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ACQUISITION OF THE SECOND LANGUAGE BY PATIENTS WITH BRAIN INJURY AFTER PROLONGED COMA

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ABSTRACT

Eight patients with cranio-cerebral trauma after prolonged coma participated in a study investigating their ability to learn a second language (L2). A severe traumatic brain injury (TBI) results in a dramatic decrease of consciousness and cerebral activity. If the state lasts more than 48 hours, it is considered a coma. Due to irreversible changes in the brain, chances of regaining premorbid physical and mental functions drastically diminish after 4 weeks of coma. Only a limited number of post-coma patients succeed in regaining full efficiency. The present study verifies whether it is possible for these patients, for whom it takes months, sometimes even years, of regular exercise to regain normal language functions in the native language, to learn an L2. The experiment was carried out within "The Academy of Life", a program of classes for in- and outpatients, whose aim is to re-adjust patients to everyday life in society after discharge from hospital. All the subjects had known English to some extent before their accidents. There were 18 sessions lasting 1.5–2 hours within a period of 6 months. The subjects were examined twice: before and after the program. The results show that learning an L2 is still possible. The subjects improved their performance in the following language components: lexicon, grammar and pronunciation. The acquisition process was delayed by post-traumatic aphasia which led to a lack of criticism of the patients' own utterances, as well as a dysfunction of the switch mechanism. The subjects also suffered from disorganization of memory and concentration. However, some patients achieved higher results than it had been expected. The relatively young age of the subjects (mean 20.6 years) increased their chances of learning an L2.

KEYWORDS: traumatic brain injury (TBI); coma; bilingualism; language mixing; aphasia.

1. Introduction

Brain injuries are the most common cause of death or permanent disability among persons up to 25 years of age (cf. Talar 2002). Ten percent of patients with head injuries suffer a severe traumatic brain injury (TBI) that results in a marked decrease of consciousness and brain activity. If the state of diminished consciousness lasts longer than 48 hours, it is considered a coma, which can last from a few days to a few weeks, or even months. However, the chances of regaining full physical and mental function drastically diminish after 4 weeks of coma due to irreversible changes taking place in the brain (cf. Minderhoud 1990).

Even after the patient awakens from coma and regains full consciousness (a process which may last for days, weeks, or months), there remain many serious problems (cf. Łukowicz et al. 2002):

- disorganization of memory (problems with memorizing and confabulations);
- difficulties with concentration;
- serious emotional dysfunctions, especially uncontrolled outbursts of aggression and chronic anxiety;
- motor disturbances, such as paresis, paralysis, hyperkinesis, ataxia and limb apraxia;
- sleep disturbances (e.g. insomnia, narcolepsy);
- loss of sensation in the limbs;
- eating problems (e.g. patients cannot swallow, cannot use utensils);
- vision and hearing problems;
- aphasia.

The present study investigates whether it is possible for patients recovering from prolonged post-traumatic coma, despite these and other persistent deficits, to learn a foreign language.

2. Polyglot aphasia

The characteristic features of post-traumatic aphasia are most probably caused by diffuse axonal injury, as well as cortical and subcortical atrophy resulting from prolonged coma, taken together with focal brain damage affecting the left hemisphere regions known to be essential for speech and language. Pąchalska and Kądzielawa (cf. Łukowicz et al. 2002) have even established a separate term for aphasia after coma, namely "post-traumatic aphasia", where, although the speech centers as such may be largely intact, the disorganization of the brain makes language production and perception difficult or even impossible. Recent advances in neuroimaging have made it clear that, although the classic left-hemisphere regions of the brain are crucial for language production and comprehension, much of the brain is engaged to a greater or lesser extent in every speech act.

Especially interesting for a linguist are case histories of polyglot aphasia. Already in 1895, Pitres postulated that "language disorders in polyglot aphasics do not always involve equally all the languages known to the patient [… R]ecovery, when it occurs, is usually progressive and systematic; the patients regain the use of one of the languages before they are able to use the others" (Pitres 1895: 26). The most familiar language reappears first. Like a child that learns to talk by first listening, the patient understands the language before they are able to speak it. With time, the patient regains memory and is gradually able to understand, and, then, to speak other languages known premorbidly.

