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# Understanding the relationship between language proficiency, language impairment and rehabilitation: Evidence from a case study

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**Abstract**
The goal of this study was to address the relationship between language proficiency, language impairment and rehabilitation in bilingual Russian–English individuals with aphasia. As a first step, we examined two Russian–English patients' pre-stroke language proficiency using a detailed and comprehensive language use and history questionnaire and evaluated their impairment using the Bilingual Aphasia Test. We then attempted to replicate and extend Kiran and Roberts' study in 2010, examining results of a primarily semantic treatment for anomia in one Russian–English bilingual patient. The patient's ability to name the trained and untrained items in both the trained (English) and untrained (Russian) languages significantly improved by achieving 100% accuracy. Finally, we examined whether improvements observed in treatment were captured by a broader language test such as the Bilingual Aphasia Test. Results are discussed with respect to factors contributing to the successful treatment and the implications of rehabilitation on assessment of language skills as a function of treatment.

**Keywords:** *aphasia, bilingualism, assessment, treatment*

## Introduction

Bilingualism is a widespread and typical phenomenon in the United States of America, as well as in many other countries in the world. According to the 2004 US Census, 18.7% of the American population, about 50 million people, speak another language – instead of or in addition to English. A lot is known about the representation of language, specifically lexical-semantic knowledge in normal bilingual individuals. For instance, it is well accepted that bilingual individuals have two separate lexicons that are representations of the two languages directly connected to a shared semantic/conceptual system (de Groot, 1992; Kroll and Stewart, 1994; Kroll, van Hell, Tokowicz, and Green, 2010). Furthermore, a shared lexical system spreads its activation to both lexicons (Green, 1998; Costa and Caramazza, 1999). In bilingual individuals with relative proficiencies, the lexicon of the dominant language is generally assumed to be larger than that of L2 because more words are known in the dominant

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language. Lexical associations from L2 to L1 are assumed to be stronger than those from L1 to L2. Conversely, the links between the conceptual system and L1 are assumed to be stronger than that from the conceptual system to L2. Additionally, it is assumed that in most language tasks the semantic system spreads its activation to both lexicons in parallel regardless of the target language. Therefore, the flow of activation from the semantic system is target-language non-specific regardless of the language in which a task is being performed (Costa, 2005; Roelofs and Verhoef, 2006).

Although there is research that explores how bilingual individuals' language systems organize and function, there has been insufficient research on the same in individuals with bilingual aphasia (Lorenzen and Murray, 2008), although attention to this topic is increasing due to practical demands of serving this clinical population (e.g. Kohnert, 2004; Edmonds and Kiran, 2006; Laganaro, Di Pietro, and Schnider, 2006; Kiran and Roberts, 2010). Recent research by Kiran and Roberts (2010) examined the effect of the semantic naming treatment in bilingual patients (English–Spanish and English–French). The results reveal various patterns of generalization post-treatment in these bilingual patients; however, generally, the bilingual patients were observed to have generalization of trained lexical-semantic abilities within and across trained and untrained languages post semantic-based treatment.

Using a case-study approach, this study examines the relationship between language proficiency, language impairment and rehabilitation in bilingual Russian–English individuals with aphasia. Although this is clearly an ambitious undertaking, this study takes a preliminary step at systematically integrating three different, but critical, aspects involved in understanding the nature of language recovery in bilingual aphasia. To provide a framework for the work described here, we begin the introduction with a brief background about assessing language proficiency in individuals with bilingual aphasia. Because there is little research concerning diagnosing lexical-semantic naming difficulties in Russian–English patients with aphasia, we will discuss the application of the Bilingual Aphasia Test (BAT) for Russian–English bilinguals. We will then transition to discussion of the semantic-based treatment and provide a theoretical framework for this therapy. Therefore, this study will seek to offer new evidence about how diagnosis and remediation of the naming deficits could be improved in the contemporary approaches with bilingual individuals with aphasia.

### *Assessing language proficiency*

To effectively conduct research or intervention with bilingual individuals, it is necessary to describe their language proficiency and language history. Several language history questionnaires exist (e.g. Marian, Blumenfeld, and Kaushanskaya, 2007) but these do not address all areas of interest and, thus, provide an incomplete view of the individual's language history. The bilingual individual's linguistic proficiency is further influenced by such factors as cultural and/or religious identities, education received in both languages, socioeconomic status, exposure to and use of each language in daily communication (Muñoz and Marquardt, 2003). There are a number of reasons to want to estimate pre-stroke proficiency and not just current language proficiency in individuals with stroke. Any classification of impairment in bilingual aphasia relies on having accurate information about pre-stroke proficiency. Planning treatment also requires estimating what the patient was able to do pre-stroke. Roberts (2008) proposes four types: self-ratings of proficiency, ratings by family members, acquisition history and patterns of use for each language. Recently, we (Kiran, Pena, Bedore, and Sheng, 2010) examined the validity of the Language Use Questionnaire (LUQ) in development that was tested on 139 participants across seven language combinations (English–Spanish, English–Hindi, Russian–English, English–Mandarin, English–Kannada, English–Turkish and English–Arabic) and found it to be a sensitive measure of patients' language use and proficiency skills (Edmonds and Kiran, 2004; Kiran and Lebel, 2007). This questionnaire obtains information about the period of age of language acquisition and a proportion of language exposure in hearing, speaking and reading domains during the entire lifetime for each individual. A weighted average of the proportion of exposure across the lifespan in the three domains is obtained for each language. Next, participants fill out a detailed educational history form in which they are asked to provide the language of instruction in each language and the language that they and their peers prefer during conversations. Also, participants estimate the time spent conversing in each language hour by hour during a typical weekday and typical weekend. A weighted average of this score reflects the proportion of the time spent conversing in one language versus another language. Finally, participants are required to self-rate their proficiency in each language in terms of their ability to speak and understand the language in formal and informal situations. Again, an average proportion score in each language reflects participants' perception of their own language proficiency. The LUQ is usually completed by the participant at home with the help of caregivers and/or significant others for more detailed information.

