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Title: Effects of syntactic cueing therapy on picture naming and connected speech in acquired aphasia

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Short title: Syntactic cues for acquired anomia

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Abstract

Language therapy for word-finding difficulties in aphasia usually involves picture naming of single words with the support of cues. Most studies have addressed nouns in isolation, even though in connected speech nouns are more frequently produced with determiners. We hypothesized that improved word finding in connected speech would be most likely if intervention treated nouns in usual syntactic contexts. Six speakers with aphasia underwent language therapy using a software program developed for the purpose*, which provided lexical and syntactic (determiner) cues. Exposure to determiners with nouns would potentially lead to improved picture naming of both treated and untreated nouns, and increased production of determiner plus noun combinations in connected speech. After intervention picture naming of treated words improved for five of the six speakers, but naming of untreated words was unchanged. The number of determiner plus noun combinations in connected speech increased for four speakers. These findings attest to the close relationship between frequently co-occurring content and function words, and indicate that intervention for word-finding deficits can profitably proceed beyond single word naming, to retrieval in appropriate syntactic contexts. We also examined the relationship between effects of therapy, and amount and intensity of therapy. We found no relationship between immediate effects and amount or intensity of therapy. However, those participants whose naming maintained at follow-up completed the therapy regime in fewer sessions, of relatively longer duration. We explore the relationship between therapy regime and outcomes, and propose future considerations for research.

* A version of the software program (STAR: Sheffield Therapy for Anomia Rehabilitation) is currently undergoing testing prior to obtaining a commercial licence.

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Introduction

Background

Therapy for the remediation of word-finding difficulties in aphasia has focused largely on nouns in isolation (see e.g. Nickels, 2002a). Repeated exposure to a picture and attempting to name it with cues leads to improved naming of treated but not untreated words (Nickels, 2002a; Wisenburn & Mahoney, 2009). This type of therapy may lead to generalised improvement in lexical retrieval in connected speech such as narrative or conversation as well, but few studies have investigated this aspect.

One method of developing anomia therapy beyond single words is to treat nouns in their usual syntactic contexts, similar to the approach used to great effect with verbs (e.g. Byng, Nickels & Black, 1994; Fink, Martin, Schwartz et al., 1992; Jones, 1986; Webster, Morris & Franklin, 2005). Of interest then is the degree to which such a therapy will impact on not only picture naming, but crucially on word retrieval in connected speech.

Lexical therapy

Lexical therapy is the term used to describe a range of approaches aimed at increasing the ease with which the person with aphasia retrieves specific words. The target words are usually nouns. The method of treatment involves exposure to a picture, with an accompanying cue designed to assist in lexical retrieval (Howard, 2000; Laine & Martin, 2005).

The methods used to cue retrieval are derived from models of spoken word production, which propose that production involves a semantic and a phonological level of representation (e.g. Caramazza, 1997; Patterson & Shewell, 1987). Hence two cueing methods are prominent: semantic cues and phonological cues. Semantic cues can lead to improved retrieval of treated words (e.g. Boyle & Coelho, 1995; Greenwald, Raymer, Richardson, & Rothi, 1995; Howard, Patterson, Franklin, et al., 1985; Law, Wong, Sung & Hon, 2006; Marshall, Pound,White-Thompson, & Pring, 1990). Semantic cues may also lead to improved retrieval of untreated words (e.g. Law et al, 2006), although this is not a general finding (see Nickels 2002a; Wisenburn & Mahoney, 2009).

Phonological cues involve exposure to all of part of the word form, from initial phoneme cues, to whole word repetition. Phonological cues can lead to improved retrieval of treated words (e.g. Fisher, Wilshire, & Ponsford, 2009; Hickin, Best, Herbert, et al., 2002; Hickin, Herbert, Best, et al., 2007; Lorenz & Ziegler, 2009; Miceli, Amitrano, Capasso, & Caramazza, 1996), but are less likely than semantic cues to lead to improved naming of untreated words (Wisenburn & Mahoney, 2009).

Improvements in picture naming are encouraging, but improved production in connected speech is more important to the individual with aphasia. The lexical therapies treat nouns in isolation, and assume or hope that the effects will generalize to improved lexical retrieval in connected speech. This is measured via picture description, narrative or conversation. The majority of studies treating nouns with a lexical therapy have not measured effects on connected speech. Exceptions are Herbert, Best, Hickin, Osborne & Howard, 2003; Hickin et al. (2007), Peach and Reuter (2009), Greenwood, Grassley, Hickin & Best (2010), and Best, Grassley, Greenwood, et al. (2011), which attempted to track changes in conversation or

connected speech. Findings to date are mixed, for example Best et al. (2011) found no improvement in conversation for around half of the participants.

Alternatives to lexical therapy

There are two possible methods of extending the scope of noun retrieval therapy beyond single word retrieval. The first approach addresses noun retrieval in an interactional or a discourse context, in an attempt to bridge the gap between the task used in therapy of associating words with pictures, and the everyday function of retrieving nouns in spontaneous speech (e.g. Greenwood et al., 2010; Herbert et al., 2003; Hickin et al., 2007; Peach & Reuter, 2009).