In order to better understand aphasia in bilinguals and polyglots, we should now discuss language organization in the brain. It is assumed that it is mainly the left hemisphere that is involved in the acquisition of L1 (cf. Martin 2001), although lesions in the right hemisphere may also lead to language disorders, such as aprosody, difficulty in grasping the meaning of semantically more complex utterances, or understanding proverbs and jokes (cf. Wolska 2000). Recent neuroimaging research shows a surprisingly high amount of right hemisphere activation for auditory speech processing. It turns out that both hemispheres play an equally important role in auditory comprehension of words. As can be seen in Figure 1, reading words also leads to the activation of some parts of the right hemisphere (the right anterior temporal lobe), though this activation is not as extensive as in the left hemisphere (cf. Stowe et al. 2003). Considering various theories on localization of complex functions, Kaczmarek (2003) concludes that speech is controlled by a set of interconnected centers, rather than individual centers responsible for a given faculty. This makes it possible for lost functions to be assumed by other centers.

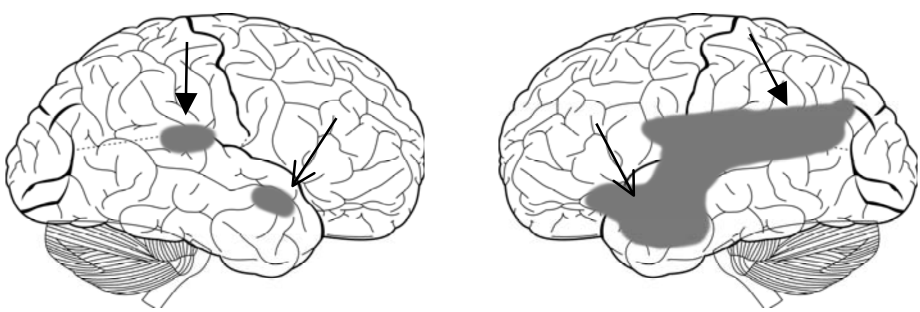

Figure 1: Minor activation of the right hemisphere for sentence relative to visual control. The right hemisphere is presented on the left side. The closed arrow indicates the posterior temporal lobe, while the open arrow indicates the anterior temporal lobe in both hemispheres. (Adapted from Stowe et al. 2003: 62).

Albert and Obler (1978) agrue that the right hemisphere contributes to language processing more in bilinguals than in monolinguals. The authors hypothesise that the right hemisphere is responsible for second language acquisition, even in adult life. If somebody who already speaks an L1 starts to learn a foreign language, the right hemisphere is primarly involved, with the left hemisphere being less active. Increase in L2 proficiency causes greater recruitment of the left hemisphere, but the right hemisphere is still engaged. This is in line with Paradis' (1994, 1995, 2004) assumption that during the initial years of mother tongue acquisition, monolingual children rely on pragmatic processing (stored in the right hemisphere) to derive an interpretation for L1 utterances. This is because they have not yet fully developed automatic linguistic competence. Curtiss and Shaeffer (2005) hypothesise that the right hemisphere is crucial in the earliest stages of language acquisition. Therefore, it is quite feasible that "in order to compensate for their lacunae in implicit linguistic competence, speakers rely on pragmatic aspects (hence, their R[ight] H[emishpere]) when using their weaker language, in the same way that children do during the acquisition of their native language" (Paradis 1995: 6). The left hemisphere begins to contribute more as grammatical accuracy has been achieved, which is possible only when basic vocabulary items have been arranged in word order sequences ruled by L2 grammar. Galloway and Scarcella (1982) add that the right hemisphere is activated in early L2 production and perception and that its main role is to process second language intonation and emotional tone.

