reading aloud. Participants who read aloud after a summary increased their speed of understanding and they had better comprehension accuracy of the texts.

However, the activation of prior knowledge before text understanding is not always positive and its effects seem to depend on the cost associated with schema activation and on the processes involved in understanding. Britton et al. (1985) pointed out the possible negative effect of schema activation during the course of reading. According to the workbench model of text processing proposed by Britton et al., some elements called "prefetching" brought to working space before the reading task begins, have

advantages for understanding, because they increase the predictability of incoming texts. Presentations of summaries, advance organizers, informative titles, outlines, headings, etc., are examples of those prefetching elements (see Mayer, 1979). However, the advantages of prefetching must be balanced against the cost associated with prefetching. One cost is the lack of WM capacity during comprehension. Thus, this model of reading assumes that "during complex reading tasks multiple processes cannot all be present on the cognitive workbench simultaneously (at the same instant of time) because the capacity of the workbench is, in general, too small to hold them all" (Britton et al., p. 232). Translation has shown to be one of these complex tasks (see Macizo & Bajo, 2005, for a review). Thus, results from our experiments demonstrated that reading times were slower and the accuracy of comprehension was poorer in the translation than in the reading conditions.

According to the workbench model of text processing, the paradoxical effect found in translation is to be expected since the readers are trying to use the summary to activate prior knowledge schemas at the same time that they are performing the additional processes involved in translation. These predictions were confirmed in this study. In Experiments 1 and 2, RTs increased and the accuracy in answering comprehension questions decreased when participants translated after a summary relative to conditions in which they translated without it. Thus, high WM demands in translation make it more difficult for readers to benefit from knowledge activation. Experiment 3 demonstrated that the paradoxical effect of schema activation, positive in reading and negative in translation, was due to the differences in cognitive costs associated with within-language and between-language tasks. When a WM load was added to the reading and repeating task, the presentation of a summary had no effect on the speed of the comprehension. Hence, the increase of cognitive load in reading reverses the facilitation effect of a summary (Experiment 1) to a null effect with a tendency to interference (Experiment 3).

Additional support for the interference derived from knowledge activation comes from second language learning studies. Yeung et al. (1998) investigated the effect of explanatory notes in reading passages on comprehension. Explanatory notes integrated with the text improved comprehension for readers in their L1 (Experiment 1). However, explanatory notes reduced comprehension when the reading task was in the participant's L2 (Experiment 5). Thus, the effect of strategies to improve understanding (i.e., presentation of explanatory notes or a summary during reading) seems to depend on the cognitive load associated with the task. Simple comprehension tasks such as reading in L1 are facilitated by the use

of these strategies, however, complex tasks such as L2 reading or translation are hindered by them.

Several alternative explanations may determine the relation between the cognitive load and the summary effect. One possibility is that readers had difficulties in generating the inferences needed to understand the text under the extreme situation of translating and active schema-maintenance associated to the summary condition. For example, it has been demonstrated the relation between WM capacity and the generation of elaborative inferences during the course of reading (Singer, Andrusiak, Reisdorf, & Black, 1992; Yuill, Oakhill, & Parkin, 1989). Singer et al. (1992) showed that participants with high WM capacity produced more and faster connective inferences than participants with low WM capacity when they read a text. Similarly, the presentation of the summary might have reduced WM resources when participants understood for translation so that they might have not been able to generate connective inferences (e.g., *the wife was sick*, in the example reported in Appendix) needed to establish local coherence (the husband was thinking whether to call a doctor because his wife was sick). It is also possible that readers compared the schema activated by the summary with the schema that they were creating on-line during the course of reading. This comparison process may increase WM load reducing understanding in a WM demanding task.

Demands on Working Memory in translation tasks

We have stated that any difference between reading and translation on the effect of the summary has to be due to the relative higher WM demands imposed by the later task. In a broad sense, WM can be defined as a general purpose short-term memory system involved in the temporary processing and storage of information (Baddeley, 2000, see Miyake & Shah, 1999, for a discussion about WM definitions). In this framework, it is hard to define the relative WM demands associated with the several processes involved in translation tasks. Translation is a complex demanding task because (a) several processes take place at one moment in time, (b) additional operations are needed such us between-language code-switching to transform earlier linguistic segments from source to target language, (c) the task is usually performed under time pressure, (d) translators have to overcome the phonological interference produced by the concurrent SL comprehension while overtly articulating the TL speech, etc. Gile (1997) attempted to specify the factors that increase WM demands in translation and define as "efforts" the relative costs associated with the processes involved in translation and interpreting. These efforts are related to SL

comprehension, TL production, coordination between these operations and efforts devoted to manage several factors including the lag between the SL comprehension and TL production.