The second approach, which has developed in the domain of verb and sentence processing, involves treatment of the target words within syntactic contexts, addressing syntactic processes directly (e.g. Byng et al., 1994; Fink et al., 1992; Jones, 1986; Webster et al., 2005). The approach assumes a close relationship between the semantic and syntactic properties of a verb. The semantic properties of verbs specify the verbs' arguments, and the syntactic sub-categorisation rules dictate the mapping of these arguments onto syntax. For example, a verb may require an agent and a patient, which map onto subject and object noun phrases. In aphasia that knowledge may be damaged, and therapy therefore needs to target the damaged syntactic components, not just the verbs' phonological or semantic properties. Jones (1986) and Webster et al. (2005) treated verbs and their argument structures, and found generalization to narrative speech. It is feasible that a similar approach targeting nouns and their syntax will also yield positive results.

Few studies have assumed a significant role for syntax in noun retrieval, possibly because of the assumption that noun syntax is relatively simple. In comparison to English verb syntax, and to noun syntax in other languages, English noun syntax appears to have less distributional and morphological complexity (e.g. Bak & Hodges, 2003; Haegeman, 1997). It is feasible that treatment of this property will yield little benefit therefore. Yet determiners carry meaning (compare *this girl* with *some girl)* and are not mere empty grammatical markers. And the fact that determiners and nouns co-occur frequently means that the former may facilitate production of the latter.

Noun syntax in production

In generative grammar the noun is the head of the noun phrase (e.g. Chomsky, 1995; Haegeman, 1997). The noun can be modified within the noun phrase by a determiner. This precedes the noun, and determines the sense conveyed. In English, determiners precede nouns highly frequently, and are said to collocate. The probability of the two co-occurring is therefore high.

Two influential theories of spoken word production propose that a syntactic level of representation mediates between semantics and phonology, termed the lemma (Levelt, Roelof & Meyer (1999) or the word (Dell, Schwartz, Saffran, Martin & Gagnon, 1997). Syntactic information is represented here, and is activated in production. For a noun this includes grammatical class, grammatical gender and the mass or count status of the noun. This also specifies the noun phrase structures available for that noun, dependent upon the sense to be conveyed. For example, 'that __' refers to one particular exemplar, whereas 'a__' refers to one unspecified exemplar.

Given the close relationship between these two word classes, it is worth investigating the effects of therapy incorporating both determiners and nouns. For reasons stated above, there is a need to be cautious however. A determiner cue cannot logically limit the set of possible noun responses to such a degree as to expect significant effects on naming. This is unlike phonological or semantic cues, which theoretically limit the set of co-activated words to the target and those words sharing semantic or phonological properties with the target.

Despite this caveat however, there is emerging evidence of a role for determiners in facilitating production of nouns. Determiners cue production of nouns in healthy speakers in French (Alario, Matos, & Segui, 2004) and in English (Gregory, Varley & Herbert, submitted). McCall et al (1997) cued noun production in people with aphasia using empty carrier phrases such as 'This is a …'. Herbert & Best (2005), Herbert & Best (2010) and Gregory, Varley and Herbert (2010) report single case data showing increased naming accuracy of nouns after determiner cues. Khwaileh (2011) found that Arabic speakers with aphasia produced more correct noun forms when asked to produce determiner plus noun combinations as opposed to nouns in isolation. The potential for determiners to form an active ingredient in therapy for word retrieval is therefore worthy of further exploration.

Mechanisms of therapy

A number of theorists claim that in aphasia linguistic knowledge is not lost, but is compromised by processing resource limitations (see e.g. Linebarger, McCall and Berndt, 2004: 270). Connectionist accounts of language production such as that proposed by Dell et al. (1997) have elaborated on the nature of these limitations. Typically such theories propose either insufficient activation or rapid decay of activation, resulting in processing inadequacies under the time constraints of language production.

Linebarger et al. (2004) go on to propose that the goal of therapy is to address those resource limitations, rather than to re-teach language per se. One method of addressing the limitations is to render processes more automatic, and hence more accessible when task demands increase. Linebarger and colleagues have addressed a range of linguistic structures in therapy, often using computer programs (e.g. SentenceShaper: Linebarger, Schwartz & Kohn, 2001). The computer program provides a scaffold for language processing in the form of a frame, which promotes accurate serial ordering within the frame, and maintains targets for production (e.g. McCall et al., 2009).

Repeated practice of target words has been proposed to address the resource limitations in production in previous anomia therapy studies. This is thought to result in strengthened connections between semantic and phonological levels of representation (e.g. Howard, 2000). In a connectionist account such as that of Dell et al. (1997) repeated activation of the semantic and phonological nodes leads to stronger connections between those nodes and more rapid activation on subsequent naming attempts. From a neuroscience perspective the latter are engendered through Hebbian learning mechanisms, in which co-activation of sets of neurons leads to their "wiring together" (Hebb, 1949 cited in Pulvermuller & Berthier, 2008).

Resource limitations affecting production of phrase or sentence structures have been explained within the framework of Garrett's (1975, 1980) model, elaborated by LaPointe and Dell (1989). The latter articulate further processes which operate between levels of the original model, which access syntactic information in what they term 'notion stores'. Semantic properties specified at the functional level elicit a search through the notion stores

for the relevant syntactic fragments corresponding to the meaning to be conveyed. In the case of nouns the notion stores supply a determiner plus an empty slot, this frame being determined at the semantic level by the sense that is to be conveyed. LaPointe and Dell (1989) further propose that resource limitations in aphasia prohibit effective searching of the notion stores. As for lexical processing, repeated practice of specific noun phrase structures will result in more rapid access to those structures, or a more effective search of the stores.

We propose therefore that there are two potential mechanisms for our therapy, both of which lower processing demands: a lexical mechanism based on repeated practice of word forms, leading to greater ease of access to those forms after therapy; and a mechanism which renders access to determiner plus slot frames more automatic, providing a context within which nouns can be inserted.