Although opinions about the localization of languages differ, it is believed by many that the process of speaking is mediated by both hemispheres. Bychowsky (1919) recalls Wernicke, who spoke only of predominance (not exclusive control) of the left hemisphere. Basing his research on lesion studies, Pötzl (1925) claimed that there is no indication for the existence of separate central mechanisms for each individual language. On the basis of the anatomy of the musculature, where an originally uniform muscle divides into a group of separate muscles which cooperate, in part synergistically, and in part antagonistically, forming a single fixed basic set, he explains that the original L1 centre splits into sub-sets which remain balanced, rarely mixing with or penetrating each other. Genesee (1982; as cited by Spolsky 1989) concludes that L1 and L2 are not subserved by individual neurophysiological substrates. At the same time, he points out that the use of the left and right hemisphere may differ in early and late L2 acquirers. Using neuroimaging techniques for brain activity measurements, Perani and Abutalebi (2005) reject the long held view that the mother tongue and the foreign language are represented in separated in different regions of the brain:

> [T]he available evidence indicates that L1 and L2 are processed by the same neural devices. The neural differences in L1 and L2 representations are only related to the specific computational demands, which may vary according to the age of acquisition, the degree of mastery and the level of exposure to each language. Finally, the acquisition of L2 may be considered as a dynamic process, requiring additional neural resources in specific circumstances.
>
> (Perani and Abutalebi 2005: 202)

Minkowsky (1927) supports this view, stating that the often systematic character of aphasia (i.e. gradual recovery in polyglots) speaks against assuming separate centres.

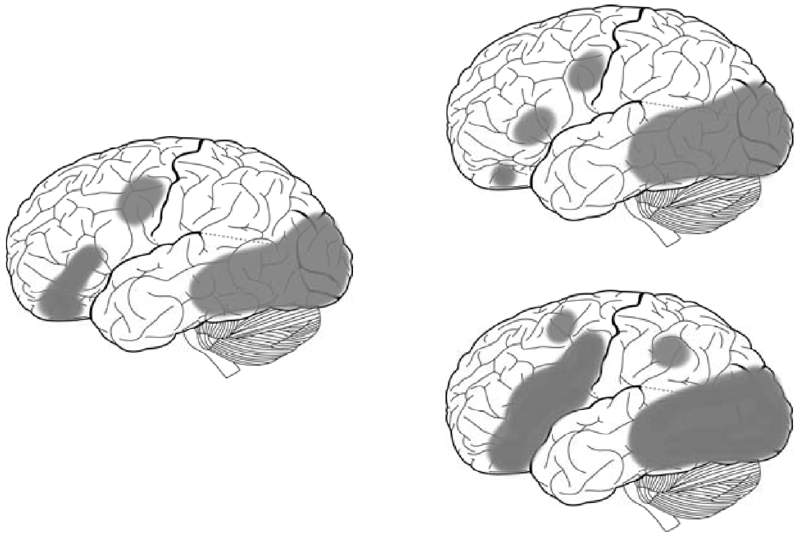

Figure 2. Rendered views of the experimental condition. Left: L1 cognate and non-cognate; top right: L2 cognate; bottom right L2 non-cognate. See discussion overleaf. (Adapted from De Bleser et al. 2003: 450.)

He also assumes that there are no spatially separated language centres in the cortex, but that the same elements are active within the same area, though in different combinations and interacting with a differential linguistic constellation. According to Minkowsky, aphasia in polyglots impairs the cortical areas responsible for linguistic functions to the extent that they are incapable of carrying the full load of responsibilities (e.g. switching from language to language, which requires more plasticity and flexibility). Recovery in aphasia occurs via language economy; this economy is due to the limitation in the capacity of the functional apparatus. Languages often compete with each other in normal conditions, for example, the activation of L2 may be impeded by words, phonemes, and grammar rules from yet another language one is familiar with. Under the pathological circumstances of aphasia, the latent opposition between languages may attain crucial importance for the viability of the function. Usually, the mother tongue, which is biologically most essential and thus the most easily mobilized language, is advanced at the expense of the other languages.

