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Cross-language generalisation in bilingual aphasia: what are we missing when we do not analyse discourse?

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ABSTRACT

Background: Cross-language generalisation has been reported in about half of all published cases of bilingual aphasia treatment. However, many of those studies report data from only single-word naming tasks. In unbalanced bilinguals with aphasia, treating the post-morbidly less proficient language may result in apparent improvement to only the treated language.

Aims: To investigate whether when tools are used to measure language abilities beyond the single-word and sentence levels, such as analysing discourse production, improvement in the post-morbidly more proficient language may be observed.

Methods & Procedures: A Hebrew-English bilingual person with mild-moderate non-fluent agrammatic aphasia was recruited. He received 36 h of Verb Network Strengthening Treatment (VNeST) in English only, with pre- and post- treatment assessment of his language abilities in both English and Hebrew.

Outcome & Results: Significant improvement was observed in the treated language (English) for noun and verb retrieval in object and action picture naming and within sentence production, but not for the untreated language (Hebrew). In discourse, greater and more widespread improvement was observed in the untreated language (Hebrew) than in the treated language (English).

Conclusions: We advocate for more wide-ranging measurement tools in the field to reduce the risk of missing valuable information regarding generalisation. Only with a more representative understanding of the effects of language treatment in bilinguals with aphasia can we better understand the mechanisms behind cross-language generalisation.

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Introduction

There are a fair number of published studies discussing factors that are assumed to affect cross-language generalisation of treatment in bilingual persons with aphasia, including pre- and post-morbid proficiency, age of acquisition, language of the environment, language distance, and damage to the hypothesised language control mechanism in the brain (e.g., Ansaldo & Saidi, 2014; Conner et al., 2018; Faroqi-Shah, Frymark, Mullen, & Wang, 2010; Goral,

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2012; Kiran, Sandberg, Gray, Ascenso, & Kester, 2013). Cross-language generalisation occurs in about half of all reported cases of bilingual aphasia treatment (Faroqi-Shah et al., 2010), and is a result of improvement in the processes involved in language and the extent to which these processes are similar or different across the treated and untreated languages. This includes processes involved in lexical retrieval of words, such as nouns (at the semantic or phonological stages) (e.g., Ansaldo & Saidi, 2014; Costa, Heij, & Navarrete, 2006; Croft, Marshall, Pring, & Hardwick, 2010) and verbs (building argument structure around verbs, assigning thematic role fillers to those argument structures) (e.g., Edmonds & Babb, 2011; Edmonds, Nadeau, & Kiran, 2009; Obermeyer, Edmonds, & Swanson, 2017). Additionally, syntactic processes such as building and producing increasingly complex sentences, and morphosyntactic processes such as gender and number agreements, may also be involved (e.g., Ansaldo & Saidi, 2014; Goral, Levy, & Kastl, 2010; Obermeyer et al., 2017). However, cross-language generalisation is hypothesised to occur only when processes of activation and/or facilitation are stronger than processes of interference or inhibition (Conner et al., 2018; Kiran et al., 2013).

How treatment affects different linguistic processes across languages in a bilingual person with aphasia is still unclear and how best to measure cross-language generalisation remains challenging. Even when we take pre- and post-morbid proficiency, age of acquisition, language of the environment, language distance and damage to the control mechanism into account, researchers and clinicians may be missing cross-language treatment effects because of limitations in measurement tools. This is most salient in literature focused on bilinguals with different post-morbid proficiencies across their two (or more) languages (i.e., unbalanced bilinguals). When the treated language is post-morbidly less proficient than an untreated language, cross-language generalisation may be overlooked if language testing is only administered at the single-word or sentence level (Croft et al., 2010; Kiran & Roberts, 2010; Kiran et al., 2013; Miertsch, Meisel, & Isel, 2009). Three studies published in the last decade examined cross-language generalisation at the single-word level in unbalanced bilinguals and did not find cross-language generalisation in some, or all, of their participants. For example, Croft et al. (2010) found that out of four participants who were unbalanced in their proficiencies across languages, in no condition (language of treatment, type of treatment) was cross-language generalisation observed in a picture-naming task when treatment was conducted in the less proficient language. Similarly, Kiran et al. (2013) and Kiran and Roberts (2010) reported on seven unbalanced bilinguals who received naming treatment in their post-morbidly less proficient language. Of these seven, two participants showed within and cross-language generalisation, two participants showed partial within- and partial cross-language generalisation, and three participants showed no cross-language generalisation as measured by a naming task.