Furthermore, we have also examined the influence of different aspects of pre-stroke language proficiency (including age of acquisition (AoA) and percent time usage) in each language in individuals with bilingual aphasia (Kiran, Grasemann, Sandberg, and Miikkulainen, 2010). In this project, we have developed a computational model of bilingual lexical access instantiated by AoA and language proficiency that when lesioned demonstrates language impairment analogous to real individuals with aphasia (Miikkulainen and Kiran, 2009). Moreover, there is a close match between pre-stroke language proficiency and the resulting naming impairment in the lesioned model and the behavioural data from patients. Therefore, there are several ways to assess pre-stroke proficiency in individuals with bilingual aphasia; the goal of obtaining pre-stroke language proficiency should be to obtain a diverse and extensive picture into the individual's language learning and use history that can likely explain the patterns of language impairment and response to rehabilitation.

### *Assessment of bilingual aphasia*

Assessment of a bilingual patient with aphasia is complicated by the organization of linguistic systems and skills that are distributed across more than a single language (Muñoz and Marquardt, 2008). At the moment, there is a lack of standardized aphasia assessment batteries available for bilingual aphasia in general and particularly in Russian. Existing Russian tests of language functioning in aphasia are not based on documented norms and lack published psychometric data pertaining to their reliability and validity (Ivanova and Hallowell, 2009). One test that is currently used in assessing aphasia in the bilingual Russian–English population is the BAT (Paradis and Zeiber, 1987). The BAT is a well-known published aphasia test that has been translated into 56 languages. Different language versions of the test were initially designed to assess bilingual patients; however, any single version of the test can be used on its own to assess language functioning in a single language.

The BAT consists of three parts, where the purpose of Part A of the BAT, 'History of Bilingualism', is to establish the patient's language history; however, it is not part of the aphasia test itself (Paradis, Libben, and Hummel, 1987). It is intended to obtain information about the patient's pre-morbid state of bilingualism and contexts of acquisition. There are two parts of the history of bilingualism section where one focuses on the patient's linguistic environment at home as a child whereas the other focuses on language(s) of education. Overall, the information on pre-morbid language history can be supplied by friends, relatives and colleagues. The general scoring method of this and rest of the test parts is using +/– or '0' or digits corresponding to the patient's choice. A score of '0' is entered when the information is altogether unavailable. Although authors state that it is ideal when both pre- and post-morbid performances across both languages are measured, it is not always possible (rarely, in cases of elective surgeries). Therefore, the BAT's Part A is a qualitative and criterion-referenced portion of the test that is used to capture a general idea of language proficiencies by the patient.

Questions about the patterns of use for each language identifying strengths and weaknesses are administered in the beginning of Part B of the BAT. Part B of the BAT is used to distinguish where the patient's language abilities break down in terms of verbal expression and auditory comprehension at a word, phrase/sentence and spontaneous conversation levels. Certain subtests measure semantic processing including Semantic Categories, Synonyms and Antonyms I and II. Some of these also indirectly test a patient's working memory and, thus, are considered 'complex tests of language use'. They require the patient to hold an array of four words simultaneously in their memory, while matching them to either visually presented or auditorily presented stimuli. The Antonyms subtests also use adjectives that are not strictly comparable to the common nouns used in the other two tests. Phonological processing is measured through word and sentence repetition and to a certain extent through object naming. Additional tests examine various aspects of auditory comprehension that include simple pointing, grammaticality judgement and complex commands. The BAT B version also includes several tests examining reading and written output (including dictation and copying).

Part C of the BAT measures bilingual skills in a specific pair of languages. It consists of four tasks in each direction – recognition of translation equivalents, production of translation equivalents, translation of sentences and grammaticality judgements. Within each task, the patient's performance in one language may be compared with his or her performance in the other.

Although the BAT is widely used by bilingual practitioners to diagnose patients, there has not been much empirical research providing salient psychometric evaluation of this measure. One study that looked at the short form of the BAT in Russian was performed by Ivanova and Hallowell (2009) who analysed data collected on a large sample of Russian monolingual patients with aphasia ($N = 83$). Ivanova and Hallowell's (2009) analysis revealed that reliability was a concern in the following tasks: pointing, simple and semi-complex commands, verbal auditory discrimination, lexical decision and reading comprehension of words. The authors further report that, in general, participants performed near ceiling levels. Based on aphasia diagnosis and severity ratings, the observed distribution of item difficulty and the average score of 80% indicated a lack of desired sensitivity in characterizing the deficits of patients with moderate to mild aphasia, who comprised a large proportion (65%) of the sample in this study. It is not possible to evaluate concurrent validity of the BAT based on other assessment batteries, as there are no standardized language tests available in Russian (Ivanova and Hallowell, 2009). What needs to be emphasized is that the participants in this study were monolingual Russian patients with aphasia. Therefore, the results and analysis of the BAT's short form from Ivanova and Hallowell's study may not directly be applied to bilingual Russian–English individuals with aphasia. Nevertheless, the BAT is the only available Russian–English bilingual assessment measure that tests auditory comprehension and verbal expression in each language individually and bilingual skills when using both languages simultaneously. It is, importantly, several steps ahead of any other developed and validated assessment for bilingual aphasia.

*Lexical-semantic treatment in bilingual aphasia*

Although assessment of language processing provides an input into potential behaviours that can be targeted in treatment, it does not provide an understanding regarding the nature of impairment. In the context of monolingual population with aphasia, treatments based on models of lexical-semantic processing that emphasize strengthening semantic information at the semantic/conceptual level have been successful in facilitating generalization to untrained semantically related items (Drew and Thompson, 1999; Coelho, McHugh, and Boyle, 2000; Kiran and Thompson, 2003).

Pertinent to this study, there have been specific studies that look at the effect of the semantic-based treatment and identify which language – dominant or non-dominant – is the best to use for this therapy. One such study by Edmonds and Kiran (2006) facilitated semantic-based treatment and examined generalization to untrained semantically related items in the trained language and translations of the trained and untrained items in the untrained language in three English–Spanish bilingual individuals with aphasia. Their results demonstrated a within- and across-languages effect on generalization related to pre-stroke language proficiencies. When these results are fit into the context of the extant theoretical framework (Kroll and Stewart, 1994), it is reasoned that for individuals with relative differences in proficiency between the two languages, connections between the more proficient language (e.g. English) and the conceptual system are stronger than those between the less proficient language (e.g. Spanish) and the conceptual system. Furthermore, the connections between the less proficient language and the conceptual system are weaker than the connections between the less proficient to more proficient language to the conceptual system. When rehabilitation is provided in the less proficient language, the connections between the less proficient language and the more proficient language are further strengthened, thereby resulting in improvements in both the less proficient and the more proficient language.

