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Green, D.W., Ruffle, L., Grogan, A. et al. (6 more authors) (2011) Parallel recovery in a trilingual speaker: the use of the Bilingual Aphasia Test as a diagnostic complement to the Comprehensive Aphasia Test. Clinical Linguistics & Phonetics, 25 (6-7). pp. 499-512. ISSN 0269-9206

https://doi.org/10.3109/02699206.2011.560990

Clin Linguist Phon. Author manuscript; available in PMC 2011 December 01.

Published in final edited form as:
Clin Linguist Phon. 2011 June ; 25(0): 449–512. doi:10.3109/02699206.2011.560990.

Parallel recovery in a trilingual speaker: the use of the Bilingual Aphasia Test as a diagnostic complement to the Comprehensive Aphasia Test

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Abstract

We illustrate the value of the Bilingual Aphasia Test in the diagnostic assessment of a trilingual speaker post-stroke living in England for whom English was a non-native language. The Comprehensive Aphasia Test is routinely used to assess patients in English but only in combination with the Bilingual Aphasia Test is it possible and practical to provide a fuller picture of the language impairment. We describe our test selection and the assessment it allows us to make.

Keywords

language control; recovery patterns; interference

Introduction

Following stroke, speakers of more than one language display different patterns of speech recovery (Paradis, 1998; 2001; 2004; see also Fabbro, 1999). In parallel recovery all languages are recovered to the same degree relative to their pre-morbid levels. By contrast in differential or selective recovery one language is much better preserved compared to others. The various recovery patterns offer the opportunity to study the neural bases of the effects of stroke and so help develop a principled basis for the treatment of aphasia. In order to further this goal, we clearly need to identify the pattern in the first place and this requires adequate diagnostic tools. In the case of non-native speakers of English who live and work in the United Kingdom, we can use tests developed to assess native speakers of English. A test such as the Comprehensive Aphasia Test (CAT, Swinburn, Porter & Howard, 2004), for instance, includes measures of receptive and expressive language performance but it does not provide a means to assess performance in other languages. The Bilingual Aphasia Test

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Declaration of interest: The authors report no conflicts of interest. The authors alone are responsible for the content and writing of this article.

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allows us to assess performance in other languages using a common set of tests. It is therefore a vital diagnostic complement to our use of the CAT.

Different patterns of recovery may reflect the ease with which individuals can select and control the language of use (Green, 1986; Paradis, 2004; 2009). In normal speakers, behavioural (Gollan & Acenas, 2004; Kaushanskaya & Marian, 2007; Kroll, Bobb, & Wodniecka, 2006)) and neuroimaging research (Abutalebi & Green, 2007; van Heuven & Dijkstra, 2010) establishes that the languages of a bilingual are jointly active during the processing of just one of the languages and that they potentially interfere with one another. In addition to our clinical assessments, therefore, we also determine whether or not the recovery pattern reflects a broader problem in controlling interference by making use of explicit conflict tasks. In a previous paper (Green, Grogan, Crinion, Ali, Sutton & Price, 2010), we found that parallel recovery in one patient was associated with impairments in resolving both verbal and non-verbal conflict whereas in a second patient there was only a problem in resolving verbal conflict.

Here, we present the case of a trilingual stroke patient to illustrate our use of the BAT in combination with our existing English language tests for the monolingual population. Test scores are pertinent and so also are errors. Where test scores are similar across languages we should also expect a common pattern of errors, within the syntactic constraints of each language. In addition, we report the performance of our speaker on a set of explicit conflict tasks. Our data suggest that, for this patient, recovery is parallel across all of her languages, and is associated with a selective problem in resolving verbal interference.

Method

The study was approved by the National Hospital for Neurology and Institute of Neurology Joint Ethics Committee.

Participants

Case description of the trilingual participant with aphasia

Pt1 is a right-handed female trilingual speaker with normal vision and aged 44 at the time of testing. She had suffered a left temporo-parietal infarct, probably caused by a cardiogenic thrombo-embolism three years previously, which included Heschl's gyrus and extended into the posterior part of the insula (see figure 1).

