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Application of computer technologies in English education based on hypotheses in language attrition

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ABSTRACT: Both the regression hypothesis and the threshold hypothesis are long-term concepts in the field of language attrition. So far, both concepts have undergone only a few empirical studies. Conclusions on the regression hypothesis have yet to be reached; although it is acknowledged that the threshold hypothesis seems to have some validity. The study reported in this article is an exploration of the application of computer technologies in English education after testing both the threshold hypothesis and regression hypothesis using Event Related Potentials (ERPs) and functional Magnetic Resonance Imaging (fMRI). The results for the threshold hypothesis were more convincing than the results for the regression hypothesis. It is discussed that computer technologies might help to prevent and prohibit language attrition.

INTRODUCTION

Language attrition may be referred to as the process whereby acquired language knowledge decreases due to relatively less use or for other reasons, such as brain damage. An often-cited example is that language learners forget the second language (L2), while immersed in the first language (L1) for a long period or that the immigrants' L1 is degraded when they remain long in an L2 environment. Attempts were made in this study to explore the application of computer technologies in English education by focusing on those who have been away from L2 learning for a certain time and whether the regression and threshold hypotheses are valid.

The regression hypothesis holds that the path of attrition is the mirror image of the path of acquisition. What is learned earlier is maintained longer, and what is learned later is more prone to rapid attrition; this is also referred to as first in, last out [1]. This hypothesis is a theory first proposed by Jakobson in terms of the acquisition and attrition of phonology [2] and later introduced into the field of language attrition by Freed in 1980 [3]. Nevertheless, no empirical studies have been conducted and a review of literature shows that very little evidence has been found to support this long-held hypothesis. For example, Jordens, de Bot and Trapman [4] studied German case-marking, since this linguistic element *meets the conditions of gradualness and a more or less fixed order of acquisition*. The sequence of L1 attrition was not found to mirror that of acquisition, although they imagined that it might be applicable to L2 attrition. Another similar example is that of Håkansson's who explored syntax and morphology in the language of expatriate Swedes, which revealed that sequences of attrition did not correspond to those of the acquisition of Swedish language [5].

There is another hypothesis, referred to as the threshold hypothesis, which disagrees with the regression hypothesis. It argues that what is least subject to attrition is what is learnt the best or enforced most frequently rather than what is learnt the first. Once a learner's language knowledge reaches a certain threshold, then, it tends to be less susceptible to attrition. Otherwise, it is easily attritted. The technical term *threshold hypothesis* is used to include various conceptions in this field, such as the neurolinguistically connected activation threshold hypothesis proposed by Paradis [6] and the well-accepted critical threshold hypothesis [7]. The activation threshold hypothesis was applied firstly in the field of language aphasia, where the facility of reactivation of linguistic representations possibly depended on frequency of use prior to brain damage [8]. The activation hypothesis argues that the higher the activation is, the stronger the degree of stimulation needed to reactivate the linguistic representation. Neisser demonstrated that a general critical threshold should play a role during the process of language acquisition [7]. If learners' knowledge overcame this threshold, the acquired linguistic knowledge would be relatively long lasting, which was considered as evidence of Bahrick's report on language retention in Spanish as an L2 [9].

Until now, there has been no direct study committed to language attrition conducted by means of Event Related Potentials (ERPs) and functional Magnetic Resonance Imaging (fMRI). Other fields, such as language inhibition, language suppression and language filtering, possibly having some relationship to language attrition, have undergone empirical studies via ERPs and fMRI. This study was concerned with language inhibition. This refers to the process whereby bilinguals control the non-target language when they use the target language. When bilinguals speak in the intended language they must be able to inhibit or filter non-target language representations. When bilinguals inhibit the non-target language for a certain time, the non-target language may be vulnerable to attrition. Therefore, language inhibition may be transformed into language attrition. It is also proposed in psycholinguistic models of language production that bilinguals possess an intentional control mechanism that inhibits non-target language representations. In language comprehension, control mechanisms might play a role to prevent or inhibit cross-language interference [10].

