THE EFFECT OF BACKGROUND KNOWLEDGE ON FIRST AND SECOND LANGUAGE COMPREHENSION DIFFICULTY ··

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ABSTRACT

First and proficient second language users listened to a passage while concurrently performing a calculation verification task. The number of correct calculations achieved in the dual-task was compared to a single-task condition to index difficulty of language comprehension. Access to background knowledge was manipulated between participants by the presentation of a topic sentence. The difference between first and second language comprehension difficulty was greater when background knowledge was unavailable than when it was available. As each participant relied solely upon information from the speech signal for comprehension when the topic of the passage was not provided, it was concluded that the processes involved in decoding the speech signal generally consume more resources in second language than first language users.

1. INTRODUCTION

Second language comprehension is accompanied by a large amount of mental effort in the early stages of acquisition, but this is assumed to disappear as the processes involved in comprehension become more automatic (e.g. [1]). However, experimental studies of difficulty in second language comprehension are scarce (e.g. [1-3]) and none have compared first language users with proficient second language users. Therefore, the aim of the present study is to examine comprehension difficulty in proficient second language users.

The notion of proficiency in a second language is controversial. The selection of second language users who score highly on language tests which are based on the performance of first language users could allow one to fall prey to the "native speaker fallacy" [4]. That is, it is possible that the outcome of second language acquisition is qualitatively different from first language acquisition. The exclusion of certain second language users based upon their apparent "failure" to perform near native levels on language tests may actually introduce a bias. The distinction between first and second language users is also controversial, as the issue of maturational constraints on language acquisition is still being debated. The sample of second language users used by Johnson *et al.* [5, 6] overcomes these concerns by selecting participants who were not exposed to English before the age of 10, arrived in their English speaking country of residence after the age of 15, and had been living in that country for at least 5 years. They claim that these individuals have reached an end-state in their second language acquisition. The use of this sample avoids any preconceptions about the nature of a developed second language system. This study will adopt the same sampling criteria for its proficient second language comprehenders.

The concept of difficulty, or mental effort, can be found in theories of attention. Just and Carpenter's model of working memory [7] is a theory of attention concerning language comprehension. It claims that human comprehension ability is constrained by a pool of resources which fuels both storage and computation. Higher demands on processing result in less available resources for storage. Difficulty in comprehension occurs when the available pool of working memory resources is inadequate to cope with the demands of storage and computation.

Comprehension is another concept which is in need of definition, as one can talk of comprehending words, phrases, sentences or discourse [8]. Furthermore, comprehension processes are not necessarily specific to language, but may also apply to our understanding of the physical and social worlds [9]. According to mental model theorists, comprehension involves the building of a structure. In the linguistic domain, the comprehension of a message requires that combinations of words be used to construct a set of representations of entities in contact, which form a mental model [8]. A particular mental model can receive activation from various inputs such as the speech signal and sensory systems, and the theory is compatible with the notions of capacity limitations such as those espoused by Just and Carpenter's theory of working memory. In order to isolate the difficulty of specifically linguistic processing, as opposed to comprehension in general, it is necessary to control for information from other sources.

Previously formed mental models can also be adapted to aid in the comprehension of a new situation. This is consistent with the well-established finding that access to background knowledge can facilitate recall from a passage. Bransford and Johnson [10] created passages with vague, anaphoric references. Recall of ideas from these passages was facilitated when they were preceded by a topic sentence or relevant picture. In terms of the theories presented, when listeners do not have access to the topic, they must devote all of their working memory capacity to the formation of a mental model, leaving fewer resources available for storage. On the other hand, those who are given the topic are able to adapt an existing mental model, thus leaving more available resources for the storage of information.

Similarly, late second language learners come to the acquisition process with prior knowledge which may ameliorate their difficulty of comprehension. If an existing mental model can be adapted, then less information is required from the speech signal for comprehension to occur.

This is partially confirmed by several studies which have found that second language students are able to recall more information from passages when the topic is familiar than when it is unfamiliar (e.g. [11, 12]). However, recall does not necessarily provide information about difficulty of comprehension. Recall necessarily follows comprehension and may involve processes of construction or reconstruction [13]. Therefore, the present study requires a measurement of difficulty *during* comprehension, rather than *a posteriori*.

A dual-task method was developed for the purpose of measuring comprehension difficulty on-line. It involved the presentation of single-digit calculations next to a total which was either correct or incorrect. The number of correct verifications scored during comprehension was compared to a baseline to obtain an index of comprehension difficulty. This was called the "dual-task decrement".