Born in Germany to German parents, her family moved to the United States for two years when she was a year old. She was exposed to English outside the home during this period, and began speaking English, but this ceased at the age of three when the family moved to Colombia. During her four years in Colombia, she attended a German-speaking school where some Spanish was taught, but the majority of lessons were in German. Her father remarried after her mother died and the family returned to Germany. Pt1 continued to use Spanish when speaking to her Colombian stepmother, and German with the rest of the family and at school.

At 13 she moved with her family to Argentina, where she completed her secondary education in a bilingual German-Spanish school in Buenos Aires leaving with qualifications in both languages: the Spanish Bachillerato at 18, and the German Abitur at 19, which included English as a foreign language. She then returned to Germany for 18 months before moving to England to complete a BA in modern languages (German, Spanish and English). At the age of 24 she married a Chilean national and has lived in England ever since. Before her stroke, she worked as a management consultant with English as her primary language.

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With her close family she uses German, Spanish and English. She speaks Spanish primarily to her husband (who does not speak German) and German to her daughter, who attends a German-speaking school. With relatives abroad she speaks German to her father and brother, and his daughter and Spanish to her stepmother. Her circle of friends in England includes speakers of all three languages. She reported that post-stroke she has the sensation of inappropriate language switching in conversation, but family and friends report that they have never observed this. Indeed she appears remarkably fluent in normal conversation. On our language history questionnaire, she scored her language use as spread evenly across all languages (33% for each), both before and after her stroke. She also scored her pre-stroke proficiency as 9 (native speaker level) on all three languages and in all areas (speaking, understanding, reading and writing).

Control participants

We matched Pt1 with 4 unimpaired, female, right-handed speakers from our multilingual database who were non-native speakers of English with German as their first language and with a Romance language (Spanish/French or Italian) as a further language. Some also spoke a fourth language. Table 1 summarises the language information for Pt1 and these participants. Their self-ratings of English were comparable to the self-reported pre-morbid rating of Pt1 but lower for their Romance language. Their proportional use of their languages varied. In all cases English was a late-acquired second language as in the case of Pt1. Matching the age of acquisition of the patient and controls is important because current evidence suggests that early exposure to a language does not necessarily predict that the language will be accessible in adulthood unless it is combined with continued minimal exposure (Pallier, Dehaene, Poline, Le Bihan, Argenti, Dupoux & Mehler, 2003). Early exposure may nevertheless speed relearning (Oh, Au & Jun, 2009).

Procedure

All participants completed a Language Background Questionnaire that covered acquisition and use of each language. They were asked to estimate their proficiency in reading, writing, speech understanding and comprehension on a scale from 1 (very low proficiency) to 9 (native speaker level), pre-morbidly in the case of Pt1. Mean values are shown in table 1.

For Pt1, testing took place in three sessions over the course of two days. In the first session, she was assessed in English using the Comprehensive Aphasia Test (CAT, Swinburn et al, 2004). The second two sessions took place on the same day with a break between languages. German and Spanish testing incorporated spoken picture description and naming tasks from the CAT in addition to subtests from the relevant Bilingual Aphasia Tests (BAT: Paradis & Libben, 1987). Because of the significant effects of fatigue after stroke and the demands made of our participant during testing, we limit the test battery to the core areas of comprehension, spoken production, and reading. In addition to these assessments, Pt1 completed subtests of the relevant Bilingual Aphasia Tests. A proficient trilingual speaker of English, German and Spanish administered tests in German and Spanish and scored all the data in all three languages in conjunction with native speakers.

Our control participants also completed the spoken picture description task in English and in German. The descriptions were elicited by native speakers and scored by the person administering the test using the CAT criteria. Tests for each of the languages were completed in different sessions on the same day with a break between the different languages.

In addition to these assessments, Pt1 and the controls completed a set of explicit conflict tasks, viz:- a lexical decision task in English; a Stroop test in both English and German (Pt 1 also completed a Stroop test in Spanish) and a non-verbal flanker task. All participants also undertook the Raven's Progressive Matrices Test as a measure of fluid intelligence.