3. L1 and L2 vocabulary

In line with research carried out during the first decades of the previous century, the analysis of the organization of the bilingual lexicon by De Bleser et al. (2003) reveals that distinct neural substrates for the different languages of a bilingual individual do not exist. Instead,

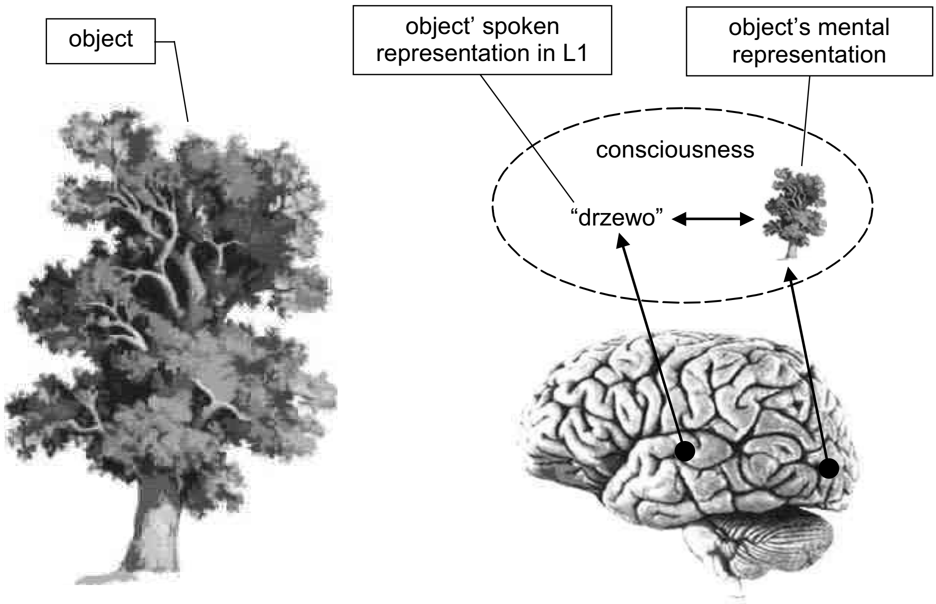

Figure 3. Naming in the mother tongue. (Adapted from Pąchalska et al. 2003.)

> there are significant areas of overlap which are activated during processing in either L1 or L2, especially if there is high proficiency in L2. In fact, we found hardly any difference of activation between L1 and high proficiency, cognate items in L2. Similar areas also subserved L2 non-cognate naming. However, these items generated additional increased activity of the left anterior temporal area [...] and of some left inferofrontal areas [...]. Thus, low proficiency but not high proficiency bilingual processing requires extensions of the frontotemporal regions responsible for similar linguistic functions in monolinguals.
> (De Bleser et al. 2003: 453)

The low proficiency non-cognate items in the study involved additional increased activation patterns. The activation was restricted to areas that are involved in phonological and lexical retrieval, that is, the inferior frontal and inferior temporal gyri (Figure 2).

Pąchalska et al. (2003) have proposed a model for naming objects in L1 and L2 based on psycholinguistic bilingual lexicon models (e.g. Kroll and Stewart 1994; Chen and Leung 1989; Kroll and Curler 1988). Figure 3 illustrates the process of naming objects in the mother tongue, in which each object has both a visual and verbal mental representation in the brain. The visual representation is formed in the occipital cortex, and the verbal representation in Wernicke's area (upper part of the central-posterior temporal lobe), where it is activated by the appearance of the visual representation.