The passage used in the experiment was Bransford and Johnson's "Washing Text" [10]. The direct manipulation of access to prior knowledge was therefore made possible by the presentation of a topic sentence.

As the task had not been used previously, first it was hypothesised that the dual-task decrement would be greater, overall, in the no-context than the context condition. Second, it was hypothesised that the difference between dual-task decrements for first and second language participants in the context condition would be smaller than the difference in the no-context condition.

2. METHOD

Participants and Design. The participants were 22 monolingual English speakers and 22 second language English speakers from various language backgrounds. The second language users conformed to the criteria in [5, 6]. If the reasoning of Johnson *et al.* in [5, 6] is accepted, it can therefore be assumed they were exposed to English after any sensitive period for language acquisition and that they had reached an end-state in their second language acquisition.

Participants in each group were randomly assigned to either a context condition or no context condition, resulting in a 2 x 2 (Context x Language Background) design. There were 11 participants in each of the Context x Language Background subgroups.

Stimulus Materials and Apparatus. The washing text [10] was recorded by a male speaker onto a chrome cassette then digitised at a sampling rate of 11kHz. The speech rate was 153.5 words per minute and the duration of the passage was 68 seconds. A practice passage was digitised at 7kHz to lower computer memory requirements.

The calculations were comprised of single digit augends and addends and their totals. They conformed to the constraints in [14], which ensured that the items were of equal difficulty.

The resultant pool of calculations consisted of 56 correct and 56 incorrect items. Each item was prepared as an individual PICT graphics file for visual presentation on a computer screen.

The experiment was run on a number of different models of Macintosh computer using SuperLab software [15]. In order to overcome any non-random variation due to screen refresh rates between computers, the presentation of each calculation was preceded by 200ms delay *minus* the presentation time. In using older Macintosh computers there is some concern over millisecond accuracy when visual and auditory stimuli are presented concurrently, but since this design does not rely upon reaction time, the problem is obviated. Nevertheless, in order to equalise the experimental conditions, a 68-second silent sound file was played concurrently with the calculations in the single-task condition. Two keys were covered with adhesive tape for responding and a "tick" and "cross" displayed on either side of the screen to indicate which hand to use for a "correct" or "incorrect" response.

Procedure. Participants were given detailed verbal and written instructions for each section of the experiment. For the first section, a practice session of 36 calculation verifications was followed by the single-task condition, where participants had 68 seconds to complete as many correct calculations as possible. In the second section, participants were presented with a practice passage. They were instructed to remember as many ideas as possible from the passage to write down at its conclusion. As recall was not the dependent variable, the modality of responding was unimportant. The written modality was the most convenient as it allowed the possibility of group testing. In the final section, the participants were instructed to divide their attention equally between completing correct calculation verifications and storing information from the passage for later recall. For participants in the context condition the dual-task was preceded by a sentence announcing that the passage would be about washing clothes.

3. RESULTS

For each participant, the number of correct calculations completed in the single-task condition was taken from the number of correct calculations completed in the dual-task condition to obtain an index of processing difficulty. A 2 x 2 (Context x Language Background) factorial analysis of variance was conducted. This revealed significant ($p<.05$) main effects for Context ($F(1,40)=21.27$) and Language ($F(1,40)=18.18$).

As is evidenced by the diverging lines in Figure 1, there was also an interaction between language background and context ($F(1,40)=4.73$).
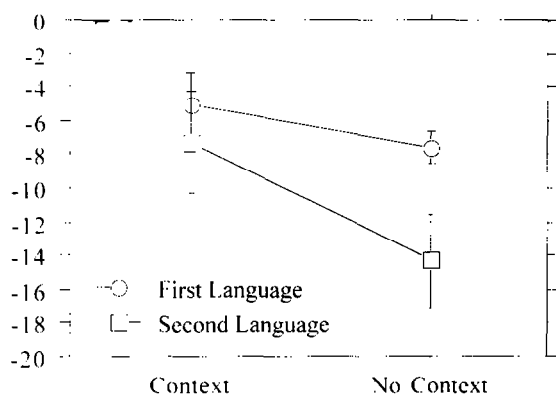
Figure 1: Results of a 2 x 2 factorial ANOVA showing an interaction between language and context. Error bars represent 95% confidence intervals.

4. DISCUSSION

The results supported the hypotheses. The main effect for Context confirms that there is a significantly greater dual-task decrement in the no-context than in the context condition. There was also a significant interaction between language and context, indicating that the disparity in scores between first and second language users in the no-context condition is significantly greater than in context condition. It should be noted that due to the relatively small cell frequencies, these results should be taken as preliminary. A larger sample is required to ensure the statistical reliability of the results.