Materials and tasks

a) Comprehensive Aphasia Test (table 2)—The CAT provides a basic cognitive screen in addition to the language battery. It includes subtests for comprehension, repetition, spoken language production, reading aloud and writing. The spoken language production tasks in response to non-verbal picture stimuli were also carried out in Pt1's other languages including digit repetition, naming and spoken picture description. The naming task involves naming a set of picture stimuli, including 24 objects and 5 actions. The same picture stimuli were used in all three languages. The spoken picture description task requires the participant to describe a scene from a picture in as much detail as possible. The same picture (from the CAT) was used in English and German which were tested on different days. However, as German and Spanish testing was carried out on the same day, the picture description task in Spanish used the "Cookie theft picture" from the Boston Diagnostic Aphasia Examination (BDAE: Goodglass & Kaplan 1972). For all languages, Pt1's responses were videoed and the first minute of speech was scored according to the criteria in the CAT manual. The overall score incorporates both content and manner of expression. The content measure is the sum of appropriate information carrying words minus any inappropriate information carrying words. To this are added values for syntactic variety (on a scale of 0 to 6), grammatical well-formedness (on a scale of 0 to 6) and speed of speech production (on a scale of 0-3). Inspection of the scores from the trilingual controls showed no significant differences between English and German.

b) Bilingual Aphasia Test (table 3)—We selected sections from the BAT that allowed us to compare Pt1's responses to verbal stimuli in all three of her languages. The majority of the tasks were carried out in each of her three languages: sentence construction, comprehension of spoken commands, written paragraph comprehension, reading words aloud, reading sentences aloud, and the translation tasks (German-English bilingualism and Spanish-English bilingualism). However, word repetition, auditory comprehension and comprehension of written words and sentences were administered in the German and Spanish BAT only because performance in English on these tasks had already been tested with the CAT and we wanted to minimize testing time by avoiding too great an overlap with the CAT.

The BAT auditory comprehension task is similar to the spoken paragraph comprehension test in the CAT: the participant listens to a short passage and is then asked a series of who/what/why questions. The BAT repetition task is carried out simultaneously with a word judgement task: the participant repeats a word and judges whether or not it is a real word (i.e., repetition followed by lexical decision). A written version of the lexical decision task was also administered in English, see explicit conflict tasks in the next section below.

In the sentence construction task, the participant creates a sentence using single words read aloud to them. In the comprehension of spoken commands the participant performs various tasks in response to commands that range in complexity from simple (e.g., /point to the ring/) to more complex (e.g., /here are three books: open the first, turn over the second, and pick up the third one/). If performance is not correct overall on the complex command, the participant is given a score for each single command performed correctly regardless of whether it was performed in the correct sequence. For the tasks assessesing comprehension of written words and sentences, the participant is asked to match the word or sentence to a picture presented with misleading foils. In the case of written word-picture matching, these take the form of phonemic distractors; for written sentence-picture matching, different syntactic alternatives are used. In the written paragraph test, the participant is given ninety seconds to read a short paragraph and is then asked similar questions to those on the spoken paragraph task.

The translation tasks are unique to the BAT amongst aphasia batteries. They assess written comprehension of both languages in the word recognition task, where the participant is presented with five words in each language and asked to match them to the translation equivalents from a list of ten possible words. Spoken word production is then assessed in the second translation task: the participant is required to produce the translation for ten spoken words in each language, ranging from high frequency concrete objects to less common abstract nouns. Finally, in the sentence production task, the participant listens to ten sentences in each language and is asked to give the translation after each one.

c) Explicit conflict tasks (table 4)—This involved the same three tasks that were used in Green et al. (2010) to examine the control of interference, namely, lexical decision, the Stroop task and a non-verbal flanker task.

For the lexical decision task, materials were taken from the Psycholinguistic Assessment of Language Processing in Aphasia (PALPA, Kay, Lesser & Coltheart, 1992). We derived non-words by changing one or more letters from real English words (not presented in the task) such that they were possible words in English (i.e., obeyed the orthographic and phonological constraints of English). After a short practice block, participants responded to a random sequence of 60 word and 60 non-word trials divided into six blocks. Each letter string was displayed on a computer screen, and participants pressed one of two response buttons mounted on a response box to indicate if it was a word or not. The programme recorded accuracy and reaction time. The task, with between-block breaks, took approximately twenty minutes.