In a follow-up study, Kiran and Roberts (2010) also administered the same semantic treatment to improve picture naming in English–Spanish and English–French bilinguals with aphasia and measured generalization to translations of the treated words and to words semantically related to the target words in each language. Their results revealed that the performance in all four patients was highly variable but reflected both within- and across-languages effects on generalization, which may be due to various factors such as each patient's pre-stroke language proficiency, AoA of each language, post-stroke level of language impairment and type and severity of their aphasia (Kiran and Roberts, 2010). These studies highlight the problem that the variability inherent in aphasia, the language structure studied and the nature of bilingualism make it difficult to draw any conclusions about the effectiveness of therapy.

This study extends the above-described treatment work to individuals with Russian–English bilingual aphasia. In this study, we will train lexical retrieval on one set of items in the weaker language of the patient (e.g. English) and examine within-language generalization to untrained semantically related items and cross-language generalization to untrained translations of the trained words and semantically related untrained words. As in the previous two studies, we will test whether strengthening semantic features potentially improves access to trained items (e.g. *broom*) and semantically related neighbours (e.g. *mop*), and from the trained word (e.g. *broom*) and to the translation in the untrained language (e.g. *metla*). Finally, we also tested whether training words in language (e.g. *broom*) resulted in cross-language generalization to the semantically related untrained items in the untrained language (e.g. *shvabra*). These predictions are consistent with theoretical models (Costa, 2005) and relevant recent studies in normal Russian–English bilinguals (e.g. Marian and Kaushanskaya, 2007), which have shown evidence for a bidirectional influence between L1 and L2.

It is not known how acquisition of lexical knowledge in the two languages impacts the diagnosis of impairment subsequent to a stroke in bilingual individuals (in this case Russian–English bilinguals) and, by extension, how these individuals with aphasia re-acquire lexical-semantic proficiencies in their two languages as a result of behavioural intervention. In this article, we make a preliminary attempt at understanding the relationship between proficiency, impairment and rehabilitation using data from two patients. Both patients provided information regarding their pre-stroke language use and background and were administered the BAT. Therefore, using data from two patients, we examined the relationship between pre-stroke language proficiency and post-stroke impairment by using a detailed and comprehensive language use and history questionnaire to measure proficiency and the BAT to measure post-stroke impairment. In the second part of this project, we attempted to examine the effect of semantic naming treatment on cross-linguistic generalization of trained and untrained items in two languages in one Russian–English bilingual with aphasia. The extent to which pre-stroke proficiencies affect those generalization patterns was also examined. Finally, using data from the one patient, we also examined whether changes in treatment were reflected in changes in BAT performance as a function of treatment. This article is organized into two parts; first, we describe two patients' language background and impairment profile. Next, we describe the treatment component, which involved only one of the patients.

## Method

### *Part 1. Assessment of bilingual aphasia*

*Participants*. Two participants (Russian–English speakers) with anomia post-cerebrovascular accident (CVA) were recruited at a local university clinic in Boston, MA. See Table I for a summary of the demographic information for both participants.

### *Language background*

*Participant 1 (P1)*. The participant had two previous left hemisphere CVAs 9 years and 18 months before enrolling in this study. He also suffered from extensive visual impairments as a consequence of his recent stroke. The patient reported that after his stroke, he had more difficulty communicating in English than in Russian.

The participant grew up in a predominantly Russian-speaking home in Harkiv, Ukraine. He had minimal to no exposure to English before his moving to the United States in 1976 when he was 42 years old, at which point he learned English as a Second Language (ESL) at an evening class. The LUQ (Kiran, Pena et al., 2010) was administered to the participant to identify his pre-stroke exposure: time spent conversing, language of instruction and self-rating of proficiency in English and Russian. Based on this questionnaire, P1 reported being exposed to Russian for approximately 77% during his lifetime and to English 23% during his lifetime. In terms of time spent conversing in each language during the time of the study, P1 reported that 82.5% of the time was spent conversing in Russian (most of his time was spent with his Russian-speaking family: P1 went to a Russian-speaking doctor and participated in activities such as chess with Russian-speaking peers). P1 reported spending only 17.5% of his time conversing in English during activities that included occasional shopping, weekly therapy at Emerson College and monthly sessions at the BU Aphasia Resource Center once a month on Saturdays.

Table I. Demographic data, language history and language proficiency ratings across languages for participants P1 and P2.

| Demographic information | | | | | | Language background | |
|---|---|---|---|---|---|---|---|
| Pt | Sex | Age | Education | Etiology | MPO | Family/social | Education and work background |
| 1 | M | 76 | > 15 years in Russian | Left CVA | 18 months and 10 years | Born in Ukraine, USSR<br>Started studying English at age 42<br>Russian from birth<br>Married to bilingual Russian speaker<br>Spoke both English and Russianwith family | Educated in Russian<br>ESL classes once in the United States. Read and wrote in Russian and English. Retired; previously employed as an electrical engineer or a local engineering company |
| 2 | M | 55 | > 15 years in Russian | Left CVA | 1.5 years | Born in Latvia, USSR<br>Started studying English at age 42<br>Married to bilingual speaker<br>Spoke Russian only with parents, siblings, relatives and friends<br>English with children, son-in-law and othern professionals | Educated in Russian<br>ESL classes once in the United States<br>Read and wrote in Russian and English<br>Post-stroke returned to work part-time as an electrical engineer for a local engineering company |

Note: MPO, months post onset; CVA, cerebral vascular accident.