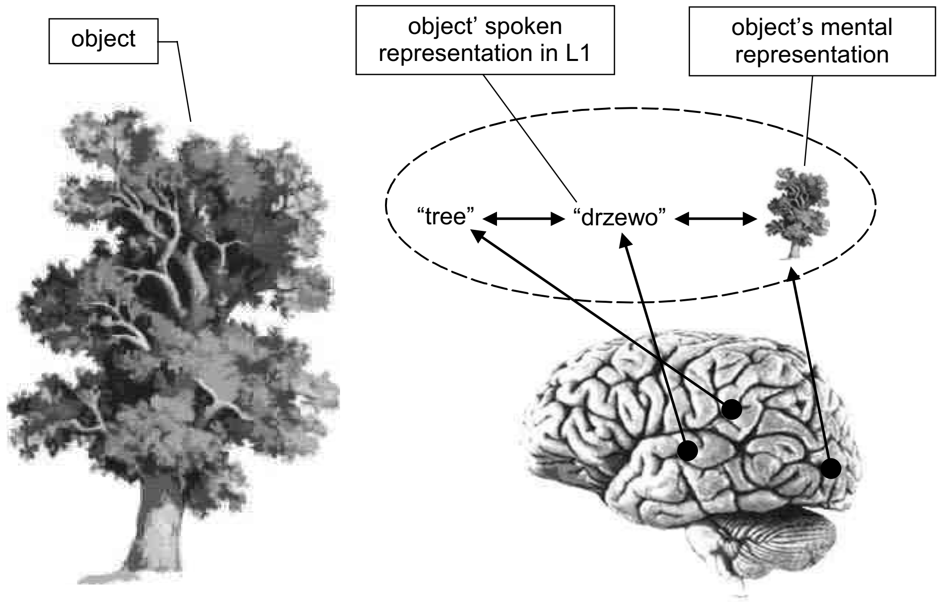

Figure 4. The first phase of naming in the second language. (Adapted from Pąchalska et al. 2003.)

In the first phase of second language learning, one acquires a new L2 word exclusively via the first language by "word-to-word" association (Figure 4). The visual representation in the occipital cortex activates the verbal representation in Wernicke's area, of course in the mother tongue; this in turn activates the corresponding L2 word, which resides in long-term memory. Thus the name of the object in the mother tongue is an essential mediator between the object and its name in L2.

As one becomes proficient in the foreign language, the L2 word gradually acquires its own direct association with the object. However, in order to use the second language, the first language has to be "silenced", that is, its activation has to be suppressed (Figure 5). Since the suppression of L1 in order to allow L2 to function affects not only naming, but also syntax and pronunciation, the "silencing" must be early and global, i.e. it is the language as a whole that is "switched off" and not individual phonemes, words, and grammatical rules.

According to the above model, during the initial stages of the acquisition of the second language, the learner adds L1 to the mother tongue. Prator (1972), when discussing acquisition of the first and the foreign language, even uses the term "adding" for learning L2. It is only when one has a fluent command of L2 that one can be said to be bilingual, that is, when L2 is able to function without the mediation of L1 in the cerebral structures.

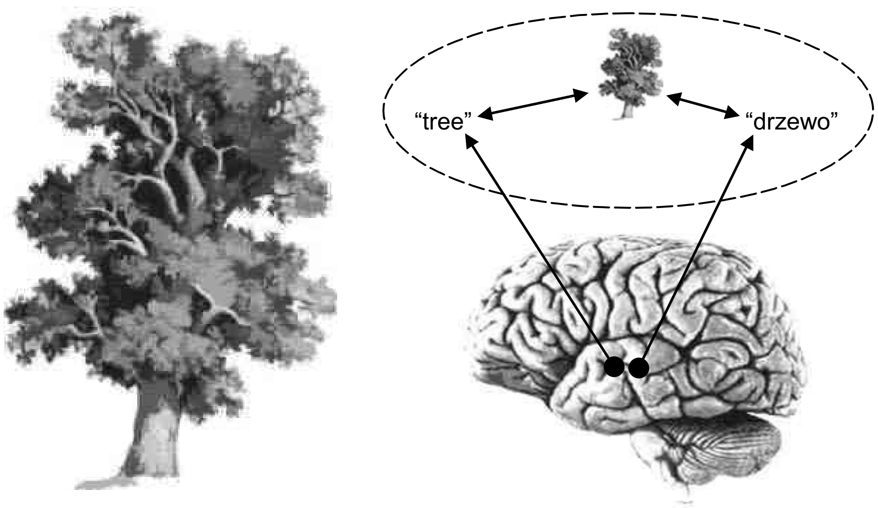

Figure 5 .The second phase of naming in the second language. (Adapted from Pąchalska et al. 2003.)