Assuming that the use of Bransford and Johnson's Washing Text [10] provides an adequate test of comprehension in general, the present results demonstrate that language comprehension consumes more working memory resources for second language comprehenders than first language comprehenders when background knowledge is unavailable (in the no context condition). In comparison, there is very little difference or no difference at all between the resource consumption of first and second language users when background knowledge is available (in the context condition).

In the no context condition, the participants in this study are forced to rely solely on information from the speech signal. Under these conditions it appears that it is far more difficult for second language users to understand the passage than first language users. However, when the full support of background knowledge is available this difference is much smaller. This suggests that for second language users the processes involved in decoding speech generally consume more resources than those of their first language counterparts. This is not to say that proficient second language users experience difficulty in their everyday comprehension. On the contrary, background knowledge can be used to facilitate comprehension in just about any situation and there are many non-linguistic contextual cues which can also aid in comprehension. It is only in those situations where the

second language user is forced to rely solely upon information from the speech signal for the formation of a mental model that we might expect difficulty in comprehension.

Future research should address whether the differences observed between first and second language comprehenders are qualitative, quantitative or a mixture of both. That is, it should be ascertained which speech decoding processes cause the higher level of resource consumption in second language users and whether these are the same processes which are used to perform the same computation in first language users. Within-group differences should also be taken into account. That is, the strategies employed by second language users may differ across individuals, based upon factors surrounding their method of instruction and first language background.

5. REFERENCES

1. Takano, Y. and Noda, A., *A temporary decline in thinking ability during foreign language processing.* Journal of Cross-Cultural Psychology. 1993. **24**: p. 445-464.

2. Johansson, G., Laaksonen, T., and Ljunggren, G., *Performance of language-related mental tasks in a secondary language: Pilot studies of mental load and strain.* Reports from the Department of Psychology, Stockholm University, 1992. **759**.

3. Takano, Y. and Noda, A., *Interlanguage dissimilarity enhances the decline of thinking ability during foreign language processing.* Language Learning, 1995. **45**: p. 657-681.

4. Bley-Vroman, R., *What is the logical problem of foreign language learning?*, in *Linguistic perspectives on second language acquisition*, S.M. Gass and J. Schachter, Editors. 1989. CUP: Cambridge, MA.

5. Johnson, J.S. and Newport, E.L., *Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language.* Cognitive Psychology, 1989. **21**(1): p. 60-99.

6. Johnson, J.S., Shenkman, K.D., Newport, E.L., and Medin, D.L., *Indeterminacy in the grammar of adult language learners.* Journal of Memory & Language, 1996. **35**(3): p. 335-352.

7. Just, M.A. and Carpenter, P.A., *Paradigms and processing in reading comprehension.* Journal of Experimental Psychology: General, 1992. **111**: p. 228-238.

8. Glenberg, A.M., Kruley, P., and Langston, W.E., *Analogical processes in comprehension: Simulation of a mental model,* in *Handbook of psycholinguistics.*, G. Morton Ann, Editor. 1994. Academic Press, Inc, San Diego, CA, US. p. 609-640.

9. Gernsbacher, M.A., Varner, K.R., and Faust, M.E., *Investigating general comprehension skill.* Journal of Experimental Psychology: Learning, Memory, and Cognition, 1990. **16**: p. 430-445.

10. Bransford, J.D. and Johnson, M.K., *Consideration of some problems of comprehension*, in *Visual information processing*, W. Chase, G., Editor. 1973, Academic Press: New York.

11. Markham, P. and Latham, M.L., *The influence of religion-specific background knowledge on the listening comprehension of adult second-language students.* Language Learning, 1987. **37**: p. 157-170.

12. Schmidt-Rinehart, B.C., *The effects of topic familiarity on second language listening comprehension.* Modern Language Journal, 1994. **78**: p. 179-189.

13. Trabasso, T. and Suh, S., *Understanding text: Achieving explanatory coherence through on-line inferences and mental operations in working memory.* Discourse Processes, 1993. **16**: p. 3-34.

14. Geary, D.C., Cormier, P., Goggin, J.P., Estrada, P., and Lunn, M.C.E., *Mental arithmetic: A componential analysis of speed-of-processing across monolingual, weak bilingual, and strong bilingual adults.* International Journal of Psychology, 1993. **28**: p. 185-201.

15. Haxby, J.V., Parasuraman, R., Lalonde, F., and Abboud, H., *SuperLab: General-purpose Macintosh software for human experimental psychology and psychological testing.* Behavior Research Methods, Instruments, & Computers, 1993. **25**(3): p. 400-405.