With respect to language of instruction during his education, this participant stated that his previous education in speaking, writing and reading, starting from kindergarten and ending with his graduate degree, was exclusively Russian before he moved to the United States. Neither of his parents spoke English nor were they exposed to English. After moving to the United States at the age of 42, the patient attended an ESL class for a year and gained employment as an engineer, which increased his use of and exposure to English. The LUQ results based on the participant's self-rating of his proficiency (with the help of his wife) further reflect that his confidence in reading, writing and speaking in Russian was at 100% and his confidence in the use and knowledge of reading, writing and speaking in English was at 75%. Based on the patient's answers on the LUQ, his post-stroke proficiency in reading, writing and speaking abilities in Russian was calculated at 90% (as opposed to 100% pre-stroke) and at 50% in English (as opposed to 75% pre-stroke). The participant spoke English with a significant Russian accent. At the time of participating in this study, the patient did not participate in any other concurrent therapy or experiments.

*Participant 2 (P2).* The participant (55-year-old male) had one previous transient ischaemic attack in 2009 that resolved and another left hemisphere CVA later that year before enrolling in and subsequently withdrawing from this study due to scheduling conflicts. The participant was diagnosed with mild expressive aphasia. Most of the previous therapy he received was in English. The participant grew up in a predominantly Russian-speaking home in one of the Baltic Republics, USSR. He had minimal exposure to English at school before his moving to the United States in 1991 when he was 40 years old, at which point he started learning ESL. As an adult, he spoke both English and Russian to his spouse, daughter, other relatives and friends. The patient did not complete the LUQ; therefore, his pre-stroke and post-stroke L1 and L2 proficiencies could not be calculated. For this reason, P2's information is subjective relative to P1; he rated himself as being more proficient in Russian in his daily interactions and reported having difficulty finding words when conversing with unfamiliar interlocutors. Before his stroke, he used English at work and Russian after work. The participant was formally educated in Russian and holds a PhD in Electrical Engineering from a polytechnic institute. He has been working as a chief engineer at a local business in the Greater Boston area since moving to the United States. After his stroke, he came back to work part-time in his previous position as a chief engineer. The participant spoke English with a significant Russian accent.

*Assessment of language impairment*

*Participant 1 (P1).* Overall, P1's performance in Russian was superior to that in English on all BAT subtests (see Table II). His performance on the various subtests of the BAT before the bilingual aphasia therapy revealed an overall superior performance with accuracy ranging from 80% to 100% in Russian across receptive tests such as pointing, semi-complex commands, semantic categories, synonyms, antonyms, semantic acceptability, judgement of words/non-words, sentence repetition, object naming, semantic opposites, reading words and sentences aloud and reading comprehension of words and sentences. Accuracy on English ranged from 80% to 100% for subtests such as pointing, object naming, antonyms and copying words. These results indicated that in Russian, P1's deficits fell into two broad categories: comprehension of syntactically manipulated sentences (e.g. complex commands, judging grammaticality) and written output (e.g. copying, dictation). In English, however, the deficit was widespread and included auditory comprehension for simple and complex syntactic material, phonological processing and production (e.g. repetition and judgement of real/non-words), reading and written output. In both languages, access to semantic knowledge and

Table II. Performance on selected subtests of Bilingual Aphasia Test before and after treatment.

| Task | Possible | P1 | | | | P2 | |
|---|---|---|---|---|---|---|---|
| | | Pre-treatment | | Post-treatment | | Pre-treatment | |
| | | English (%) | Russian (%) | English (%) | Russian (%) | English (%) | Russian (%) |
| Bilingual Aphasia Test (BAT) – Part B | | | | | | | |
| Pointing | 10 | 80.0 | 100.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Semi-complex commands | 10 | **60.0** | 90.0 | 90.0 | 100.0 | 100.0 | 90.0 |
| Complex commands | 5 | **20.0** | **60.0** | **20.0** | **60.0** | 100.0 | 100.0 |
| Verbal auditory discrimination | 16 | **62.5** | 81.3 | 75.0 | 100.0 | 87.5 | 100.0 |
| Semantic categories | 5 | **40.0** | 100.0 | **60.0** | 100.0 | 100.0 | 100.0 |
| Synonyms | 5 | **40.0** | 80.0 | 80.0 | 80.0 | 100.0 | 100.0 |
| Antonyms | 5 | 80.0 | 80.0 | 80.0 | 100.0 | 100.0 | 100.0 |
| Antonyms II | 5 | 80.0 | 100.0 | 100.0 | 100.0 | 80.0 | 80.0 |
| Grammaticality judgement | 10 | **60.0** | **60.0** | **50.0** | 90.0 | 80.0 | 80.0 |
| Semantic acceptability | 10 | 70.0 | 90.0 | 90.0 | 100.0 | 100.0 | 100.0 |
| Repetition | 30 | **13.3** | **63.3** | 83.3 | 100.0 | **66.7** | 100.0 |
| Judgement of words/Sentence repetition | 7 | **28.6** | 85.7 | **14.3** | 85.7 | 71.4 | 71.4 |
| Series (automatics) | 3 | **66.7** | **66.7** | 100.0 | 100.0 | 100.0 | **66.7** |
| Object naming | 20 | 90.0 | 100.0 | 90.0 | 100.0 | 90.0 | 95.0 |
| Semantic opposites | 10 | 100.0 | 100.0 | 80.0 | 90.0 | **50.0** | 70.0 |
| Listening comprehension | 5 | **40.0** | 80.0 | 80.0 | 80.0 | 100.0 | **60.0** |
| Reading words aloud | 10 | 80.0 | 100.0 | 100.0 | 100.0 | 80.0 | 100.0 |
| Reading sentences aloud | 10 | 70.0 | 100.0 | 90.0 | 90.0 | 70.0 | 100.0 |
| Reading text | 6 | **50.0** | 83.3 | 83.3 | 83.3 | **66.7** | **66.7** |
| Copying | 5 | 80.0 | **60.0** | 100.0 | 100.0 | 100.0 | 100.0 |
| Dictation | 5 | **40.0** | **40.0** | **60.0** | 80.0 | 100.0 | 100.0 |
| Dictation sentences | 5 | **20.0** | **20.0** | **20.0** | **40.0** | 80.0 | 80.0 |
| Reading comprehension (words) | 10 | 70.0 | 90.0 | 90.0 | 90.0 | 90.0 | 90.0 |
| Reading comprehension (sentences) | 10 | **50.0** | 80.0 | 70.0 | 80.0 | 70.0 | 90.0 |
| Bilingual Aphasia Test (BAT) – PART C | | | | | | | |
| Word recognition | 5 | 100.0 | 80.0 | 100.0 | 100.0 | 100.0 | 100.0 |
| Translation of words | 10 | **20.0** | **40.0** | 5.0 | 50.0 | 100.0 | 100.0 |
| Translation of sent | 6 | **50.0** | 100.0 | 50.0 | 83.3 | 100.0 | 83.3 |

Note: Scores below 70% (suggestive of an impairment) are in bold face.

object naming appeared to be relative strengths. Notably, there were no tests that P1 performed worse in Russian than in English. Translation of words and sentence (BAT Part C) was clearly harder in English than in Russian, although translation of sentences was more accurate than translation of words in Russian.