A fourth study examined both single-word naming and sentence production using the scores of the Bilingual Aphasia Test (BAT) (Paradis, 2011) on a variety of linguistic domains (lexicon, semantics, syntax, and morphology) in one treated and two untreated languages of a trilingual with aphasia (Miertsch et al., 2009). The researchers found that the treated language (French, the third-acquired language – L3) and one untreated language (English, the second-acquired language – L2) improved in semantics, lexicon, and syntax after lexical-semantic training. The other untreated language (German, the native language – L1) did not improve in any of these domains. The BAT also includes a story sequence subtest; however, a detailed scoring of the discourse produced was not reported. It is possible that a more detailed discourse analysis may have identified cross-language generalisation to the untreated L1.

Support for the necessity of analysing discourse in addition to single-word naming and sentence production comes from a number of reported studies that considered discourse level production as one of their outcome measures of bilingual aphasia treatment and found generalisation to a post-morbidly more proficient language after treatment in a post-morbidly less proficient language (Altman, Goral, & Levy, 2012; Goral et al., 2010; Goral, Rosas, Conner, Maul, & Obler, 2012; Knoph, Simonsen, & Lind, 2017). For example, in a case study of a trilingual Hebrew (L1), English (L2), French (L3) participant with aphasia, morphosyntax treatment and treatment to increase language production rate in L2 resulted in improvements to both morphosyntax and speech rate at the sentence level in L2 and L3, but not in L1 (Goral et al., 2010). We can compare this to discourse production that was analysed in this same participant (in a different study). There we find that sentence grammaticality and complexity improved in L2 and L3; in L1, where complexity of sentences was already high pre-treatment, grammaticality of those complex sentences increased (Altman et al., 2012). Furthermore, at the lexical level in discourse production, more types, and tokens of nouns and verbs were produced in both L2 and L1 (Altman et al., 2012). Without using discourse production as a tool for measuring cross-language generalisation, no generalisation would have been observed to the post-morbidly more proficient L1.

When the post-morbidly more proficient language is relatively spared before treatment commences than the less proficient language is after treatment, this may result in no obvious improvement in single-word naming or sentence production in the untreated language, especially when the more proficient language is at or near ceiling. However, more sensitive measures of language for tasks that are intrinsically more complex than single-word retrieval or production of isolated sentences, such as discourse (e.g., Kavé & Goral, 2017), are necessary to identify cross-language generalisation in these circumstances. If cross-language generalisation is a result of improvement in language processing, rather than improvement to specific language tasks, then these improvements should generalise across languages and across tasks; they will be observed if measured with appropriate tools. To directly examine the extent to which cross-language generalisation to a more proficient language may depend on the tools used to measure language change, we conducted a study with the aim of investigating cross-language generalisation of treatment effects at the single-word, sentence, and discourse levels of language production in a bilingual person with aphasia. We hypothesised that in a post-morbidly unbalanced bilingual person with aphasia who received treatment in his less proficient language, cross-language generalisation may be observed in measures of discourse production in the more proficient language even if no cross-language generalisation is observed in single-word naming and sentence production in that language.