The Stroop task (Stroop, 1935) for each language contrasted performance on neutral trials with that on conflict trials (see Long & Prat, 2002). A neutral trial consisted of five capital Xs printed on a black background in a single colour: red, yellow, blue or green. A conflict trial consisted of a capitalised colour word (e.g., red, yellow, blue and green or its translation equivalent) in an incongruent colour on a black background. Following a practice block, participants completed two blocks of 24 experimental trials (half neutral, half conflict). Trials occurred in a pseudo-random sequence such that each colour and colour name appeared equally often with no repetition of a colour name on adjacent trials (i.e., the design avoided negative priming from a previous trial) and no occasion in which a colour word was the name of the hue on the current trial. Stimuli were displayed such that the first letter of the colour word (for conflict stimuli) or the first X (for neutral stimuli) was centred on the screen. For the control participants, each stimulus remained on the screen until a vocal response was detected by the voice-activated relay. The next trial started after 1 second. All naming latencies were recorded and the experimenter noted whether the response was correct or not in the language being tested. For Pt1 the task was self-paced. She triggered the next trial by pressing the space bar and all vocal responses were recorded for subsequent analysis in order to identify errors and to record correct reaction times. With a short-break half way through the experimental trials, each Stroop task took about eight minutes.

In the non-verbal flanker task (the Attentional Network Test, see Fan et al., 2002) participants pressed one of two response buttons mounted on a single response box to indicate whether a central arrow pointed left or right. The arrow appeared above or below fixation and was accompanied by flanking arrows pointing in the same direction (congruent trials) on half the trials and arrows pointing in the opposite direction on half the trials (incongruent trials). Following a practice session with feedback, participants completed 140 trials, half of which were congruent and half of which were incongruent. The task, with breaks, took approximately thirty minutes.

Raven's progressive matrices

As a basic screen for general cognitive impairment we used the 12 items of set A from the Raven's coloured progressive matrices (Raven, 1938).

Results

Assessment of English and other languages using the CAT

Linguistic tests from the CAT (see table 2) show Pt1 to be aphasic with relatively unimpaired cognitive function. She presented with significant impairments in the areas of spoken language comprehension, repetition and naming. She also scored within the aphasic range on written sentence comprehension and reading aloud.

Her error pattern points towards an impairment in phonological working memory and in accessing output phonology. This is particularly apparent in her difficulties with repetition tasks. Her digit span was two, one, and one for English, German and Spanish, respectively, i.e., she had a severe deficit in memory for speech sounds across all her languages. She also struggled to repeat single words which were low frequency or polysyllabic. Her responses included a mixture of phonemic distortions and semantic errors, consistent with deficits in retaining speech sounds while accessing semantics. Examples include “crose, cross” for /crucifix/, “cold, frozen” for /defrosted/ and “wine” for /vine/. When repeating sentences, Pt 1 resorted to circumlocution in an attempt to convey the meaning of the sentence, e.g. “the bird runs after the other one” for /the cat chased the bird/

Unsurprisingly, these difficulties in retaining speech sounds were also reflected in the comprehension tasks. On spoken words, Pt1 chose semantic distractors on five occasions in 16 trials (30% error rate), e.g. “teapot” for [kettle] and “elbow” for [knee]. Comprehension of spoken sentences was discontinued after four consective errors in identifying reversible sentences such as /the nurse shoots the butcher/ and /the policeman is painted by the dancer/.

In the naming section, difficulties in retrieving phonemes were again evident. Examples of errors include “click” for [camera], “animal” for [elephant] and “but..bitter” for [butterfly]. There was no evidence of any difficulty in selecting English though we noted one possible cross-linguistic error. In naming the action of threading a needle, she responded “eeling oil” in English and “einölen” in German (to oil). The German target was /einfädeln/ and the response may be described as a mixed phonemic/semantic error, where the target has been corrupted by interference from the word ’Öhr’, the eye of a needle. Interestingly, the semantic associations from this error appear also to have influenced her response in English, since there is no other close semantic or phonemic target.