Computer based therapy

A number of studies have delivered aphasia therapy via specially devised software programs (e.g. Katz & Wertz, 1997; Wertz & Katz, 2004; Laganaro, Di Pietro, & Schnider, 2003; Laganaro, DiPietro & Schnider, 2006; see also Fink, Brecher & Sobel, 2005; Wallesch & Johannsen-Horbach, 2004). Computerised software programs can be designed to control the presentation of the stimuli, the feedback mechanisms, and the amount and frequency of therapy. If programmed in this way the person with aphasia can complete the therapy regime relatively independently, at times that are best for them. The autonomy thereby conferred is attractive to people with aphasia (Wade, Mortley, & Enderby, 2003)

Amount and intensity of therapy

Previous studies of anomia therapy vary in the amount and intensity of the intervention. The range of reported regimes is wide, from a two-week program (Marshall et al., 1990) to a year-long program (Hagen, 1973 cited in Basso, 2005). In a review of the literature Bhogal, Teasell, and Speechley (2003) concluded that the optimum regime consists of over 8 hours a week for eleven weeks. Sufficiently intensive or 'massed' therapy is now also regarded as crucial to success (e.g. Pulvermuller et al., 2001). Some dissenting evidence comes from a study by Sage, Snell and Lambon Ralph (2011) which found little difference between their intensive and non-intensive regimes. Both regimes provided a considerable amount of therapy, and compared delivery over two versus over five weeks.

The current study

The aim of the study was to investigate the effects of combining syntactic cues with a lexical therapy. We predicted that picture naming would improve, as repeated practice at target words makes them more accessible (e.g. Nickels, 2002b). We also predicted that by treating determiners with nouns within noun phrase structures, we would increase speakers' production of determiner plus noun combinations in connected speech. As a result nouns in general would be more accessible in connected speech. This same mechanism might also lead to improved naming of untreated words. We remained equivocal about this aspect however, as the outcome was measured via picture naming, a task which does not require explicit determiner production.

In this study we used mass and count nouns, as these differ in English with regard to the types of syntactic structures in which they are frequently produced. Singular count nouns

appear frequently in the structure *a + noun* for example *a thief* but much less frequently in the structure *some + noun*. The opposite is the case with what are termed mass nouns. Mass nouns appear frequently in the structure *some + noun*, for example *some money*, and much less frequently in the structure *a + noun*. Count and mass nouns were used to ensure that determiner selection constituted an active component in the therapy, requiring the participants to consider the combinatorial properties of the target words. We delivered this therapy via a computer software program. The program is fixed, in that there are six sessions of therapy to complete, but flexible, in that it allows users to undertake the sessions over as many sittings as they require, of durations suitable to them. The program provides the structure of the noun phrase, thereby scaffolding production for the user.

Methods

Participants

Six people with aphasia took part in the study. Two had non-fluent agrammatic aphasia, and four had fluent production, but varied with regard to their residual grammatical capability. All were monolingual speakers of British English. They presented with word-finding difficulties as part of their aphasia, which in all cases was due to a single left hemisphere cerebro-vascular accident. None of the participants presented with dysarthia or apraxia of speech. None had any previous history of neurological disease, psychiatric illness, or language impairment. They were recruited via a local voluntary services organization. Ethical approval for the study was obtained from the University of Sheffield Ethics Committee. Informed consent to participate was obtained via aphasia-accessible written information and consent form.

Tables 1 and 2 here

Background details for the participants are shown in Tables 1 and 2. Fluency was determined using the criteria established by Goodglass and Kaplan (1983). Aphasia classification was based on performance on language tests shown in Table 3, based on Davis' (1993) classification.

Given that the focus of the study was determiner and noun processing, we also provide a measure of this prior to therapy. We asked participants to retell the Cinderella story. We audio-recorded and transcribed the samples, and calculated the determiner index as a measure of the integrity of noun phrase syntax. The analysis followed the guidelines of Saffran, Berndt and Schwartz (1989). We identified the total set of noun phrases requiring an obligatory determiner. We then coded these according to whether the determiner had been produced or not. The determiner index was then computed by dividing the number of noun phrases which included a determiner, by the total number of noun phrases in the set.

Table 3 here

JM and MJ had agrammatic non-fluent production, producing short phrases containing predominantly content words, and few grammatical markers. Both showed some impairment in sentence comprehension, in particular with reversible and moved argument structures. Both were within normal limits on all tests of semantic processing. Both made semantic errors in picture naming, and JM also made phonological errors. JM showed a lexicality effect in production, with better performance on words than non-words. MJ showed a modality effect with good repetition but severely impaired reading aloud. In connected speech both JM and MJ's determiner index values were low and indicative of their severe problems with syntax in production.

GE and RP were able to produce grammatically complex sentences, with frequent word finding difficulties. GE showed some impairment in sentence comprehension, making errors to reversible SVO sentences and embedded clauses. RP showed intact sentence comprehension. Semantic processing was within normal limits for both, and both made semantic errors in picture naming. GE had impaired output phonology, with better production of words than non-words in both modalities. RP performed well in reading aloud and repetition of words, and repetition of non-words, but showed impaired reading aloud of

non-words. Both GE and RP had a relatively high determiner index, with RP showing little impairment in this domain.