4. Post-coma patients and L2 acquisition

Since aphasia is only one of the numerous consequences of brain injury and subsequent coma, only a limited number of patients manage to regain full physical and mental efficiency. If so, one could ask whether it is possible for these patients to learn a second language. Publications devoted to aphasia in bilinguals and polyglots are numerous, but there are very few works on the ability of patients with brain injury to learn foreign languages that they knew, to a better or worse extent, before the accident. To answer the above question, research was carried out in the Department of Rehabilitation at the Bydgoszcz Academy of Medicine in Bydgoszcz, Poland. Since 2001, this department has been specializing in the medical management and rehabilitation of patients who, as a result of an accident,[1] have suffered a traumatic brain injury resulting in coma. Comprehensive rehabilitation starts from the first days of coma and lasts for months, sometimes even years, after the moment the patient wakes up. At the beginning of 2003, Prof. Maria Pąchalska, the President of the Polish Neuropsychological Society, established the "Akademia Życia" [Academy of Life], a program of classes for in- and outpatients, whose goal is to help patients re-adjust to normal everyday life in society after their discharge from hospital. In June 2003, within the "Akademia Życia", Prof. Pąchalska and the present author set up the "Akademia Języka Angielskiego" [Academy of English]. During monthly meetings, patients who knew some English before the acci-

[1] The most common cause of brain injuries is motor vehicle accidents, whose number is constantly rising due to the increased number of automobiles in Poland, along with the poor condition of many Polish roads.

dent, spoke and wrote in English, learned new grammatical rules and vocabulary items, and practiced pronunciation.

4.1. Subjects

The "Akademia Języka Angielskiego" was attended by 8 patients ranging in age from 8 to 32 years (average age 20.6 years) with brain damage (including but not limited to frontal syndrome) after prolonged coma. The subjects all knew English to some extent before the accident. There were 2 advanced students with Cambridge certificates, 1 intermediate student, and 5 beginners. For obvious reasons, the patients chosen could already communicate well enough to be able to follow instructions and to express themselves. It should be mentioned that it takes months of regular exercise, if not years, before patients after coma regain normal language functions in the native language.[2]

4.2. Method

Each session of the "Akademia Jęyzka Angielskiego" lasted 1.5–2 hours. The meetings were conducted in a group setting and individually, for a total of 18 sessions within a period of 6 months. The subjects were examined twice, once before and once after the program. The following research instruments were used:

(1) An interview in English, which revealed the patient's level of competence in L2.
(2) The "Rivermead" Behavioural Memory Test (Wilson 2002), in which the subjects were asked to follow commands of both verbal and non-verbal nature. The instructions were presented in Polish and in English.
(3) The Neurolinguistic Test of Attention (Pąchalska and MacQueen 2001), testing the patients' ability to perform a double-criterion identification task in lists of English words, Polish words, and nonsense words; for the present purposes, the patients were tested once with instructions given in Polish, and once with instructions given in English.
(4) The Clinical Test of Language Competence in English, prepared by the author, and specially designed to examine patients after prolonged coma. It analyses the subject's command of the main components of the second language, with particular attention to: (1) grammatical correctness (including syntax); (2) vocabulary, (3) pronunciation, and (4) mistakes attributable to brain dysfunction.

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[2] The degree to which the patient's language capacities recover depends on several factors, including the size of the injury, the duration of the coma (the longer, the worse), and rehabilitation.

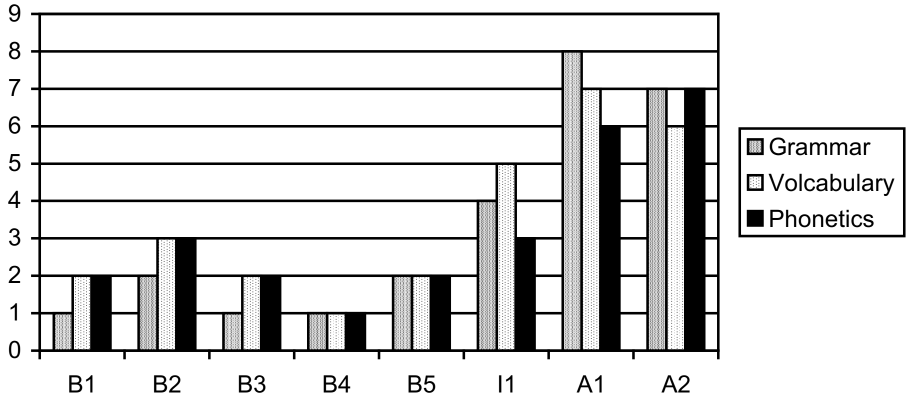

Figure 6. The results of the Clinical Test in Language Competence in English carried out before the program.