A literature review also supports the relationship between inhibition and attrition. Memory inhibition can have significant effects on processes that may not be immediately associated with attrition, such as the experience of psychological disorders or the acquisition of new languages. One study by Levy and Anderson suggests that people who are learning a new language may actively suppress knowledge of their native language [15]. Reasonably, when people are using their native language, the acquired foreign language may be inhibited as well, causing language attrition. Therefore, it seems worthwhile to review the studies on language inhibition before researching language attrition via fMRI and ERPs.

Neuroimaging results favour the idea that inhibition mechanisms cannot directly influence lexical activation during word identification, see for example van Heuven et al [11] and Kerkhofs et al [12]. The ERP data of Kerkhofs et al show that the word frequencies of inter-lingual homographs in both the target language (English) and the non-target language (Dutch) exerted a significant influence on the N400 effect (an ERP response) [12]. The fMRI data of van Heuven et al evidenced that conflicts in inter-lingual homograph processing occurred at both the response level and in the word identification system [11]. Such conflicts would have been offset if bilinguals had been able to inhibit the non-target language understanding of the inter-lingual homographs.

Data by van Heuven et al suggested that bilinguals failed to regulate activation in the word identification because of conflicts between the target and non-target understandings of inter-lingual homographs [11]. This gives rise to differences in brain activation between homographs and control words. By contrast, in the study by Rodríguez-Fornells et al [13], bilingual Spanish/Catalan and monolingual Spanish subjects were instructed to press a button when presented with words in one language, while ignoring words in the other language and pseudo-words. The brain potentials of bilingual subjects in response to words of the non-target language were not sensitive to word frequency, indicating that the meaning of non-target words was not accessed by bilinguals. The fMRI activation patterns of bilinguals included a number of areas previously implicated in phonological and pseudo-word processing, suggesting that bilinguals use an indirect phonological access route to the lexicon of the target language to avoid interference. This suggested that bilinguals were able to inhibit the non-target language in word identification.

The results of Rodríguez-Fornells et al are not in conformity with a sea of behavioural data showing that bilinguals cannot inhibit non-target language representations [13]. Possibly, their findings might be due to the specifics of the go/no-go task that was used and their no-go responses may not have been sensitive enough to pick up non-target language effects. Furthermore, the bilinguals who participated in this study were early balanced bilinguals. Most bilingual studies have been conducted with late unbalanced bilinguals. Early and late bilinguals might differ fundamentally in their language control abilities and this might explain the absence of non-target language influence in the early bilinguals. However, the error data of the ERPs study showed differences between low and high frequency non-target Catalan words, which suggests that Catalan words may have been activated after all [10]. The data of Martin et al obtained via ERPs also demonstrate that task demands cannot directly inhibit the word identification system, because semantic priming effects were found in both the task's relevant and irrelevant language, although participants were required to ignore the words in the irrelevant language [14].

It seems appropriate to test both the regression and the threshold hypothesis by using negative English sentences. Larsen-Freeman and Long developed sequences of negative English sentences as: 1) Negation outside sentences; 2) Negation on partial elements; 3) Negation on link and modal verbs within sentences; and 4) Negation on action verbs within sentences [16]. The overall aim of the study is to: 1) identify the attrition sequence of negative English sentences; 2) test the regression hypothesis; 3) test the threshold hypothesis; and 4) discuss the application of computer technologies in English education in order to prevent and prohibit language attrition.

METHODS - PARTICIPANTS

All the participants were Chinese speakers, for whom English was a foreign language. Generally, participants were students from Nanjing Foreign Languages School (a middle school), and were English teachers and workers who had received undergraduate education. Workers did not receive any English education and had no immediate access to English when working. Specifically, the above participants were divided into three groups. Group 1, to identify the developmental sequence of negative English sentence acquisition, consisted of 12 middle school students (3 from 1st, 2nd, 3rd and 4th semester respectively); 6 females and 6 males (mean age: 17.5). Group 2 was made up of 12 workers who had completed their undergraduate education (3 workers had graduated for 6, 12, 18 and 24 months respectively), among whom 6 scored over 500 points and 6 less than 400 points in College English Test Band 4 (mean age: 24.3).