DP and PI made grammatical errors in spoken production involving substitutions of function words, and both made spoken errors in output. Both had impaired sentence comprehension. They made errors on reversible sentences, and embedded clauses. DP and PI had impaired semantic processing and output phonology. They made semantic and phonological errors in production, the latter resulting in real or non-words. In DP's case non-words predominated, which rendered her spoken production unintelligible at times. DP showed a modality effect, with better repetition than reading aloud. PI showed a lexicality effect, with better processing of words than non-words. Like GE and RP both DP and PI had a relatively high determiner index.

Oral naming

Assessment of word-finding was conducted using 80 pictures of everyday items devised by the first author for a previous study (Herbert & Best, 2005; 2010). Items were presented as colour photographs on a computer screen. Participants were instructed to name the item using one word only. The last response within the first five seconds after exposure to the picture was recorded. Responses were audio-recorded and coded as follows: correct, visually related, semantically related, phonologically related (target and response share at least 50% of phonemes), semantically and phonologically unrelated word or phonologically unrelated non-word, and no response. Picture naming performance is shown in Table 4.

Table 4 here

None of the participants made significant numbers of visual errors. All produced semantic errors, and all apart from MJ produced phonological errors. DP differed from the other participants in that she produced a large number of unrelated errors, most of which were non-words.

Design

The study was a case series consisting of three phases: assessment and baseline phase; therapy phase; and maintenance phase. Each phase lasted approximately six weeks.
The language assessments shown in Table 3 were conducted prior to therapy. A set of therapy outcome measures and a set of control tasks were used to measure the effects of therapy. These assessments were conducted twice prior to therapy, and were repeated immediately after therapy, and again after a non-intervention period of six weeks to assess maintenance. The therapy outcome measures included: picture naming of 80 items, and Cinderella narrative. The untreated language control tasks were: auditory sentence comprehension (CAT), digit span and non-word repetition.

Therapy materials

The 80 picture items referred to above were used for the therapy study. They included 40 count nouns, i.e. words which occur frequently after the determiner *a*, and 40 mass nouns, i.e. words which occur frequently after determiner *some*. After the baseline assessments the words were split into two sets of 40 items matched for baseline performance for the individual, thus an equal number of items which the person had named correctly at one test,

both tests, or neither test, entered each set. In addition equal numbers of mass and count nouns entered each set. One set was used for therapy and the second set was untreated.

Therapy procedure

The therapy was delivered via the software program on a laptop computer, which the participant used in their own time at home, with the proviso that they complete the program within six weeks. A researcher visited the participant at home prior to therapy to ensure that they could operate all the necessary functions for the computer and that they understood the activity. After completing the therapy the participants contacted the researcher, who then visited them to complete the post therapy assessments.

Therapy consisted of six sessions for the participant to complete as they wished over a period of six weeks. Each session involved the set of components listed below. Each word was treated twice in each session, hence each word was exposed for naming a total of 12 times. There were three levels of therapy, two sessions at each level. A screenshot of the program is shown in Appendix 1.

Therapy components:

1. A spoken instruction to 'look at the picture and listen to the sentence'
2. Exposure to the target picture, which appeared in the centre of the screen.
3. Simultaneous exposure to a written and spoken sentence fragment at the top of the screen, which consisted of a subject noun phrase and a verb phrase such as 'I can see '. No active processing of this element was required.
4. Two boxes appeared on the screen to the right of the sentence fragment, indicating that two further words were anticipated.
5. Exposure to the spoken and written form of the whole sentence, with the determiner and the target noun appearing in the two boxes: e.g. 'I can see a table'.
6. Two opportunities to produce the determiner plus noun component, cued by the sentence fragment in spoken and written forms: 'I can see….'.
7. The opportunity to listen to their own productions, which the computer recorded.

At Level One participants completed steps 1 to 7. At Level Two step 4 included an additional component: participants were asked to select the correct determiner for the target noun. This was administered by presentation of two boxes, one containing *some* and one *a*. The participant was asked to click on one of these boxes. If they chose correctly the program moved to step 5. If they selected the wrong determiner the program presented the correct one by highlighting the target determiner and deleting the distracter. All other steps were as described above. At Level Three step 4 included a different additional component. The program provided two opportunities to produce the determiner and noun without any cues, and to listen to their responses, before exposure to the correct forms in step 5.

Connected speech

Participants were instructed to tell the story of Cinderella, using a picture book to support their recall of the events. Narratives were audio-recorded, and noun phrase structures were then analysed. All transcripts were checked by two of the researchers. Inter-rater reliability was computed by dividing the total number of agreements by the total number of identified items. This resulted in 0.93% agreement for nouns and 0.97% agreement for determiners. Disagreements were then resolved by discussion.

As the therapy focus was on determiner and noun combinations in noun phrases, we addressed this directly in the connected speech outcome. We therefore analysed the total number of determiner plus noun combinations at each assessment point.

Amount and intensity of therapy

The software for the STAR program tracks the individual's use of the program. The six sessions could be undertaken all in one period, or split as flexibly as the participant required. We were able to generate data for all participants in the form of the total amount of time spent using the program, and the mean length of the periods of time when the participant was active on the program. We then compared these variables to the outcomes of therapy both immediately after therapy and at follow-up six weeks later.

Untreated control tasks

Untreated control tasks were repeated throughout the study to control for effects of generalized language processing improvements, as opposed to specific effects of therapy. These consisted of auditory sentence comprehension, digit span, and non-word repetition.

Results

The results are organized in four sections: effects of therapy on picture naming of treated and untreated items, effects on determiner plus noun combinations in the Cinderella narrative, relationship between regime of therapy and outcomes, and effects on untreated control tasks.