Method

The participant was a 71-year-old native speaker of Hebrew who started to learn English in late childhood (after age 11). When he was in his 30s he began to use both languages daily (Hebrew mostly with family and friends, English at work and with friends) and was highly fluent in both languages throughout adulthood, in all language modalities (speaking, understanding, reading, and writing), until he sustained a stroke in 2009, seven years prior to our study. Post-stroke, the participant was diagnosed with non-fluent aphasia,

characterised by agrammatic, simple sentences, word finding difficulties, and mildly impaired comprehension. His L2 (English) was post-morbidly less proficient than his L1 (Hebrew), with a WAB-R Aphasia Quotient of 67.0 in English (moderate aphasia) and 80.5 in Hebrew (mild aphasia) (Kertesz, 2006). Prior to recruitment, the study was approved by the ethics committee at the City University of New York (Internal Review Board), and the participant gave written consent to take part in the study. The participant cannot be directly identified via the paper.

The participant received Verb Network Strengthening Treatment (VNeST) in English only, following a published protocol (Edmonds, 2014). He received treatment three times per week for 6 weeks, for a duration of 2 h per session – totaling 36 h of treatment. All sessions were monitored for treatment fidelity by the researcher who provided the treatment, and 10% of sessions were also observed by a second researcher. Treatment fidelity was calculated as a percentage of the number of steps in the VNeST protocol that were administered correctly – this was found to be high (over 98%).

VNeST is designed to maximise the strengthening of processes involved in language production: The semantic and syntactic activation involved in this treatment are hypothesised to strengthen the process of building argument structure around verbs and retrieving thematic roles for those argument structures (Edmonds, 2016; Edmonds & Babb, 2011; Edmonds et al., 2009). Additionally, the treatment does not involve picture naming or picture description, thereby reducing the fixation on specific pictures and increasing generalisation of verbs to other contexts. Due to the presumed shared semantic system across languages (e.g., Kroll & Tokowicz, 2005; Paradis, 1993), the shared Subject-Verb-Object word order for basic sentences in English and Hebrew, and the shared argument structures in the verbs chosen for this study across Hebrew and English, cross-language generalisation was predicted to occur after VNeST.

Multiple baseline pre- and post-treatment testing was conducted with a subset of tasks from a large bilingual testing battery, which was designed to be psycholinguistically comparable across the two languages (Goral & Borodkin, unpublished). This language battery includes tasks of both comprehension and production for single-words and sentences, as well as discourse production. Here we report on production only, since comprehension was at or near ceiling for all tasks. Production tasks included: (1) Noun retrieval – A subset of 30 pictures of objects from the *Multilingual Naming Test* (Gollan, Weissberger, Runnqvist, Montoya, & Cera, 2012); (2) Verb retrieval – A subset of 27 pictures of actions from the *Action Naming Test* which is a subtest of the *Verb and Sentence Test* (Bastiaanse, Edwards, & Rispens, 2002); (3) Sentence production – A picture-based sentence production task using a subset of 21 pictures from the *Object and Action Naming Battery* (Druks & Masterson, 2000); (4) Picture sequences – A discourse task based on three different 4-picture sequences – a subset of story sequences from the *Narrative Story Cards* (Helm-Estabrooks & Nicholas, 2003); (5) Personal story – A discourse task requiring a response to a request for a personal story about three different given topics.

For noun and verb retrieval in single-word object and action picture naming, accuracy scores were measured. For sentence production, *Complete Utterances* (CU) were calculated, where a score of 1 indicated a relevant Subject-Verb-Object sentence, and a score of 0 indicated either an irrelevant sentence, or a relevant sentence that was missing either a subject, verb or object (Edmonds, 2014; Edmonds et al., 2009). For these closed tasks (noun and verb retrieval in single-word object and action picture naming, and

sentence production based on pictures), the McNemar test of equal change was used to determine whether significant change occurred between pre-treatment testing and post-treatment testing.

For the two discourse tasks, the following measures were used: (1) Number of nouns and verbs, (2) CUs, (3) Correct information units (CIUs), which are words that are part of the discourse and are both interpretable and add new information (Nicholas & Brookshire, 1993), and (4) CIUs as a proportion of total verbal units – which is a measure of verbal efficiency. For these more open tasks, significant change was measured by Non-overlap of All Pairs (NAP) effects; NAP is a measure of overlap between all data points pre-treatment and all data points post-treatment and it specifies the degree of improvement by indicating a strong, medium or weak effect of the treatment on any given measure (Parker & Vannest, 2009). A score of 0 indicates no change. Negative NAP scores indicate post-treatment scores were worse than pre-treatment scores, and positive scores indicate better post-treatment scores than pre-treatment scores. For all tasks, inter-rater reliability was conducted on a third of all the data and was calculated to be high (over 90%).