Group 3 (mean age: 31.6) involved 12 English teachers, who had taught English for at least one year, and was regarded as the control group to compare with the other groups.

STIMULI

Stimuli consisted of 120 negative English sentences designed according to the four developmental stages reported by Larsen-Freeman and Long [16]. Every 30 sentences represented one stage. Participants had to judge whether each sentence was true or false. Each sentence was presented at a time in white at the centre of a black screen, connected to a computer. The stimuli were 1 cm high and on average 5 cm wide. The viewing distance was approximately 50 cm.

PROCEDURE

Participants were tested individually. The instruction, which appeared on the screen at the beginning of the experiment, stressed speed, as well as accuracy. Each trial started with a black screen followed by a cue. After 1,000 ms, the stimulus was presented in the middle of the cue frame. The cue and the stimulus remained on the screen until a response was given. The interval between the response of the participant and the next cue was 500 ms.

PROCEDURE FOR RECORDING AN ELECTROENCEPHALOGRAM (EEG)

Continuous electroencephalogram (EEG) from 64 Ag/AgCl active electrodes held by an elastic cap was recorded. The electrode montage included midline sites (Fz, FCz, Cz, CPz, Pz) and sites over left (F3, F7, FT7, FC3, C3, CP3, C3, CP3, P3, TP7) and right (F4, F8, FT8, FC4, C4, CP4, P4, TP8) hemispheres. Six other electrodes were attached over the left and right mastoids, below the right and left eyes (for monitoring vertical eye movements and blinks), at the corner of the right and left eyes (for monitoring horizontal eye movements). Bioelectrical signals were amplified and were continuously sampled (24 bit sampling) at a rate of 256 Hz throughout the experiment. The EEG was filtered offline using EEGLAB software. The signal from the left mastoid electrode was used offline to re-reference the scalp recordings.

IMAGING PROCEDURE

The experiment consisted of 4 sequential scanning sessions where 250 volumes were obtained for each session without gap (TR = 2000 ms, 200 mm FOV (field of view), 64 × 64 matrix, TE = 35, 36 pure axial slices, 3.15 × 3.15 × 3.5 mm voxel size). Slices were collected in an interleaved order. At the beginning of each session, three (3) additional volumes were obtained, to allow for T1 equilibration (excluded in the analysis). Before the experiment, high-resolution anatomical images (SPGR; 1 mm sagittal slices) were obtained. Head motion was minimised by using cushions and by clearly instructing the participants before they entered the scanner. Imaging data were pre-processed via SPM5 (scanning probe microscopy). A slice-timing correction to the first slice was performed ahead of realignment of the images to the first one. Then, acquired data were formatted to an Echo Planar Imaging (EPI) template. The images were then sampled into 2-mm cubic voxels and, finally, processed with an 8-mm FWHM (full-width-at-half-maximum) isotropic Gaussian kernel.

To model task-related activity in each of the corresponding conditions, the canonical haemodynamic response was convolved with the onset of each trial. The linear model was used for statistical analyses. A fixed-effect model was used to linearly contrast each participant's brain activity for the effects of interest. The researcher then conducted the second-level analyses via one-sample *t*-tests using SPSS16.0. Regions of activation were identified using a conservative significance threshold of $p < 0.0005$ with a cluster size threshold of 20 voxels.

RESULTS AND DISCUSSION – BEHAVIOURAL DATA

Generally, the RT (regression trend) analysis of variance (ANOVA) reveals a significant main effect at different stages of the development of negative English sentences for middle school students. This showed that the developmental sequences of negative English sentences are in conformity with those demonstrated by Larsen-Freeman and Long [16]. By contrast, the RT analysis of ANOVA fails to reveal a significant main effect at different stages of attrition of negative English sentences for workers, which indicates that the forgetting processes for negative English sentences do not mirror the acquisition. This result obviously does not support the regression hypothesis. However, the threshold hypothesis is supported, since it is found that English teachers are more resistant to attrition than are students and workers, possibly because the English teachers have reached the threshold while students and workers have not.