*Participant (P2)*. In general, P2's performance on the BAT was better than P1's performance in both languages. Specifically, superior performance (80% accuracy or higher) was observed on several subtests including auditory comprehension (e.g. pointing, complex commands), phonological processing (judgement of words/non-words), semantic knowledge (semantic categories, synonyms), word retrieval (object naming) and written output (dictation of words and sentences) in both languages. With respect to deficits, there was less uniformity relative to P1 between the two languages; thus, no specific deficit pattern emerged (see Table II).

Nevertheless, in Russian, P2 showed deficits in generating automatic series (even though in English he was able to do this task perfectly), in reading text and in listening comprehension. His repetition of both words and sentences in English was weaker (below 80%) than in Russian. His series (automatic language) scores were weaker in Russian than in English (66.7%) possibly because he used names of the days, months and numbers more often in English for his work than at home in Russian. P2's scores in the subtest of reading sentences aloud were weaker in English than in Russian. His reading comprehension at the paragraph level was equally low in both languages and his scores in reading sentences were weaker in English than in Russian.

*Results*. Both P1 and P2 exhibit similar aphasia profiles (mild anomia post-CVA) as well as pre-stroke language proficiencies: they were both late bilinguals learning English in their forties and had advanced degrees in engineering from the former Russian republics. They also both attended ESL courses shortly after their arrival in the Unites States. Both reported using English primarily at work and Russian at home, and, therefore, their profiles showed relative differences in their language use for English and Russian. Given the relative similarity in demographic factors (age, language learning history), it is interesting to note that although P1's performance in Russian is stronger than English, P2's performance in Russian and English is comparable. P1's scores in Russian and English BAT subtests varied significantly: his scores in the Russian subtests were significantly higher in accuracy (mean = 79% accuracy) pre-treatment than scores in the English (mean = 56% accuracy; $t\ (28) = -5.1$, $p = 0.0001$). In contrast, P2 did not demonstrate a significant difference between his performance on the BAT in English (mean = 88% accuracy) and Russian (mean = 89% accuracy; $t\ (28) = -0.43$, $p = 0.66$). Although P2's performance on all BAT tasks reflected a less severe impairment than for P1 and no difference between the two languages, there were some interesting similarities as well. For instance, both patients had relatively unimpaired simple comprehension, could retrieve single words accurately and could read single words aloud accurately, thereby allowing for some interesting comparisons of language impairment between the two languages.

Therefore, when examining the BAT assessment results, it appears that both P1 and P2 are more impaired in English than in Russian. For P1, the difference is marked; his scores in the Russian subtests were at 79% accuracy on average whereas his scores in the English subtests were at 56% on average. P2, however, demonstrated a more uniform deficit in both languages, an average of 86% in English and 89% accuracy in Russian. On closer inspection, however, it is clear that for P1, the effect of brain damage seems to be relatively uniform for both languages. In other words, the relative difference between the two languages persists even after stroke. P2 however was more proficient in Russian than in English but impairment levels in English and Russian were similar.

### *Part II. Treatment study*

*Participants.* Only P1 was involved in the therapy component of the study. Upon completion of the BAT assessment, P1 participated in the 10-week treatment programme.

*Stimuli*. Before the initiation of the therapy programme, P1 was administered a naming test consisting of four lists with approximately 90 stimuli in each set. The first set (English set 1, e.g. *broom*) consisted of visually represented English nouns ranging as high–mid-frequency nouns obtained from the International Picture Naming database (Bates, D'Amico, Jacobsen, Szekely, Andonova, Devescovi, Herron, Lu, Pechmann, Pleh, Wicha, Federmeier, Gerdjikova, Gutierrez, Hung, Hsu, Iyer, Kohnert, Mehotcheva, Orozco-Figueroa, Tzeng, and Tzeng, 2003). For each item in English set 1, a semantically related category coordinate (based on Edmonds and Kiran, 2004) was included in English set 2 (*mop*). Although the

English sets (set 1 and set 2) were matched for frequency and familiarity based on the International Picture Naming database (Bates et al., 2003), we were unable to obtain equivalent Russian norms. Hence, Russian set 1 (*metla*) was a translation of English set 1, and Russian set 2 (*shvabra*) was a translation of English set 2. P1's performance on this task revealed 41% for English set 1, 78% for Russian set 1, 42% for English set 2 and 73% for Russian set 2. From these lists of stimuli, 15 words and their semantic pairs that the patient could not name across the four sets (English set 1, Russian set 1, English set 2 and Russian set 2) or at least in three of the four sets were selected for treatment. An additional 10 English words and their Russian translations were chosen as control words. The control words were selected such that they were not semantically related to any of the target words. Several other criteria were employed to select treatment stimuli, including eliminating cognates from the English and Russian sets. Furthermore, certain images used as stimuli were changed to accommodate the cultural background of the participant. For example, the picture of 'a church' was replaced with picture of a typical Russian church (see Appendix 1 for a list of stimuli used in treatment). Colour pictures were chosen from Art Explosion Software® (NOVA Inc., Calabasas, CA, USA) and from C-O-L-O-U-R library photos from Communication Skill Builders Inc., Arizona, AZ, USA.