Results

The results showed significant improvement in the treated language (English) for noun and verb retrieval in single-word object and action picture naming, as well as for noun and verb retrieval within sentences, based on the McNemar test of equal change ($p < .05$). In the untreated language (Hebrew) no improvement in either noun and verb retrieval insingle-word object and action picture naming, or noun and verb retrieval in sentences, reached significance, although verb retrieval of single-word action naming approached significance (see Table 1).

In the discourse tasks, medium NAP effects were observed in English for only CUs and number of nouns in the personal story task. Number of verbs and CIUs in the personal story task showed weak NAP effects, and the measure of verbal efficiency (CIUs/total verbal units) showed a negative NAP effect. For the picture sequence task, there was either no effect or a negative effect for all measures. In Hebrew, medium and strong NAP effects were observed in both the picture sequence task (number of nouns, CIUs) and the personal story task (CUs, number of verbs and CIUs/total verbal units). For the picture sequence task, CUs and number of verbs showed negative NAP effects, and verbal efficiency showed a weak effect. For the personal story task, number of nouns and CIUs showed negative NAP effects (see Table 2).

Table 1. Raw scores and McNemar scores for noun and verb retrieval in single-word object and action naming, and within sentences (Relevant Subject-Verb-Object retrieval).

		English		Hebrew	
Test		Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Noun retrieval – naming of objects	Raw (out of 30)	16	20	24	27
	McNemar	**4.0***		**1.8**	
Verb retrieval – naming of actions	Raw (out of 27)	6	10	14	19
	McNemar	**4.0***		**3.57**	
Noun and verb retrieval in sentences (Relevant Subject-Verb-Object retrieval)	Raw (out of 21)	4	11	15	16
	McNemar	**7.0***		**0.11**	

*significant for $p < .05$

Table 2. Raw scores and NAP effects for the discourse data (picture sequence tasks and personal story tasks).

Discourse – picture sequences									
English					Hebrew				
	Pre	Post	NAP	NAP effect*		Pre	Post	NAP	NAP effect*
CUs	1	1	0	n/a	CUs	11	8	−.44	Negative
No. nouns	36	28	−.56	Negative	No. nouns	45	60	0.56	Medium
No. verbs	8	9	−.12	Negative	No. verbs	19	26	−.12	Negative
CIUs	41	40	0	n/a	CIUs	43	58	0.56	Medium
CIUs/total verbal units	0.24	0.23	0	n/a	CIUs/total verbal units	0.37	0.32	0.12	Weak
Discourse – personal story									
English					Hebrew				
	Pre	Post	NAP	NAP effect*		Pre	Post	NAP	NAP effect*
CUs	14	19	0.56	Medium	CUs	29	32	0.44	Medium
No. nouns	103	118	0.34	Medium	No. nouns	150	125	−.34	Negative
No. verbs	34	40	0.12	Weak	No. verbs	46	86	1.00	Strong
CIUs	148	187	0.12	Weak	CIUs	204	198	−.12	Negative
CIUs/total verbal units	0.41	0.40	−.12	Negative	CIUs/total verbal units	0.48	0.54	0.66	Medium

*NAP effect: Negative effect = negative score; Strong effect = 0.86–1.00, Medium effect = 0.33–0.85, Weak effect = 0–0.32

Discussion

In this study, we investigated cross-language generalisation to a more proficient language following treatment in a less proficient language of a bilingual person with aphasia. We enrolled a post-morbidly unbalanced Hebrew-English bilingual person with aphasia and administered 36 h of VNeST in his less proficient English. We hypothesised that even if no cross-language generalisation would be observed in single-word naming and sentence production in his more proficient Hebrew, cross-language generalisation may be observed in measures that assessed discourse production in that language.