EVENT RELATED POTENTIALS (ERP) DATA

Retrieved from the data in the left sites was a significant main effect between middle school students from different semesters. Further analysis showed that LAN (left anterior negativity) amplitude in participants for the 1st stage negative sentences were significantly lower for the first semester than for other semesters. Similarly, the amplitude in the 2nd, 3rd and 4th stage negative sentence is also significantly lower than in other semesters. No consistent significant differences were found between workers and English teachers, although LAN amplitudes were significantly larger in workers than in English teachers. No significant differences were found in the data obtained, either from the right or the midlines.

The data obtained from the midline sites showed significant main effect, where P600 amplitude in English teachers was significantly lower than that in both students and workers. Students in higher semesters showed significantly lower N600 amplitude than did those in lower semesters.

Processing of English sentences is mainly represented by two components: 1) a negative-going wave between 300 and 500 ms after target onset; and 2) a late parietally distributed positivity with an onset around 500 ms called P600 [17]. The LAN component has been observed to phrase-structure violations [18], the processing of subcategorisation information [19] and agreement violations [20]. The P600 has been found to covary with several syntactic anomalies, such as phrase-structure violations [21], subjacency violations [22], agreement violations [23] and subcategorisation violations [24].

In this study, LAN amplitudes being found lower in corresponding semesters suggests that students in corresponding semesters had less brain processing than those in other semesters. For example, students in the first semester showing significantly lower amplitude in the 1st stage negative sentence, which demonstrates that they need less brain processing in this stage of negative sentences sequence. This seems in conformity with the negative English sentence acquisition sequence. Nevertheless, no evidence was found in this study to support the reverse attrition sequence of negative sentences. Therefore, the regression hypothesis is not fully evidenced.

In addition, LAN amplitude being significantly larger in workers than that in English teachers suggests that workers might need more processing resources than English teachers do. English teachers might have reached the threshold and, hence, be more resistant to attrition and less brain processing is thus needed. The P600 amplitude in English teachers being significantly lower than that in both students and workers also suggests this phenomenon. This is supportive of the threshold hypothesis.

IMAGING DATA

Among students, activations of negative sentences at each stage were identified by comparisons between the four-stage negative sentences. Processing of the 1st stage negative sentences was compared with that of 2nd, 3rd and 4th stage sentences. Similarly, processing of the 2nd stage negative sentences was compared with that of 1st, 3rd and 4th stage sentences, 3rd with 1st, 2nd and 4th, and 4th with 1st, 2nd and 3rd. ANOVA analysis, 4 (four stages of negative sentences) ×3 (students, workers and English teachers) was conducted, which did not reveal any significant differences ($p > 0.0005$) between different stages of negative sentences among the participants, although an activation of the fronto-parietal motor areas was revealed.

The results are in conformity with previous literature on the processing of negative sentences. It is argued that based on the available evidence, sensory-motor cortices are activated during a variety of language comprehension tasks for both concrete and abstract language. Yet this activity depends on the context in which perception and action words are encountered. Although modality-specific cortical activity is not a *sine qua non* (e.g. indispensable element or condition) of language processing, even for language about perception and action, sensory-motor regions of the brain appear to make functional contributions to the construction of meaning and, therefore, should be incorporated into models of the neuro-cognitive architecture of language [25].

COMPUTER TECHNOLOGIES AND LANGUAGE ATTRITION

The most obvious finding to emerge from this study is that the threshold hypothesis is almost validated, while the regression hypothesis is not fully evidenced. On the one hand, the threshold, as most literature proves, is universally acknowledged. In this study, both behavioural and ERP data were supportive of the threshold hypothesis, despite the data acquired from fMRI not favouring the threshold hypothesis. On the other hand, the regression hypothesis was not supported by evidence from the data of behavioural study, ERPs and fMRI experiments. This seems contradictory to many beliefs, but consistent with the opinion of Keijzer who conducted a study on the L1 attrition of Dutch in Anglophone Canada [26].

Her study compared language acquisition in children with language attrition found in healthy emigrant populations and compared it with language use in non-attritted, adult speakers. Especially, it examined the parallels and divergences between advanced stages of L1 Dutch acquisition (in adolescents) and the L1 attrition of Dutch immigrants in Anglophone Canada, as opposed to control participants. She found some evidence that attrition occurred. Nevertheless, the regression hypothesis was not supported [26].