One way to demonstrate the higher WM demands during translation is to evaluate within and between language tasks while manipulating the SL. Recent studies have followed this strategy by comparing pairs of tasks in which translators processed SL information varying in complexity (interlexical homographs vs. control words; Macizo & Bajo, 2006; complex relative sentences vs. control sentences; Macizo & Bajo, 2004). These studies converge on the conclusion that it is hard to cope with WM demands because of the SL complexity in translation. The work reported here has extended the comparison between tasks by contrasting reading, sight translation and semi-consecutive translation. This multi-task comparison allowed us to isolate the specific reason why SL comprehension becomes difficult in translation tasks.

The presence of a summary hinders SL understanding in sight translation as compared to reading (Experiment 1). We argued that translators cannot deal with the cost associated with schema activation because they are performing SL-TL code-switching processes at the time they understand. However, the differences between reading and sight translation could be interpreted not as due to the additional reformulation processes required in translation but as due to the simultaneity of the SL perception/ TL production or to the phonological interference produced by the concurrent processing of two language streams. Experiment 2 ruled out these alternative explanations since the same negative effect of summary on SL understanding was replicated when professionals performed semi-consecutive translation. In semi-consecutive translation participants first read a sentence and, afterward, they proceed to translate it. Therefore, neither perception/production simultaneity nor phonological interference is possible in semi-consecutive translation. Rather, the search of semantic matches between the lexical and syntactic entries in the SL/TL languages (code-switching process) seems to underlie the difficulty of handling the cost associated with maintain schemas activated during the course of understanding in translation. In fact, in agreement with horizontal views of translation proposing parallel access to the TL before the SL has been fully understood (Gerver, 1976; Macizo & Bajo, 2006), previous studies have demonstrated that before finishing the understanding process in semi-consecutive translation, the professionals retrieve lexical and syntactic TL properties (Macizo & Bajo, 2006; Ruiz et al., in press). This parallel access produces slower reading times and poorer comprehension in translation than in reading conditions (e.g., Macizo & Bajo, 2006). The same lower

performance in translation (Experiments 1 and 2) than in reading (Experiments 1 and 3) is observed in this study and reflects the higher cost associated with translation tasks.

Implications for training translators

In this study we have explored two types of translation, sight translation (Experiment 1) and semi-consecutive translation (Experiment 2). The experiments were designed to implement the natural conditions in which translators work everyday. We used the moving window technique which produces similar reading patterns that those observed in normal reading (e.g., Just et al., 1982). Moreover, in Experiment 1, participants were asked to translate at their own pace, thus resembling natural sight translation in which they do not produce word-by-word translations (Goldman-Eisler, 1972). In semi-consecutive translation the written text has to be orally produced in the TL so they alternate between reading and speaking. This contrasts with sight translation where the professional has to read and rephrase the SL text simultaneously. The alternations between comprehension and production were implemented in our Experiment 2 by asking participants to produce the translation at the end of each sentence. Thus, the results obtained in our experiments may be generalizable to everyday situations in which the translators work.

The present study has applied implications for training translators and interpreters. A recent approach in teaching translation is called the "process-oriented perspective" (Gile, 1994; Martins, 1992). According to this view, students of translation receive training in the cognitive processes involved in translation and interpretation. For example, the sequential model of translation proposed by Gile is a pedagogical view of training translators by focusing on two main phases, comprehension and reformulation. From this study it can be drawn that not all of the strategies that have been shown useful in reading have the same positive effect on translation. When translation strategies impose high WM resources such as the activation of schemas before translating texts, they hinder the translators' comprehension processes. Therefore, low WM demanding strategies should be used to help translators' performance without increasing cognitive load in translation. For example Agrifoglio (2004, p. 61) suggests that one of the most effective strategies to reduce WM demands in translation would be to mark key elements and segment units during a preparation phase in which translators were allowed to identify grammatical structures that differ markedly between the source and the target language. Gile (1995) describes a similar strategy based on the use of slashes and brackets to separate subordinate

clauses from main clauses. Probably, the activation of these grammatical structures might facilitate the translation processes without increasing cognitive demands.