Remarkably, Pt1 scored within normal limits on the spoken picture description despite her strongly aphasic performance in most other areas. Relative to the trilingual controls, her score on the English spoken description task was outside the aphasic range (she scored 36 with the normal cut-off of 15.4, see table 4). This can be attributed to her excellent functional strategies which capitalise on her ability to manipulate morphology and syntax. Combined with her ability to access the sounds for a reasonable number of common information-carrying words, she is able to produce rapid speech that masks her difficulties in other tasks. In German, she also performed within the normal range (34: cut-off, 23.2) and her Spanish score (39) was comparable.

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Nevertheless, closer inspection of Pt1's descriptions revealed them to be hesitant with repetitions. In German, there were no language intrusions and gender and pronominal reference were intact. Likewise, in Spanish, gender and reference were appropriate with minimal cross-language intrusions (exceptions being "un cookie" and "el water" and "un flat" though she later succeeded in producing "una torta" and "el agua"). Intrusions occurred in the context of word-finding difficulties, as indicated by multiple hesitations and attempts at initial word sounds. We think it unlikely that this is evidence of involuntary language switching given the testing context and her performance on other tasks. Instead, such intrusions may reflect an attempt at self-cuing or a last communicative resort given that the tester was also trilingual. Clearly where there are good grounds for believing there is a problem in selecting the correct language then the tester should not speak the patient's other language (see Paradis & Libben, 1997).

On more constrained tasks such as confrontation naming, Pt1's word-finding impairment was much more pronounced (she named 12, 9 and 3 out of 24 objects correctly in English, German and Spanish, respectively). The majority of errors were phonemic: examples include "Schnellen..Sch" for [snail] for the target "*Schnecke*", "Krabse"[crab] for the target "*Krebs*" and for Spanish, "spoon, cucha, cuche, coche[spoon] for the target "*cuchara*" and "pin, pi, una pierra, pita"[pineapple] for the target "*piña*". There were also a number of semantic errors and circumlocutions: "Foto" for [camera]; "Habe/Haar"/ [brush] and "para comer en Francia" for [snail]. In terms of cross-language intrusions, the correct name was produced in English instead of German on two occasions and in English instead of Spanish on five occasions. There were varying levels of impaired performance for naming actions (2; 4; 0, out of 5, for English, German and Spanish) but no occasions in which an action was correctly named in the wrong language.

Assessment of performance in three languages using the BAT

A significant advantage of the BAT is that it provides both single word and sentence level measures using tests that are matched across languages. Details of the assessment are presented in table 3.

The impairment in repeating words in English was paralleled in German and Spanish. Pt1 scored below 50% correct in both cases. Her errors again displayed a pattern of phonemic distortions and semantic substitution. Examples of the first include "Nesste" for /Nessel/ and "Pallt" for /Plant/ in German, and "goto" for /gorro/ and "oso" for /hueso/ in Spanish. Semantic and mixed phonemic/semantic errors include "dinero" in response to /mil/ in Spanish and "Stroht" for /Strauch/ in German.

Comprehension difficulties identified on the CAT were also evident in Pt1's severe problems in understanding complex commands in all three languages (5; 12;7 out of 20 for English, German and Spanish, respectively) though she was less impaired in German. In the sentence construction test Pt1 was impaired in all three languages with rather worse performance in Spanish. In all cases, her typical error consisted of missing out one or more of the required elements. For example, in English, given /chair/doctor/sit/, the response was "The doctor is at home" and given /pencil/write/blue/paper/, it was "I'm writing a book". In German, the comparable responses were "man setzt sich beim Doktor hin" (missing out /Sessel/) and "Ich male alles gelb" (missing out /Bleistift/, /schreiben/ and /Blatt/). In Spanish, they were "Estamos hablando con el doctor" missing out /silla/ and /sentarse/ and "Voy a escribir un libro muy bonito" missing out /lapiz/, /azul/ and /papel/..