The regression hypothesis takes the sequences of attrition and acquisition into consideration. The brain structure is largely a mystery for scientists, including the sequences of its learning and forgetting. Besides, there might be other factors, e.g. motivation, frequency of use, age, initial proficiency, attitude and social activities, influencing language attrition and both hypotheses. Multi-disciplinary co-operation might be able to study both hypotheses involving these factors.

Both hypotheses are difficult to examine without the co-operation between various disciplines such as linguistics, psychology, pathology, computing and neurology. The threshold hypothesis indicating the *threshold* will divide between that easily attritted and that resistant to attrition. Below the division, the memory is more fragile than that above the division. The memory might be made up of neuron structures and complicated networks. This is in urgent need for co-operation between the various fields. The threshold hypothesis in language attrition is nearly universally acknowledged, but the establishment of specific thresholds for different languages in different countries and areas might not be easily determined. To reach a certain threshold is the essential task for learners to maintain their acquired proficiency. Therefore, it becomes urgent for learners to develop proper learning strategies to realise this goal.

Nowadays, learning English by means of the computer has become more and more popular around the world, and China is no exception. Most English-language learners in China are immersed in a Chinese environment and they rarely have immediate access to English settings. Computer technologies, able to create English settings, might play an important role in helping them to reach the threshold, hence, making learners more resistant to attrition.

Using computer technologies, it is easy to sort out the linguistic elements most vulnerable to attrition and expose students to them more frequently. By contrast, if the linguistic elements are less subject to attrition, computer technologies can be used to inform students and shift their focus to those more easily attritted.

For many learners, the ultimate aim of learning English might be to orally express English and understand people's English speech. Computer technologies allow software to be designed to carry standard English pronunciations and a rich range of listening material. Good native speakers' pronunciation can be selected and integrated into the software. Recordings of popular news, hot reporting and other interesting materials can be considered as training tools to improve learners' listening skills. As for speaking skills, software can be developed that contains evaluation criteria to test learners' pronunciation, and to detect and correct learners' improper pronunciation. The software can be designed to score learners' pronunciation and point out the defects in pronunciation. In this way, learners can learn to speak standard English with a mobile and obedient *teacher*.

Reading and writing are also essential skills in commanding the English language and cannot be ignored in an English education. Reading can be easily interrupted by distractors, such as noise, calls and other interferences. Computer technologies can surround the learners with reading materials to attract the learners so that interferences are minimised. Furthermore, learners can also be exposed to reading materials on a large computer screen to maximise the learners' comfort. Background reading voices can also accompany the reading materials in case learners prefer listening to reading. For non-English speakers, writing might be a difficult skill to command, since learners keep making grammatical mistakes due to interference from their mother tongue. A grammatical checking program could be integrated into the software to hint and correct the wrongly written language when writing is being carried out.

However, there are also defects in education through computer technologies. One example is where teachers tend to present their courseware in a routine way without any animated stimulation. Students might lose interest in, and be fed up with, this mode of teaching, although it can be very informative. Consequently, when teaching, teachers should not only present their courseware, but also should pay much attention to students' reaction and stimulate the interaction between students and teacher.

CONCLUSIONS

This study has gone some way towards enhancing the understanding of language attrition and the application of computer technologies. It is suggested that the threshold hypothesis might be reasonable while the regression hypothesis might be in need of further study. However, this research has also thrown up many questions in need of further investigation. It is recommended that further research be undertaken in the following areas: linguistics, computing, psychology, neurology and other related disciplines, and the relationship between language attrition and computer technologies were also a focus.

An issue that was not addressed in this study was whether the computer technologies can exert an influence on the process of language attrition. Further empirical studies are still needed to identify the interaction between computer technologies and English language education. The learning process involves psychological factors, such as memory, motivation and attitudes. English learning and teaching is a complicated process that might improve with the aid of computer technologies and other neurological disciplines. Nevertheless, learning English coupled with computer technologies is still problematic if not properly handled. Multi-disciplinary co-operation is necessary to look into both language attrition and application of computer technologies.

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