Picture naming

Performance on picture naming for the treated and untreated sets at each assessment point is shown in Figures 1a and 1b, and effect sizes for the treated and untreated sets are shown in Table 5. We used McNemar's test (one-tailed) to look at statistical differences. All comparisons compare one time point with the previous time point. Baseline stability is shown by a lack of significant difference between A1 and A2, a positive effect of therapy is shown by a significant difference between A2 and A3, and successful maintenance of therapy effects is shown by a lack of significant difference between A3 and A4 (Figures 1a and 1b).

Effect sizes were included as participants may show improvement in naming without that showing statistical significance. To analyse effect sizes we used the formula described by Busk and Serlin (1992) and used by Robey, Schultz, Crawford, and Sinner (1999), which subtracts the mean pre-therapy score from the mean post-therapy score, and divides that sum by the pre-therapy standard deviation. We used the effect size magnitudes for aphasia therapy outcomes cited by Robey et al. (1999), which are 2.6, 3.9, 5.8, small, medium and large, respectively, and indicate thresholds for significant effects of therapy.

Figures 1a and 1b here

Table 5 here

For all treated and untreated sets there were no significant differences between baselines 1 and 2. This indicates that prior to therapy performance was stable.

Effects on treated words

Immediate effects of therapy on treated words are shown at A3 (Figure 1a). Comparison of performance between A2 and A3, i.e. immediately prior to and after therapy, shows an increase in scores at A3 for all six participants. These increases were significant for five people, with only PI's increase failing to reach significance. The value of p for McNemar's test for all five participants was $p \leq 0.007$. JM, MJ, GE, and PI maintained their scores at A4. RP and DP's naming deteriorated significantly however (RP: $p = 0.008$; DP: $p = 0.0008$). Effect size data are shown in Table 5. Large, medium or small effect sizes were found for all participants for treated sets.

Effects of therapy: untreated words

The data for the untreated sets are shown in Figure 1b and Table 5. Five participants showed a small increase in naming at A3, but this was not significant for anyone, and insignificant or small effect sizes only were found. There were no significant comparisons between A3 and A4, indicating that performance on these untreated sets remained stable throughout the study.

Connected speech data

Mean scores pre- and post- therapy for determiner plus noun constructions in the Cinderella narrative are shown in Figure 2. The data were analysed using the Poisson Trend Test (David Howard, personal communication), and effect sizes were also calculated. These are shown in Table 6.

Figure 2 here

Table 6 here

Figure 2 shows significant increases in determiner plus noun constructions after therapy for MJ, GE, RP, and DP, but no significant difference for JM or PI. Poisson trend test values for these four participants were MJ: $z = 2.31$, $p = 0.01$; GE: $z=1.92$, $p = 0.03$; RP: $z = 2.27$, $p = 0.012$; DP: $z = 2.68$, $p = 0.004$. Large or medium effect sizes were found for GE, RP and DP.

Amount and intensity of therapy

The total time spent using the program and the mean length of each session are shown in Table 7, along with the numerical gain in successful picture naming immediately after therapy and at follow-up six weeks later.

Table 7 here

Correlational analyses

There was no relationship between total time spent using the programme and outcomes at A3 and A4, as measured by the total increase in pictures named correctly: A3, $r = 0.08$, n.s.; A4, $r = -0.27$, n.s.). There was no relationship between mean time spent per session using the programme and the outcome at A3 ($r = 0.18$, n.s.). There was a significant relationship between the mean time spent per session on the programme, and the maintenance of therapy effects at A4 ($r = 0.74$, $df = 4$, $p = 0.05$).

Participants who spent more time per session maintained the therapy effects better than those who spent less time in each session. For example, GE spent a small amount of time using the programme, completed longer sessions on average, and maintained his gains at A4. In contrast RP spent a large amount of time using the programme, completed shorter sessions on average, and did not maintain his post therapy gains.

Untreated control tasks

Table 6 here

Scores for each participant at each assessment point are shown in Table 6. There were small increases in performance between mean scores prior to therapy and mean scores post therapy for some of the tasks, but no comparisons were significant, and effects sizes ranged from -1.23 to 1.76, i.e. no effects met the minimum threshold of 2.6 identified as a small effect size by Robey et al. (1999).

Discussion

In this case series we found positive effects of combining determiner cues with a lexical cueing therapy, in terms of improved picture naming of treated words, and increased determiner plus noun production in the Cinderella narrative. Four of the six participants responded positively to this new method. We also investigated the relationship between the amount and intensity of therapy and therapy outcomes, and identified a possible new variable in that domain.

As predicted, and as shown in a number of previous therapy studies of word-finding (e.g. Fillingham, Sage & Lambon Ralph, 2005; Hickin et al., 2002; Miceli et al., 1996), exposure to and repetition of the word form led to increased lexical retrieval for items treated in therapy. This indicates that, despite the additional processing demands potentially incurred by the determiner component of the therapy, repeated exposure to and production of target nouns had its usual reported effect of ensuring easier access to those nouns on subsequent occasions. Therapy effects on naming of treated words maintained after six weeks for four of the participants. For two participants (RP and DP) there was a decrease in naming, despite significant effects immediately after therapy. This may be explained by their elected regime of small and frequent sessions (see discussion below). Moreover, the total amount of therapy may have been insufficient for them. In this study each word was attempted twelve times only over six weeks. More therapy delivered more intensively may be required to ensure lasting change.