In the translation tests, Pt1 performance was at ceiling in recognizing the translations of single words between English and German and English and Spanish and vice versa. However, she was markedly impaired when required to produce the translations of words or sentence though Spanish to English translation was relatively less impaired. In translating the English word [wall] she said "Wend"..“Wende” rather than the target "Wand". In Spanish, [napkin] elicited the circumlocution "la que uno se pone para comer" ("the thing you put on to eat"). Similarly, sentence translation was characterised by omission of sentence elements and circumlocutions when she was unable to retrieve the target word, e.g., in Spanish "cuando vienes *cuando hace frio* y vienen allá, *como se llaman arriba*" (respectively, '*when it's cold*' for the target word /winter/ and '*what they're called up there*' for the target /mountains/). A similar example in German is 'meine Zeit ist vorbei, wo es schön war' ('my *time* is over, *when it was nice*' for the target /vacation/).

Explicit conflict tasks

Performance on the CAT and the BAT showed that Pt1 is aphasic in all languages. In line with these data, paced conditions (see table 4) reveal impaired performance in verbal conflict tasks but not in the non-verbal conflict task. Specifically, she performed with normal accuracy in the non-verbal flanker task even on the incongruent trials.

In contrast, in English lexical decision, her ability to correctly identify a word was normal but she was less accurate than normal when identifying non-words. In the case of the Stroop tasks, she was impaired either in overall accuracy or in responding correctly to incongruent trials. In Spanish, her overall accuracy was low (around 70% correct). For the vast majority of the 48 experimental trials, she named in the correct language but in the German Stroop, an English colour word was produced incorrectly on one occasion and in the Spanish Stroop, an English colour word was produced incorrectly on four occasions. In short, on paced conflict tasks, Pt1 shows impaired performance on all verbal tasks with comparable impairments across languages in the Stroop task but with no marked impairment in selecting the correct language. Impaired control of verbal interference in Pt1 is combined with normal performance in resolving non-verbal interference.

Discussion

Overall, on both paced and non-paced confrontation tasks, Pt1 shows a comparable pattern of deficit across her three languages. The BAT reveals a deficit in all three languages and complements the assessment of the CAT in English. In the spoken picture description task where Pt1 had greater freedom to select her own words and expressions her scores were within the normal range but her speech remained hesitant with repetitions. Although there were intrusions from a non-target language in some tasks these were rare. Further, her verbal deficit dissociates from intact performance on a non-verbal conflict task.

Pt1 therefore shows a parallel pattern of recovery with a reasonably intact ability to select the correct language but a marked difficulty in selecting word forms within the selected language. Her problems in word selection arise even when she knows the words in question and can retrieve them (as in the Stroop task) suggesting that resolving competition between potential candidates is crucial to understanding her deficit. Of course, as a trilingual speaker, using all three languages on a regular basis, it is likely that there is competition with lexical candidates from her other languages. Prior to her stroke Pt1 may well have been adept at resolving such competition. Practice in resolving interference between languages appears to enhance the efficiency of mechanisms for controlling interference in general. Normal bilinguals, for instance, show an advantage in the non-verbal flanker task (Costa, Hernández & Sebastián-Gallés, 2008) and in other non-verbal tasks (see Bialystok, 2009, for a review). Such practice may induce changes in the brain explaining the delayed onset of Alzheimer's Disease in bilingual patients (Bialystok, Craik & Freedman, 2007) and accounting for Pt1's normal performance on the flanker task. Pt1's sense that she switches inappropriately

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between languages is not borne out by the data here but nonetheless her stroke may make it more effortful for her to avoid switching from one language to another.

From a therapeutic point of view the BAT provides a vital complement to the CAT. Where the treated language is a non-native language, patients and their relatives need assurance that treatment will not impair the recovery of the native language (see Faroqi-Shah, Frymark, Mullen & Wang, 2010; Kohnert, 2009 for reviews of cross-language transfer). For Pt1, her parallel pattern of recovery, indicates that it should not be critical if treatment is delivered in English (her therapist's language and her L3). All her languages should continue to recover.