Our results show that treatment in English significantly improved noun and verb retrieval in English, but not in the untreated Hebrew, as measured by single-word object and action naming and sentence production tasks. These results are consistent with previously reported findings that in unbalanced bilinguals with aphasia, treatment in the less proficient language may show no cross-language generalisation effects to the untreated, more proficient language (Croft et al., 2010; Kiran & Roberts, 2010; Kiran et al., 2013; Miertsch et al., 2009). However, results from single-word naming and sentence tasks do not provide the whole picture, since the tools being used may not be sensitive enough to detect changes in an untreated, more proficient language. In the case of our participant, Hebrew was the better-spared language, and linguistic abilities in Hebrew before treatment commenced were better than linguistic abilities in English after treatment had been administered, in single-word naming and sentence tasks. It is, therefore, possible that because of this post-morbid disparity between language proficiencies, significant improvement from treatment was not observed in Hebrew for single-words and sentences.

By using discourse measures – in addition to measures of single-word and sentence production – as a tool for identifying improvement, we can see that in our participant, improvements in English were confined to measures reflecting direct retrieval practice during

VNeST – CUs and number of nouns retrieved (during VNeST the verb is initially provided, therefore there is more practice retrieving nouns than verbs across the treatment block). Furthermore, these improvements were limited to the personal story task; for the picture sequence task no positive NAP effects were observed in English. This is likely due to task difficulty, because describing specific objects and actions within a picture sequence is more constrained than producing nouns and verbs while relating a personal story.

In Hebrew, however, we see a different pattern. Improvements were observed for each measure in one of the two discourse tasks: noun and verb retrieval, relevant Subject-Verb-Object sentences (CUs), relevant and interpretable information (CIUs) and efficiency of language production (CIUs/total verbal units). Although cross-language generalisation was not observed across all measures and all tasks, as seen by some weak and negative NAP effects, this is predictable following VNeST due to individual differences in impairment levels (Edmonds, 2016). Furthermore, this is in line with other published studies where cross-language generalisation was observed in discourse – improvements were not observed in all measures and in all tasks for any given participant (e.g., Altman et al., 2012; Goral et al., 2010, 2012; Knoph et al., 2017). Our results suggest that, as predicted, VNeST in English increased the semantic and syntactic activation, which is shared across the two languages in the context of this treatment. This strengthened and improved the processes necessary to build argument structure around verbs and to retrieve thematic roles in both languages, the results of which can be seen in the post-morbidly better-spared language in the improvement to various aspects of discourse. In other words, the generalisation of linguistic improvement to the more demanding tasks involving discourse production was clearly evident in the more proficient language but not in the less proficient language. Conversely, no significant change was observed in the more proficient language but only in the less proficient language for single-word naming and sentence production.

How we interpret our observations is crucial since there is a relationship between linguistic processes that are improved by treatment, relative language proficiency, and task difficulty. While on the surface it may seem unlikely for an untreated language to improve if the treated language has not, in any given task, when we consider this complex relationship, we can recognise that generalised treatment effects are multi-faceted and may be expressed differently in different tasks and in different languages. However, without sufficiently varied measurement tools we are more likely to miss valuable information regarding cross-language generalisation.

To conclude, our case study shows that discourse production can improve in the untreated language of a bilingual person with aphasia as a result of generalisation from the treated language, even when discourse production in the treated language does not improve. While cross-language generalisation may not occur in all participants, even when testing discourse (Knoph, Lind, & Simonsen, 2015; Miller Amberber, 2012), we run the risk of missing valuable information regarding generalisation if we do not test participants with a variety of tasks that include single-word naming, sentence production and discourse. Without testing and reporting on all these linguistic levels, we cannot be confident that we fully understand and correctly interpret treatment effects. As the research field of bilingual aphasia continues to expand, we hope that with more comprehensive language testing researchers are able to get a more representative idea of the effects of language treatment.

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