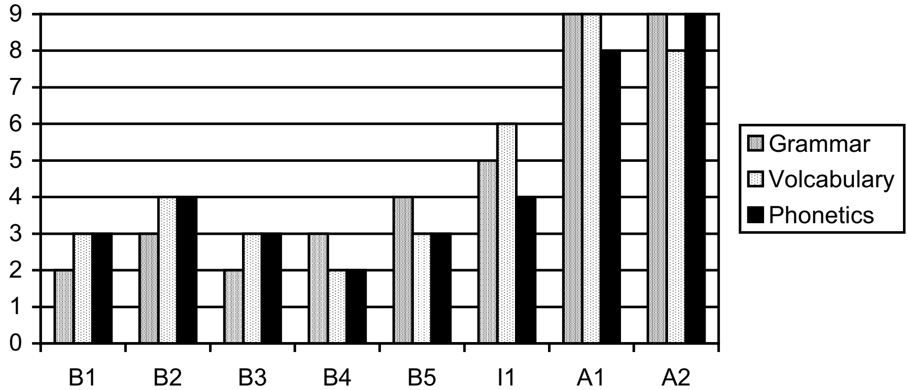

Figure 7. The results of the Clinical Test in Language Competence in English carried out after the program.

4.3. Results

The "Rivermead" Test (Wilson 2002) revealed that verbal tasks in Polish were completed better than those in English by the beginners (B) and the intermediate student (I). The advanced subjects (A) performed considerably better when they were instructed in English. As for non-verbal tasks, the results for 5 of the 8 patients were higher when they were addressed in L2. In the Neurolinguistic Test of Attention (Pąchalska and MacQueen 2001), real words in Polish were easier for 4 patients, 2 students scored more points in English, and the 2 remaining achieved equal results in both languages;

while in nonsense words type II (non-verbal), all the subjects but one (the intermediate student, who scored 80% for L1 and L2) responded better to English instructions.

Figures 6 and 7 illustrate that in the Clinical Test of Language Competence in English carried out before and after the programme of L2 acquisition, all the patients improved their skills in English. The command of the three language components rose by 11% in grammar, 10% in vocabulary, and 10% in phonetics.

4.4. Discussion

The results of the experiment clearly indicate that learning a second language after coma is still possible. The subjects' performance improved in all of the investigated components of language: vocabulary, grammar and pronunciation. However, the process of acquisition was hindered and slowed down by various factors. The patients tended to subconsciously mix languages due to a lack of criticism of their own utterances and they also exhibited problems with code-switching. Code switching is the capacity of a bilingual to choose the language in accordance with the interlocutor (Meisel 1994). Language mixing, on the other hand, refers to the inability to differentiate between two languages of the bilingual. In other words it is the use of "indiscriminate combinations of elements from each language" (Redlinger and Park 1980: 337), e.g. an insertion of words or syntactic structures of one language when speaking the other. Rossi et al. (2003) also differentiate between pathological switching and pathological mixing. The former phenomenon involves mixing various languages in the course of saying one utterance, the latter – switching languages in different utterances, without paying attention to sociolinguistic and/or pragmatic communication code.

Those patients who mixed languages produced many English sentences containing Polish words. Here are some examples of this contamination:

Jesteś very beautiful. Masz piękne włosy i face.
Masz fajne eyes. Very, very fine. Very, very good.
She has fine nóg.
You are beautiful, too, and masz fajne hair włosy.
Ania is beautiful and uwielbiana.
Pee pee siu and kupę. I have to go to WC teraz.
I'm old dwadzieścia sześć.
I'm learn w school in English.

Language mixing was also evident in writing. One of the patients (age 26 years) produced a description of the author of the present article. In addition to using Polish words, he made a number of spelling mistakes (e.g. *teacher* written as *teczer*, *beautiful* spelled first as *biutifól*, and, then, as *biutiful* (see Figure 8).