A specific advantage of using the BAT is that its detailed assessment suggests possibilities for intervention and provides a way to chart progress against baseline. Ansaldo, Saidi and Ruiz (2010) report an exemplary illustration of the value of detailed assessment. Their Spanish-English patient switched inappropriately between languages in response to his anomia producing the translation of the intended word. Precisely because translation was relatively better preserved that naming, the treatment approach developed by Ansaldo et al. (2010) encouraged the patient to switch back to the correct language by translating the word he had produced inappropriately. Such an intervention is not possible for Pt1 as word translation is also poor (Table 3).

Pt1 shows a comparable pattern of performance across languages that reflects impairments in phonological working memory and accessing output phonology. In her case, the question arises as to whether or not a phonologically-based treatment for anomia in English would improve output in German and Spanish. A reasonable expectation is that only cognates will be facilitated (see reviews cited above) indicating a deficit at the level of output planning rather than in accessing a lexical concept as such.

The detailed assessment of the BAT is also important from the point of view of understanding the neural bases of recovery. Patients with parallel recovery, for instance, allow us to investigate the neural networks involved using just one language with the reasonable assurance, at least in the case of word production tasks, that a common network would be revealed in other languages.

Conclusion

By using the Bilingual Aphasia Test to complement an assessment in English afforded by the CAT it is possible to establish whether or not there is a common pattern of performance across different languages both in terms of impairments and in the nature of the errors involved. For Pt1 such data confirm a pattern of parallel language recovery. Data from the English tests of the BAT also provide an internal validation for certain scores on CAT standardised on monolingual speakers of English. Obtaining a broader picture of language performance across all the speakers' languages is important for therapeutic interventions and as a basis for neuroimaging studies of recovery.

Acknowledgments

This work was supported by the Wellcome Trust

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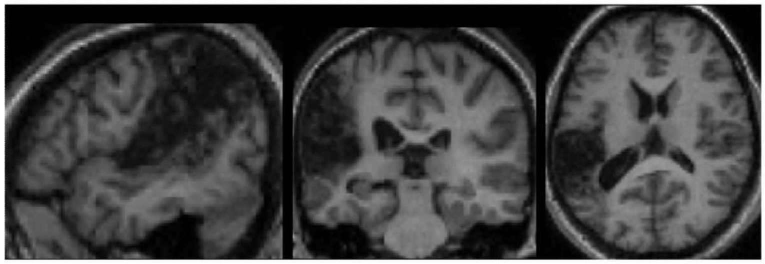

Figure 1. Structural scan displaying left temporo-parietal stroke damage in Pt1

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Table 1

Language background information for Pt1 and trilingual controls

Participants	
Pt 1	
Age (years:months) at testing:	44
Time post stroke (years:months)	2:9
Native language:	German
Age (years:months) English acquired:	2: (initially)/17:
Age (years:months)Spanish acquired	3:
Resident in UK; years:months	24: 6

	Current Usage [1]	***S.R.P*** [2]
English:	33	9
German	33	9
Spanish:	33	9

Trilingual Controls (N =4)	**M**	**Range**
Age (years: months) at testing	38.8	31-44
Native language	German	
Age (years:months) English acquired	10.8	10-12
Age (years: months) L3acquired[3]	17.8	14-25
Number of languages	3/4	3-4

	Current Usage		**S.R.P**	
	M	**Range**	**M**	**Range**
English	50.0	30-65	8.9	8.5-9.0
German	32.5	10-50	9.0	-
L3 (Spanish/French/Italian)	17.5	5-30	7.9	7.0-9.0

[1]Current daily usage in %;

[2]SRP=Mean self-rated proficiency (/9) averaged over speaking/listening/reading and writing; premorbid level for Pt 1

[3]L3 = Spanish/Italian/French

Table 2

Scores for Pt1 on the Comprehensive Aphasia Test (CAT)

All scores are t-scores. Those in bold are below the cut-off for unimpaired performance