*Development of semantic features for treatment*. As in Kiran and Roberts (2010), we developed a set of 12 yes/no questions for each target word similar to the approach of Semantic Feature Analysis treatment (Boyle and Coehlo, 1995; Coelho et al., 2000; Boyle, 2004; Kiran and Roberts, 2010). Six of the questions elicited a 'yes' response and were pertinent to the target item and included (1) the superordinate category (e.g. *fruit; insect*); (2) function or common use; (3) general characteristic 'is a' (e.g. *is sweet; is made of metal*); (4) physical characteristic (e.g. *has skin/peel; has wings*); (5) typical location (e.g. *found in a garage*); and (6) a personal association for each patient (e.g. *reminds me of. . .*). The remaining six features were distractors that elicited a 'no' response as they were not relevant to the target example. The associations were worked out with the patient during each session with assistance from the clinician as needed and could not contain the words previously mentioned in each word's specific features.

*Design*. The experimental design was a single case study with multiple behaviours in baseline. The participant received two initial baseline sessions on the 40 English items ($N = 30$ trained, $N = 10$ control items) and 40 Russian translations to examine stability in naming performance. Treatment then began on one set of items in one language (e.g. English set 2). Naming accuracy on the trained set and the remaining three sets of stimuli (English set 1, Russian set 1 and Russian set 2) and the control items was tested every second treatment session. Once P1 achieved 80% accuracy in naming pictures for two consecutive sessions, treatment was terminated.

*Baseline measures*. Stimuli were presented in language blocks with the order of stimuli pseudorandomized within each block to ensure that items from the same category (e.g. *apple* and *orange*) were not presented sequentially. Before presentation of stimuli in each language, the bilingual clinician conversed with the participant for a minimum of 5 minutes to ensure that the participant was aware of the target language. Oral responses were considered correct if they were clear and intelligible productions of the target item. Self-corrected responses, dialectical differences, distortion/substitution or addition/omission of one vowel or consonant were allowed. All other responses, such as (1) cross-linguistic correct responses (i.e. correct name for the item but in the wrong language (e.g. *drill/дрель*)), (2) cross-linguistic semantic responses (e.g. *апельсин* (orange)/*fruit*), (3) cross-linguistic unrelated words (e.g. *кольо* (ring))/*rake*), (4) semantic errors (*leg/arm*), (5) unrelated word responses (e.g. *garlic/radio*), (6) neologisms, (7) perseverations (syllable, word or neologisms produced three or more times during the specific probe session) and (8) no responses (NR)/'I don't know' (IDK) responses, were scored as incorrect (Edmonds and Kiran, 2006).

*Treatment.* Each set of target items was practiced using a seven-step semantic feature-based treatment (Edmonds and Kiran, 2006; Kiran and Roberts, 2010): (1) the patients attempted to name the picture and was told if their answer was correct or not; (2) the clinician named the object; (3) the clinician placed the printed name of the picture on or below the picture; (4) the patient read a short sentence or phrase describing one of 12 semantic features of the object; (5) the patient sorted them into piles/groups of correct/incorrect features; (6) the picture was turned over for P1 who was then asked the same 12 yes/no questions regarding these features (e.g. *Is it a fruit? Is it found on the roof?*); and (7) the patient named the picture again. Even if the participant named the picture correctly in step 1, the whole procedure was followed. For the first session, the clinician explained what each question was about – category name, function and so on – to make the patients aware of the structure of the therapy. There were a total of eight treatment sessions, four times a week for approximately 90 minutes per session.

*Treatment probes.* Every second session began with administration of probes to measure progress on the target words and generalization within and across languages to the related words and the control set of words. The language first assessed alternated from one probe session to the next. Responses to naming probes were the primary dependent measure for the participant.

*Data analysis.* Effect sizes (ES) were calculated comparing the mean of the data points in the final treatment phase and the post-treatment phase to the baseline mean divided by the standard deviation of baseline (Beeson and Robey, 2006). Based on comparable naming treatment studies in aphasia, an ES of 4.0 was considered small, 7.0 was considered medium and 10.0 was considered large (Beeson and Robey, 2006).

*Treatment results.* Naming accuracies for the trained and untrained set for the patient are displayed in Figure 1. The participant was trained in English (his non-dominant language). After two baseline sessions, naming of set 2 improved to a high of 100% (ES = 7.0). Concomitant changes were observed in the semantically related but untrained Russian set 2 (ES = 3.5) that improved to a high of 100%. English translations (English set 1) of the untrained items also improved to a high of 100% (ES = 7.7), continuing the rising baselines pattern pre-treatment. Performance on the trained English semantically related set (English set 2) showed a significant improvement to a high of 100% (ES = 7.0). Because performance on both Russian sets reached over 60% accuracy, treatment was not provided in Russian.

Performance on the English unrelated control items showed an improvement from 50% to a high of 60% (ES = 1.0). Performance on the Russian untreated controls showed an improvement from 50% to 95% (ES = 0.3).

*Results on pre–post-assessment.* Several of the BAT measures administered pre-treatment were administered again post-treatment (see Table II). The post-treatment performance revealed that P1 performed stronger in Russian than in English. A $t$-test ($t$ (25) = –3.8, $p$ = 0.001) indicated that the pre-treatment and post-treatment scores in the English subtests were significantly different, suggesting an improvement in the participant's overall English auditory comprehension and verbal expression abilities subsequent to treatment. Furthermore, there was a significant difference in the participant's Russian post-treatment scores as compared with his Russian pre-treatment scores on the BAT, $t$ (25) = 3.18, $p$ = 0.0036, which may suggest that the semantic-based treatment in English may have generalized to the patient's Russian lexical-semantic abilities.

The participant's scores on the Recognition of Translation and Production of Translation Equivalents subtests in Part C testing bilingual skills in both languages simultaneously were not statistically significant.