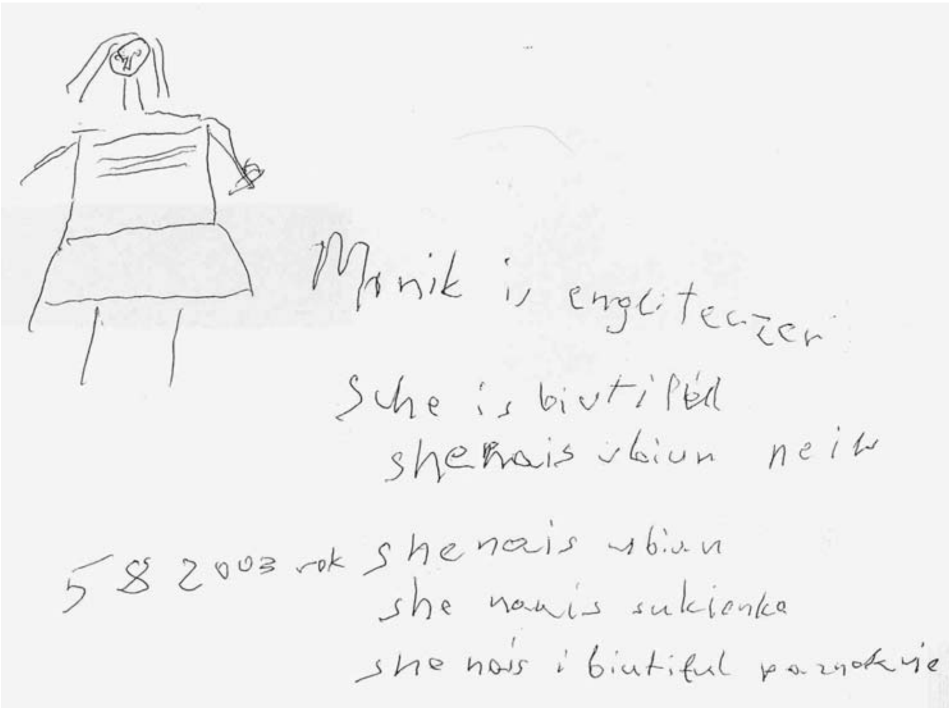

Figure 8. Description written in English by a 26-year-old male patient.

Especially interesting is the fact that some patients spoke English many hours after the classes. When one of the subjects (age 24) was asked why she continued to speak English, while her interlocutor spoke Polish, she replied (in English) that she had not spoken English for a long time, and that speaking English was a great pleasure for her, so she was not willing to stop. It may well be, however, that this answer is an intelligent confabulation,[3] used by the patient in an attempt to mask her inability to switch back to Polish. It has been reported in the literature many times (e.g. Paradis 1997) that the energy cost in the brain to switch back to L1 from L2 is significantly higher than to switch from L1 to L2.

Another problem delaying the learning of a foreign language by the subjects was posed by disturbances of memory and concentration. The patients often did not remember what had happened around them a moment ago, or were unable to say what they had been doing earlier in the day. Moreover, they tired relatively quickly, and it was difficult for them to concentrate on a given task for a longer period. Apart from this, some

[3] Patients with brain damage frequently produce confabulations, in which they unconsciously fill in memory gaps with incorrect information.

patients lacked motivation to exercise and study. For all these reasons, it was difficult to encourage them to study harder.

Younger subjects showed increased chances of successful return to health. It is generally believed that the younger the patient, the faster recovery of the injured brain, though this is by no means a unanimous opinion. Brain damage after the age of 5 diminishes the likelihood of the restoration of language functions (cf. Neil 2001). Brain injury in children very often handicaps language only for a short time. The same injury in the adult brain causes irreversible language disorders. In the course of brain development, cells and tissues, along with the physiological functions they serve, gradually become specialized. This process is called "differentiation", which entails the loss of plasticity of tissues (Lennenberg 1974). Healthy specialized cells and tissues can no longer assume the functions of damaged areas with such facility as in children. Teuber (1975, as cited by Neil 2001), who investigated soldiers with head injuries, came into the conclusion that younger patients regain speech more effectively than older ones.

5. Conclusions

The present study reveals that comatose patients with brain damage are capable of learning a second language by extending L2 vocabulary, improving the use of grammatical structures, and correcting pronunciation. However, a number of factors, such as post-traumatic aphasia and problems with memory and concentration, hinder the process of L2 acquisition. Yet some patients performed better that had been originally expected. The experiment described here is only a pilot study, and further research is needed.

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