COGNITIVE		
Line bisection	66	41
Semantic memory	60	51
Recognition memory	48	48
Total memory	54	50
Gesture	**51**	55
Arithmetic	53	44
REPETITION		
Total	**43**	60
Words	**44**	57
Complex words	**38**	62
Non-words	**46**	53
Sentences	**39**	63
NAMING		
Total	**51**	63
Objects	**49**	62
Actions	**49**	63
COMPREHENSION		
Spoken total	**43**	57
Spoken words	**44**	53
Spoken sentences	**44**	61
Spoken paragraphs	60	49
Written total	**52**	60
Written words	55	55
Written sentences	**50**	59
READING		
Total	**49**	61
Words	**48**	62
Complex words	**51**	61
Function words	49	49
Non-words	**52**	58
WRITING		
Picture names	**51**	55

Table 3

Bilingual Aphasia Test (BAT) scores for Pt1 in English, German and Spanish

	English	**German**	**Spanish**	
EXPRESSION				
Sentence construction (/31)	19	19	13	
REPETITION				
Words (/30)	See Table 2 for CAT data	10	12	
COMPREHENSION				
Pointing (/10)	10	10	10	
Simple and semi-complex commands (/10)	9	7	5	
Complex commands (/20)	5	12	7	
SPOKEN COMMANDS TOTAL (/40)	24	29	22	
Spoken paragraph:questions (/5)	NA	3	1	
Written words (/10)	NA	10	9	
Written sentences (/10)	NA	7	6	
Written paragraph (/6)	3	3	4	
READING				
Lexical decision (/30)	NA	28	29	
Words reading aloud(/10)	10	9	10	
Sentences reading aloud(/10)	3	3	5	
TRANSLATION	*English to German*	*German to English*	*English to Spanish*	*Spanish to English*
Translation recognition Word (/5)	5	5	5	5
Translation production Word (/10)	3	4	2	4
Sentence (/18)	2	3	4	7

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Table 4

Mean accuracy for the conflict tasks (lexical decision, Stroop and the non-verbal flanker task) for Pt1 and trilingual controls together with their spoken picture description scores in English and German, age and Raven scores

Figures in bold for Pt1 indicate the scores beyond the normal cut-off. [M= mean, SD = standard deviation; Normal Cut off = 2 SD below the normal mean for accuracy or above the normal mean for CR. E = English, G = German, S = Spanish. W= word, NW = non-word; N = neutral trial, I = incongruent trial; C = congruent trial; CR = conflict ratio and is the decrease in accuracy under conflict relative to a no-conflict condition –please see text for further descriptions.

Participant group			**Composite picture description task**			**English lexical decision task**			**Stroop tasks**									**Flanker task**		
Participant with aphasia			**Language**			**Accuracy %**			**Accuracy %**									**Accuracy %**		
Pt1	Age	Raven	E	G	S				English			German			Spanish					
						W	NW	CR	N	I	CR	N	I	CR	N	I	CR	C	I	CR
	44	11	36	34	39	.98	**.68**	**.31**	**.88**	**.75**	.15	**.91**	**.67**	**.26**	.71	.74	−.04	1.0	.98	.02
Trilingual controls																				
	Age	Raven																		
1.	44	11	37	46		.95	.88	.07	1.0	.90	.10	1.0	1.0	.00				1.0	.97	.03
2.	41	11	65	63		1.0	.98	.02	1.0	1.0	.00	1.0	1.0	.00				1.0	.97	.03
3.	39	12	37	35		1.0	1.0	.00	1.0	1.0	.00	1.0	1.0	.00				1.0	.97	.03
4.	31	10	36	43		.98	.98	.00										1.0	.97	.03
M	38.8	11	43.8	46.8		.98	.96	.02	1.0	.97	.03	1.0	1.0	.00				1.0	.97	.03
SD	5.5	.82	14.2	11.8		.02	.05	.03	.0	.06	.06	0.0	0.0	.00				.00	.00	.00
Normal cut off			*15.4*	*23.2*		*.94*	*.86*	*.08*	*1.0*	*.85*	*.15*	*1.0*	*1.0*	*.00*				*1.0*	*.97*	*.03*