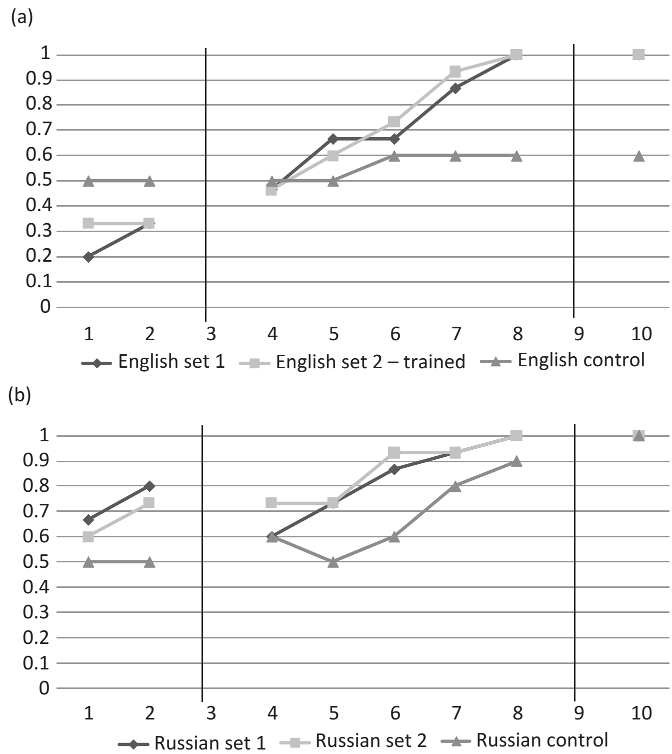


Figure 1. Naming accuracy for Participant 1 on (a) English set 1 (semantically related to set 2) and English set 2 (trained) and (b) Russian set 1 and Russian set 2. Control (unrelated) items in English and Russian are illustrated in the same graph as the generalization items. On the *x*-axis, the numbers represent probe sessions. On the *y*-axis is percent accuracy on the naming probes. The graph is divided into a baseline phase, treatment phase and post-treatment phase.

## Discussion

The goal of this study was to address the relationship between language proficiency, language impairment and rehabilitation in bilingual Russian–English individuals with aphasia. There were two components to this project. In the first part, we compared two Russian–English patients' pre-stroke language proficiency using a detailed and comprehensive language use and history questionnaire and evaluated their impairment using the BAT. In the second part, we then attempted to replicate and extend Kiran and Roberts' (2010) study, examining results of a primarily semantic treatment for anomia in one Russian–English bilingual patient. Additionally, we examined whether improvements observed in treatment were captured by a broader language test such as the BAT if we could tease apart the issues of proficiency and impairment from improved naming subsequent to successful rehabilitation. Each of these issues will be addressed in greater detail.

### *Relationship between pre-stroke proficiency and impairment*

As described in Part I, both participants were late learners of L2 (English) and were more proficient in Russian than in English before their respective strokes. Therefore, it can be assumed that before the brain injury, Russian was the stronger language and English was the weaker language. Based on the theoretical framework described in the Introduction, it may be likely that because English was learned during adult life, the English lexicon was likely sparser than Russian, and the connections between English and Russian were likely stronger than from Russian–English. When examining the BAT assessment results, P1 was more impaired in English than in Russian; his scores in the Russian subtests were at 79% accuracy on average whereas his scores in the English subtests were at 56% on average. P2, however, demonstrated a more uniform deficit in both languages, an average of 86% in English and 89% accuracy in Russian. If we did not take P1's pre-stroke proficiency into account and only considered the BAT scores to understand the nature of this impairment, this patient's profile can be misinterpreted as a relatively greater language deficit in English compared with that in Russian. On closer inspection, however, it is clear that for P1, the effect of brain damage seems to be relatively uniform for both languages. Specifically, English was the weaker language before stroke and, consequently, this patient has lower scores on the English BAT. Conversely, Russian was the stronger language before stroke; post-stroke performance on the Russian BAT is higher than that on the English BAT. In other words, the relative difference between the two languages persists even after stroke. P2, however, was more proficient in Russian than in English but impairment levels in English and Russian were similar and less systemic. It could be speculated that this patient's brain damage affected the two languages differentially; however, as this patient's overall performance is high, it is difficult to draw any significant conclusions about the data. Nevertheless, comparing the two patients provides an interesting insight into the relative impairments between the two languages; when comparing P1 and P2, an apparent differential impairment between the two languages for P1 is in fact an equal impairment in the two languages when differential pre-stroke proficiencies in the two languages is taken into account.

Although the BAT, or for that matter any formal language measure, is not particularly useful in estimating the severity of aphasia in two languages, it does provide a quantitative assessment of impairment in the two languages. And, when the BAT results are interpreted in the context of each individual's pre-stroke proficiencies, a clearer picture of the patient's impairment in the two languages begins to emerge. Obviously, our current measures to obtain pre-stroke proficiencies are quite subjective and prone to inter- and intra-individual variability. Hence, attempting to integrate information from qualitative LUQs and quantitative language impairment measures can be difficult and inconsistent. Clearly, for the science to move forward, more tests need to be developed that take into account some measure of a patient's pre-stroke language status in the two languages (Roberts and Kiran, 2007; Roberts, 2008).

### *Effect of semantic intervention on naming skills*

A second goal of the project was to replicate our previous work on a semantic-based naming treatment in one patient with bilingual aphasia by examining a new language combination (i.e. Russian–English). P1 responded to the semantic-based treatment in terms of his improvement on the target items and the within- and between-language generalization and their maintenance. First, gains on trained items in the trained language occurred for this patient, providing further support for the efficacy of our previously reported treatment (Edmonds and Kiran, 2006; Kiran and Roberts, 2010). The very rapid improvement and the fact that the trained items improved so much more than the untrained ones suggest strongly that the therapy caused the gains. It is possible that frequency and regularity of the therapy (the patient had therapy four times a week for 3.5 weeks) may have been a contributing factor to his rapid improvement. Second, within-language generalization occurred for the items semantically related to the words practiced in therapy indicating that providing a semantic-based treatment that emphasized feature attributes was successful in improving access to semantically related items within the same language.

Importantly, cross-language generalization to trained items in the untrained language (Russian) also occurred, with clear improvements on translations of the target items for this patient. Cross-language generalization for semantically related targets in the untrained language (Russian) occurred highlighting the interaction between the two languages and, importantly, strengthened connections between the weaker (English) language and the stronger (Russian) language. Interestingly, there were significant changes in Russian control stimuli from 50% to 95% but not in English (50–60%) for the semantically unrelated words. This suggests that for this patient, semantic ties between words in Russian were not a critical factor in facilitating improved naming, but the fact that Russian was the dominant language and that improvements were not across all items but were attributed to semantic relatedness. Additionally, English controls did not improve also suggesting that the effect was likely due to structured therapy.