One participant (PI) failed to show a statistically significant improvement in naming, which may be explained by her phonological deficit. PI made phonological errors in all production tasks, had the worst scores for repetition of the group, and the highest incidence of phonological errors in naming. In these respects she is similar to CS, described by Hickin et al. (2002), who was the only person failing to respond to their cueing therapy. A different therapy concentrating on parameters of phonological form (e.g. Leonard, Rochon & Laird, 2008)may be indicated for participants with that profile.

We had predicted that, by improving access to determiner plus noun constructions, we would facilitate noun production generally, in both treated and untreated sets, and in connected speech. This would work through increased automaticity of production of the determiner plus slot frame, which would cue noun insertion into the slot. In the case of untreated words this prediction was not upheld, as we found little effect of therapy on untreated words. These results may however reflect the test format used, which involved production of nouns in isolation. Future investigations need to assess nouns produced with determiners to gauge the impact effectively.

We predicted that the determiner cueing component of the therapy would improve access to determiner plus noun constructions in connected speech, and that the effects of this intervention would be seen in increased production of nouns in general in connected speech, where a large percentage of noun phrases include a determiner. A positive effect of therapy on determiner plus noun retrieval was found in speakers who met two criteria: they retained some residual function in this domain, and their picture naming improved after therapy (MJ, GE, RP and DP). The two speakers who showed no change (JM and PI) differed from the above group in one of those two ways. JM had little residual noun phrase syntax, and PI's picture naming had not improved significantly after therapy. The data from the six

participants suggest that this therapy works best, in terms of its effects on connected speech, for speakers with sufficient residual determiner production in connected speech, and with relatively intact phonological representations.

The two active ingredients in this therapy were identified as priming of the lexical form, and priming of the syntactic frame. Previous studies using repetition cues have proposed that attempting to name a picture with concurrent exposure to the word form strengthens the links between semantics and phonology (e.g. Howard, Hickin, Redmond, Clark & Best, 2006; Miozzo et al., 1996; Best, Herbert, Hickin, Howard & Osborne, 2002). In a connectionist account such as that of Dell et al. (1997) this would entail increased activation of the target word's semantic nodes and phonological nodes, leading to selection of the target, as opposed to a related word. This mechanism would operate for treated words, with no effect on untreated words. Our data are in line with this account, with the small effects on untreated words not warranting a different account.

The syntactic component of the therapy arguably led to increased access to determiner plus noun structures. In Linebarger et al.'s (2004) terms, the computer program provided scaffolding for preparation of phrases for production. This meant fewer processing resources were needed for the task of retrieval of the determiner plus noun. Frequent exposure to and production of the determiner plus noun structure in therapy rendered this structure more accessible, or more easy to retrieve from what LaPointe and Dell (1989) term the notion stores. Rizzi (2010) refers to functional terms such as determiners providing a 'formal backbone' (Rizzi, 2010: 3) into which content words are inserted. It is feasible that repeated exposure to determiner plus noun frames made this 'backbone' more available, providing an empty slot into which nouns can readily be inserted. As a result the production of determiners and nouns in connected speech became more automatic for those participants with sufficient residual function in noun phrase syntax. One way of testing this hypothesis would be via reaction times and accuracy in repeating determiner plus noun phrases.
In addition to the two identified active components in the therapy, there was a potential third component, the sentence frame. This consisted of a subject noun phrase and a verb phrase, with the target noun phrase being produced as the direct object. Although the sentence structure was an inactive component, in that participants did not need to process it in order to complete the tasks, it may still have impacted on processing. This may have affected processing of the noun phrase, either positively or negatively, dependent upon the processing deficits of the individual. Future research comparing determiner cues in isolation and within sentence contexts is indicated.

The regime of therapy used here was based on those used in previous studies. We found one significant relationship between outcomes and therapy regime: the mean duration of sessions correlated with the maintenance of naming at follow-up. Those who carried out fewer, longer sessions performed better at follow-up than those who completed many short sessions. Hebbian learning principles state that sufficient practice is required to ensure long-term changes to cortical connections and hence to behaviour. Recent research has suggested that this may equate to the completion of highly frequent therapy sessions, termed massed practice (e.g. Pulvermuller et al., 2001; but see also Sage et al, 2011). We extend the notion of massed practice to include the amount of therapy within each session. Participants who completed short sessions made immediate improvements, due perhaps to short-term priming, but these evaporated quickly. Longer therapy sessions were more effective in terms of producing lasting changes to naming. The data reported here indicate

that sessions of at least 30 minutes are required. Clearly more data are required, but these findings identify a possible new variable in the debate surrounding therapy regime.

The design of the study did not allow us to compare effects of the two active components independently. It may be the case that the results we obtained would have occurred with just the lexical component. This is unlikely however, as no previous studies using lexical cues have shown the effects we found in connected speech. Future research should however compare lexical therapy, determiner cue therapy, and a combined therapy in order to tease apart the different effects of each component. This needs to be carried out for people with a range of grammatical ability.

Conclusions

We have argued here that in order to achieve generalization to noun production in connected speech, therapy for word-finding deficits in aphasia needs to integrate production of the word form with production of relevant syntactic structures. This is essential if such therapies are to have their maximum impact on people's everyday communication. The data we have presented indicate that a combined therapy can improve word-finding in picture naming and in connected speech. We have also presented some hypotheses regarding the likely mechanisms of this therapy, and the optimum therapy regime.