The results of this study also point out the necessity to train the novice translators' memory skills so that they can use external aids such as summaries or annotations without having an extra-cost in processing. These memory skills might include training in coordinating comprehension and production since these processes increase WM load during the course of the translation (Gile, 1997). It has been shown that professional translators and interpreters are able to manage the production of the target language at the time they are processing the source language (e.g., Bajo, Padilla, & Padilla, 2000). Therefore, inexperienced translators should be trained in coordinating perception and production of verbal information as a way to reduce WM load in translation so that they could dedicate WM resources to the processing of external aids.

In sum, the results of this study show a paradoxical effect of schema activation based on the type of task and the relative cost associated with the understanding processes. In reading tasks, the reader can activate and maintain relevant knowledge and make predictions about what they are going to read before the presentation of the text, and this would benefit understanding. However, when the purpose of reading is translation, the translators do not have enough resources to benefit from activated knowledge schemas. These results have important implications for teaching translators and interpreters.

RESUMEN

Activación de esquemas en traducción y lectura: Un efecto paradójico. En tres experimentos examinamos el efecto de la activación de esquemas en traductores profesionales que tenían que leer y traducir o leer en voz alta textos presentados visualmente. En el Experimento 1, la comprensión de textos se vio mejorada por la presentación de un resumen antes de la lectura de textos en voz alta. Sin embargo, la presentación previa de un resumen redujo la comprensión cuando los participantes tenían que traducirlos (traducción a vista). La interferencia producida por la lectura del resumen fue replicada en traducción semi-consecutiva (Experimento 2). En el Experimento 3, exploramos la naturaleza de este efecto paradójico manipulando la carga en memoria de trabajo (MT) asociada a la lectura. Cuando se incrementó la carga en MT, el beneficio asociado a la presentación del resumen en lectura desapareció. Los resultados son discutidos en términos de una hipótesis del coste/beneficio de la activación de esquemas durante la comprensión. Las implicaciones para el entrenamiento de traductores también son evaluadas.

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APPENDIX

Example of narrative text used in the Experiments (Marías, 1999). Texts were presented in Spanish. The English translation is presented here.

Summary

A woman felt unwell on her honeymoon. The husband went to the balcony in his hotel room. He saw a person waiting on the street.

Text

My wife had felt unwell and we had quickly returned to the hotel room, where she had gone to bed shivering and with slight nausea and a slight fever. We did not want to ring a doctor immediately in case it passed and because we were on our honeymoon and that is a journey on which you do not want the intrusion of a stranger, even for a medical examination.

We were in Seville, in a hotel which was protected from the traffic by a terrace which separated it from the street. While my wife went to sleep (she seem to go to sleep as soon as I put her to bed and tucked her in), I decided to keep quiet, and the best means of achieving this and not be tempted to make a noise or speak to her because I was bored was to go to the balcony and look out and see the people go past.

I was looking outside and thinking about the inside, but suddenly I picked a person out, and I picked her out because unlike the others, who walked past to for a moment then disappeared, this person remained motionless where she was. She was a woman around thirty seen from a distance, wearing an almost sleeveless blue blouse and a white skirt and high-heeled shoes that were also white. She was waiting, her stance was one of unmistakable waiting, because from time to time she walked one or two steps to the right or left, and with her last step dragged the sharp heel of one foot or the other, a movement of restrained impatience.

She suddenly looked up, towards the third floor where I was, and it seemed to me that she was noticing me for the first time. She peered, as if she was short-sighted or had dirty contact lenses, she blinked her eyes a little so as to see better, it seemed to me that it was me she was looking at. But I did not know anyone in Seville, what is more, it was the first time I had been in Seville.

Verification sentences

They went back to the hotel because the husband was sick. (false)

The husband went to the balcony just to see people passing by. (true)

The husband saw a woman talking on the street. (false)

The woman on the street did not speak to the husband. (true)