These results support previous findings in bilingual models of language processing and bilingual aphasia treatment research that bilingual individuals share a semantic system that simultaneously spreads its activation to lexicons in both languages. Furthermore, the results of this study support previous researches of bilingual aphasia treatment by Edmonds and Kiran (2006) and Kiran and Roberts (2010) and that the language training task, such as naming ability, in a non-dominant language is influenced by naming ability of the dominant languages.

These results also contribute to the small but growing number of studies showing the positive effects of therapy on improving language skills in bilingual patients with aphasia (e.g. Junque, Vendrell, Vendrell-Brucet, and Tobena, 1989; Laganaro, et al., 2006; Law, Wong, Sung, and Hon, 2006; Marini, Caltagirone, Pasqualetti, and Carlomagno, 2007). Furthermore, although clinically counterintuitive, it appears that training the non-dominant language in an individual with bilingual aphasia may be more beneficial in facilitating cross-linguistic generalization than training the dominant language (Edmonds and Kiran, 2006).

*Interaction between proficiency, impairment and rehabilitation*

The third goal of this article was to examine the interaction between proficiency, impairment and rehabilitation using P1 as an example. Clearly, the present data are by no means a decisive factor in untangling this complex interaction. As noted before, an apparent differential impairment between the two languages for P1 is in fact an equal impairment in the two languages when differential pre-stroke proficiencies in the two languages are taken into account. Additionally, for P1, there was a significant improvement on the scores on the BAT post-treatment compared with pre-treatment in both English and Russian. Specifically, even though English was this patient's weaker language before his stroke and performance on the BAT in English was worse than in Russian, subsequent to treatment in English, this patient improved from an average of 56% to 76% on the scores in English. Likewise, he also improved from an average of 79% to 89% scores in Russian from pre-treatment to post-treatment even though he never received any intervention in Russian. These results provide some compelling evidence that changes that occurred as a result of the semantic-based treatment can be captured by a broad language measure such as the BAT. Therefore, the BAT may be appropriate for measuring the patient's performance pre- and post-treatment across language abilities. The results, however, are only interpretable once measures of pre-stroke language proficiencies are compared with residual language proficiencies post-stroke and post-treatment.

### *Limitations of this study*

Although case studies in clinical linguistics allow a meaningful and detailed examination of potentially complex interactions, their generalizability to the population is very limited. In this study, however, we extended our previous work in Spanish–English and French–English bilinguals (Edmonds and Kiran, 2006; Kiran and Roberts, 2010) to a new language combination, Russian–English. Nonetheless, although the patient described in this study serves as a good example of the interaction between pre-stroke proficiency, impairment and rehabilitation, clearly more studies with larger numbers of patients need to be conducted to systematically tease apart each of these complex issues.

We also recognize that the aspects of the BAT require further psychometric scrutiny (e.g. Muñoz and Marquardt, 2008; Ivanova and Hallowell, 2009) and, ideally, standardization. Our recommendations in regard to stimuli are consistent with those expressed in Ivanova and Hallowell's study (2009) and these include selection of more appropriate stimuli for specific Russian subtests (e.g. Semantic opposites – item 323. The words 'hudou', *slim*, and 'tonkiu', *thin*, which have almost the same meaning in Russian, were both considered to be correct opposites for the word 'tolstuu', *stout)*. As another example, for the Antonyms II (Russian subtest), the instructions state that 'the choices *look* very similar but only one is the opposite of the word you will hear'; it may be confusing for the patient not to see the words that look similar because they are read to the examinee, but are not shown.

One other modification that could positively affect the semantic feature treatment is assigning highly structured homework tasks after each session. We came to this realization when we were informed by P1 and his wife at the end of the treatment that he practiced the target words by either asking his wife to (repetitively) name the target items or looking up the target items on the Internet. The fact that improvements were not across all items (i.e. English controls did not improve) suggests that the effect was likely due to structured therapy. Other patients, too, may benefit from the additional task of homework practice, if they are motivated, have time and have someone to practice with at home. A more systematic investigation of the homework effect is warranted in the future.

## Conclusion

The results from one bilingual patient with aphasia demonstrate that a standardized, valid and reliable assessment measure that quantifies and compares person's pre-stroke language proficiencies and pre- and post-treatment scores is much needed. Although the patient achieved all goals of the semantic-based treatment and showed statistically significant improvements in the BAT scores in his post-treatment testing, it is difficult to determine to what extent the BAT appropriately captures differential performance post-stroke. As better measures are created to quantify a person's pre-stroke language abilities and methods are developed for selecting stimuli, controlling for more factors related to those stimuli and for grouping patients based on their linguistic histories, a clearer picture will emerge. Furthermore, pre-stroke language proficiencies must be taken into consideration as they should be compared to pre- and post-treatment scores to capture any differential performance and identify whether there has been impairment in the pre-stroke baseline or whether the level of proficiency in one language was already lower than the proficiency in the other language before the stroke.

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## Appendix 1: Stimuli in English set 1 and set 2 and their Russian translations and English and Russian control items for P1.

| Participant 1 | | | | | |
|---|---|---|---|---|---|
| English set 1 | Russian set 1 | English set 2 | Russian set 2 | English control | Russian control |
| book | kniga | newspaper | gazeta | leaf | list |
| broom | metla | mop | shvabra | sleeping bag | spal'niy meshok |
| butterfly | babochka | bee | pchela | pillow | podushka |
| frog | lyagushka | lizard | yascheritsa | school | shkola |
| moon | luna | star | zvezda | celery | sel'derey |
| skunk | skunts | raccoon | enot | nail | gvozd' |
| spider | pauk | ant | muravey | clothespin | prischepka |
| table | obedenniy stol | desk | stol | rabbit | krolik |
| church | tserkov' | bell | kolokol | sword | mech |
| badge | politseyskiy znachok | handcuffs | naruchniki | snail | ulitka |
| trophy | kubok | medal | orden | | |
| fox | lisa | beaver | bober | | |
| shark | akula | dolphin | del'fin | | |
| fan | ventilyator | iron | utyug | | |
| cow | korova | donkey | osel | | |