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Table 1: Background information

Initials	Gender	Age	Handedness	Age on leaving education	Previous employment
JM	M	68	Left	16	Administration
MJ	M	42	Right	18	Administration
GE	M	81	Right	14	Manual
RP	M	57	Right	21	Professional
DP	F	76	Right	16	Administration
PI	F	63	Right	14	Manual

Table 2: Medical and aphasia information

Initials	**Time post onset (months)**	**Fluent/ non fluent**	**Aphasia syndrome**	**Associated symptoms**
JM	25	Non fluent	Broca's	Left facial paresis Right upper limb paresis
MJ	60	Non fluent	Broca's	Right upper limb paresis
GE	26	Fluent	Anomic	Facial anaesthesia
RP	48	Fluent	Anomic	-
DP	36	Fluent	Transcortical sensory	Right hemiplegia
PI	27	Fluent	Conduction	Right hemipegia

Table 3. Language assessment

Task	n=	JM	MJ	GE	RP	DP	PI	Norms
Spoken word production								
Picture naming test CAT	24	0.67	0.75	0.75	0.79	0.13	0.38	0.88-1.00
Semantic processing								
Spoken word to picture matching (CAT)	30	0.90	0.97	0.93	1.00	0.77	0.97	0.83-1.00
Written word to picture matching (CAT)	30	0.93	1.00	1.00	1.00	0.87	0.87	0.90-1.00
Pyramids and Palm Trees (three pictures)	52	0.94	1.00	0.94	0.96	0.83	0.87	0.94-1.00
Sentence Comprehension								
Auditory sentence comprehension (CAT)	16	0.81	0.69	0.75	1.00	0.69	0.75	0.81-1.00
Output phonology								
Repetition words (CAT)	56	0.66	1.00	0.74	0.95	0.95	0.49	
Repetition non words	26	0.50	0.81	0.35	0.96	0.92	0.12	
Read aloud words (CAT)	30	0.66	0.06	0.88	0.97	0.47	0.38	0.92-1.00
Read aloud non-words	26	0.35	0.00	0.50	0.81	0.00	0.00	
Phonological STM								
Digit span*	-	4.5	2.5	3.5	3.9	5.5	1.5	-
Cinderella								
Determiner index (mean of two pre therapy assessments)	-	0.11	0.22	0.66	0.92	0.73	0.81	-
Nonverbal								
Line bisection	-	NAD	NAD	NAD	NAD	NAD	neglect	
BORB picture judgement hard	32	0.94	0.97	0.97	0.97	0.88	0.81	

All scores represent % correct, except for Phonological STM, which is the mean of 10 attempts to repeat strings of numbers presented auditorily, and Determiner Index, details of which are described below. CAT: Comprehensive Aphasia Test, Swinburn Porter and Howard (2005). Non-word reading and repetition, David Howard, personal communication. BORB: Birmingham Object Recognition Test, Riddoch and Humphreys (1992).

Table 4. Picture naming

n=80	JM	MJ	GE	RP	DP	PI
Correct	0.69	0.49	0.64	0.75	0.23	0.49
Visually related error	0.01	0.01	0.03	0.01	0.00	0.03
Semantic error	0.19	0.21	0.20	0.05	0.08	0.23
Phonological error	0.09	0.00	0.08	0.08	0.08	0.11
Nonword/ unrelated word	0.01	0.00	0.01	0.03	0.28	0.05
No response	0.01	0.29	0.05	0.09	0.35	0.10

TABLE 5. EFFECT SIZES FOR TREATED AND UNTREATED NAMING SETS

	Treated words		Untreated words	
	Effect size post therapy	Magnitude of effect size	Effect size post therapy	Effect size post therapy
JM	6.43	Large	2.19	-
MJ	2.59	Small	0.85	-
GE	6.36	Large	3.54	Small
RP	3.77	Small	2.59	Small
DP	6.01	Large	2.47	-
PI	4.95	Medium	0.71	-
Mean	*5.02*		*2.06*	

Values of p for McNemar one tailed tests: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$. Effect sizes are 2.6, 3.9, 5.8 for small, medium and large respectively

Table 6: Effect sizes for determiner plus noun combinations in Cinderella story

	Value	Magnitude
JM	-1.41	-
MJ	2.47	-
GE	8.49	Large
RP	4.71	Medium
DP	9.90	Large
PI	-1.33	-

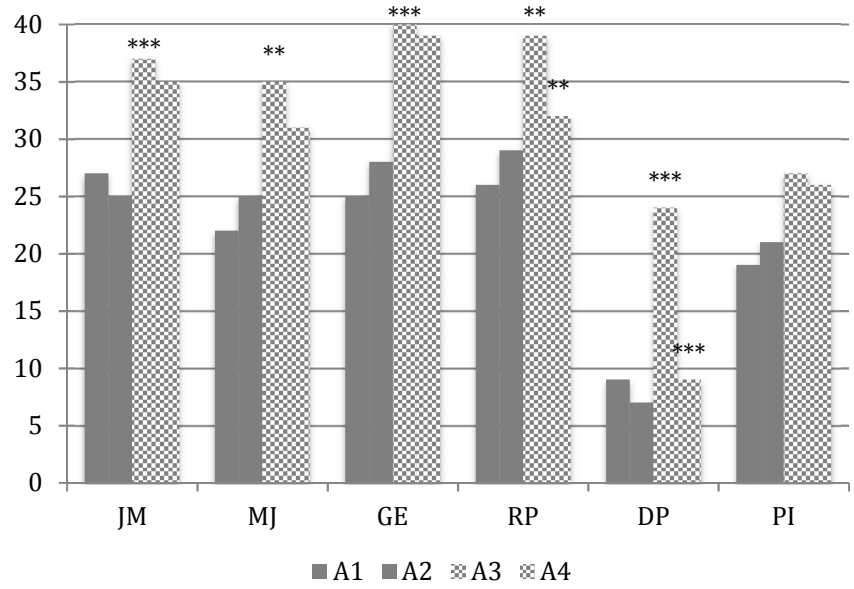
Effect sizes are 2.6, 3.9, 5.8 for small, medium and large respectively

Table 7. Therapy amount and intensity, and picture naming gains overall

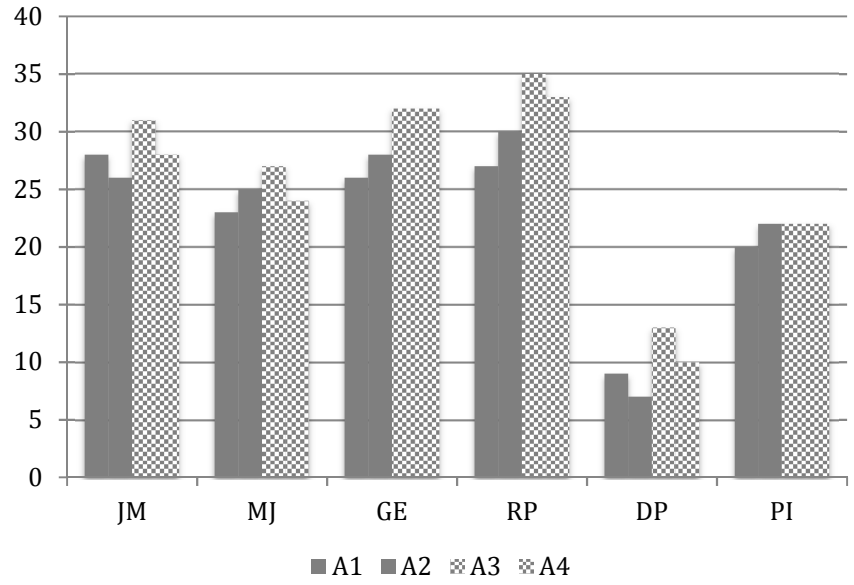
	Total time spent using program	Mean time per session	Gain at a3 (A3 – A2)	Gain at A4 (A4-A2)
JM	113	28	12	10
MJ	268	34	10	6
GE	211	35	12	12
RP	288	17	10	3
DP	173	19	17	2
PI	99	17	6	6
JM1	113	28	12	10

Table 8: Untreated language control tasks

	Baseline 1	Baseline 2	Post therapy	Maintenance
Auditory sentence comprehension (n=32)				
JM	0.81	0.78	0.81	0.81
MJ	0.59	0.59	0.50	0.49
GE	0.69	0.72	0.78	0.69
RP	0.91	0.88	0.88	0.91
DP	0.63	0.25	0.53	0.50
PI	0.69	0.75	0.78	0.75
Digit span				
JM	4.5	4.5	4.0	4.2
MJ	2.5	2.5	2.7	2.5
GE	3.5	3.9	4.3	4.1
RP	3.9	3.3	3.3	3.7
DP	5.5	4.5	4.5	4.7
PI	1.5	1.5	1.3	1.3
Non word repetition (n=26)				
JM	0.50	0.42	0.58	0.54
MJ	0.81	0.88	0.92	0.88
GE	0.28	0.19	0.16	0.19
RP	0.96	0.84	0.92	0.92
DP	0.92	0.88	0.92	0.81
PI	0.15	0.16	0.15	0.15



1a



1b

Figures 1a and 1b. Numbers correct in Treated (1a) and Untreated (1b) sets. Significance values for McNemar's test (one tailed) are: *** $p \leq 0.001$; ** $p \leq 0.01$; * $p \leq 0.05$

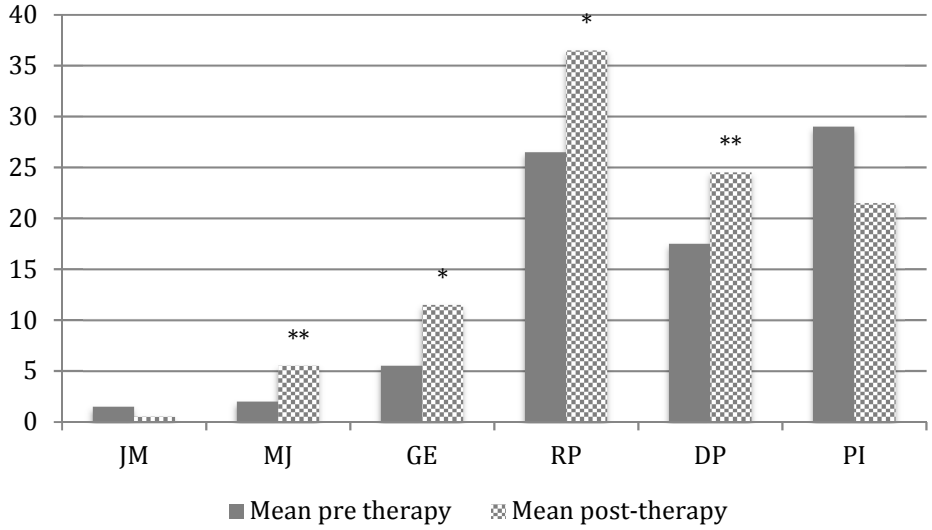


Figure 2. Cinderella story determiner plus noun combinations pre and post therapy
Significance values for the Poisson trend test are: **$p \leq 0.01$; *$p \leq 0.05$

Appendix 1