Getting Into Shape: the effect of Shape Coding on the spoken language production of two men with chronic aphasia

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ABSTRACT

Background: Shape Coding is a visual coding system that has been used to teach English syntax and morphology to school-aged children with language impairment but has the potential to support the language output of people with aphasia. While visual coding has been used effectively in a number of studies targeting basic sentence structure, these approaches are difficult to expand to include more than a limited number of arguments or to encourage individuals to produce more complex sentences. Shape Coding allows the user to work with more complex structures and verb morphology and may be valuable in improving awareness of sentence structure in adults with acquired agrammatism.

Aims: The aim of the current study is to investigate whether Shape Coding could improve the verbal output of two adult chronically agrammatic speakers.

Methods & Procedures: The study involves two men with chronic non-fluent aphasia, one of whom had previously worked with Shape Coding. Repeated baseline measures were collected three times before eight sessions of therapy and once immediately after the programme. These measured single word, sentence and narrative output, as well as communicative effectiveness. Data were analysed by examining the number of verbs used, the number of arguments included in sentences and the thematic completeness of utterances.

Outcomes & Results: For the individual introduced to Shape Coding, improvements in verb retrieval and sentence generation were observed particularly in structured tasks, with the number of obligatory arguments increasing. In tasks requiring more spontaneous production, however, marked difficulties with sentence production remained. The second participant (previously exposed to Shape Coding) was able to produce much richer language after intervention, including a greater number of both obligatory and optional arguments post-

therapy, including in the unconstrained tasks. Neither participant made a significant change on the measure of functional communication.

Conclusions: This small-scale study shows encouraging signs that Shape Coding has the potential to be of real value to adults with agrammatic aphasia. The intervention had a positive impact on both participants' output. Anecdotal evidence also suggested that the framework could be used as a prosthesis in everyday conversations, with the shapes acting as an 'internal prompt' to generating sentences. More research is needed to determine the optimal amount of Shape Coding therapy needed: a higher dosage over a longer period would give individuals more time to increase familiarity with the shapes; extending the sentence structures included would increase relevance to the person's communication needs.

Key Words: acquired aphasia; agrammatism; sentence production; narrative; intervention

INTRODUCTION

It is well documented that some people with aphasia have major problems retrieving verbs (e.g. Bastiaanse & Jonkers, 1998; Berndt, Haendiges, Mitchum & Sandson, 1997; Cho-Reyes & Thompson, 2012; Kim & Thompson, 2004; Kohn, Lorch & Pearson, 1989) and that these individuals often also have associated deficits in sentence production, with the result that they produce fewer sentences, and those that are produced are characterised by fragmented utterances, the omission of bound and free grammatical morphemes and a failure to produce the appropriate argument structure, with problems greater for transitive than intransitive verbs (e.g. Marshall, Pring & Chiat,1998; Thompson, Lukic, King, Mesulam & Weintraub, 2012; Webster, Morris & Franklin, 2005). Problems with sentence production may arise because of an underlying syntactic deficit which makes it difficult for the speaker to construct sentences: they lack the syntactic frame, or the ability to map between thematic roles and syntactic structure, required to guide production (see, for example, Schwartz, Linebarger & Saffran, 1985). Alternatively, the explanation may be non-linguistic: agrammatism may arise through strategic use of elliptical speech. That is, individuals possess the grammatical knowledge which would enable them to formulate sentences but producing output is so demanding that they minimise the effort required by focusing on the key words in a sentence (Kolk & Heeschen, 1990). Finally, some researchers suggest that problems arise because, following brain injury, individuals experience slow retrieval of linguistic information. This is known as the temporal window hypothesis (Kolk & van Grunsven, 1985): it takes an individual longer to retrieve words, and they vanish from working memory before they can be combined into sentences.

The aim of the study reported here is to investigate whether an intervention method developed for teaching English syntax and morphology to school-aged children with Specific Language Impairment (Ebbels, 2007) could improve the verbal output of two adult chronically agrammatic speakers. Shape Coding teaches language explicitly, coding the syntactic components of a sentence using shapes and colours, and providing a concrete visual frame. In the case of adults with agrammatism, Shape Coding may be of benefit whatever the cause of their difficulties in sentence production. If the basis were a syntactic deficit, Shape Coding would provide them with the sentence structure required and increase their awareness of the order in which constituents should be produced. If agrammatism were a strategy used by an individual for economy of effort, the visual structure provided by Shape Coding could provide a holding mechanism for the sentence being attempted, acting as a kind of 'scaffold' to enable them to produce all the relevant constituents. If the basis of an individual's

difficulty were slow retrieval of linguistic information, Shape Coding might function as a kind of "processing prosthesis". This type of system has been found to be effective in, for example, Sentence Shaper™ (Linebarger, McCall, Virata & Berndt, 2007), addressing performance limitation by allowing ideas to be held for longer. In the case of Shape Coding, the visual frame can be reflected on and added to as words become available. Thus this therapy targets sentence production problems between the functional level and the positional level as described in Levelt's (1989) model of sentence production. Shape Coding identifies an appropriate sentence frame that specifies syntactic roles and the order in which they will appear and then gives the individual time to retrieve lexical items.

A number of efficacy studies, treating verbs within a sentence context, have shown that agrammatic individuals can improve both verb production and sentence structure significantly with therapy (Webster & Whitworth (2012) provides a valuable review of therapy approaches used to date). These studies have used various treatment methods, including sentence completion (e.g. Edwards, Tucker & McCann, 2004), mapping therapy (e.g. Byng, Nickels & Black,1994; Rochon , Laird, Bose & Scofield, 2005) and focus on predicate-argument structure (e.g. Edmonds & Babb, 2011; Kim, Adingono & Revoir, 2007; Webster et al., 2005). These approaches have largely focused on encouraging participants to consider "who does what to whom" and to identify and use verbs with agent and theme arguments, often using colour coding of the constituents as cues (e.g. Byng et al., 1994). Rochon and colleagues (2005) reported a study of three individuals with nonfluent aphasia. In mapping therapy they were trained in a picture description task to recognise the verb, agent and theme in a variety of sentence types (e.g. passive, object clefts), using written role names and icons to reinforce the difference between agent and theme. Following treatment, production of treated items improved for the participants and there was some generalisation to untreated sentence structures. The association between verbs and the arguments of agent and theme was also the focus of research conducted by Kim et al (2007) with two people with Broca's aphasia. These individuals showed improved retrieval of verbs that had been targeted in therapy which was maintained after therapy, but no generalisation to untreated verbs. There were also improvements in sentence production in a narrative (the Cinderella story) after intervention. Whilst they are successful to a point, such approaches are difficult to expand to include more than a limited number of arguments or to encourage individuals to produce more complex sentences.

A wider range of constituents were incorporated in the tasks included in the therapy evaluated by Webster et al (2005), which targeted verb retrieval and the realization of the

predicate-argument structure for one chronic aphasic patient, NS. In this case the participant was asked to consider 'who', 'what to', 'what with' and 'where' in order to produce sentences involving a specific verb. As with other similar studies, the authors found their participant showed a significant improvement in retrieval of treated verbs, but no generalization to untreated items. Although verb retrieval difficulties were still evident post-therapy, NS included more verbs, more arguments and a greater variety of argument structures in constrained tasks. Though this intervention does encourage more complex sentences, like other approaches, it relies heavily on written language to support the linking of thematic roles to the syntactic positions of subject and object in a sentence, which is likely to be prohibitive for those for whom written language is problematic.

Syntactically complex sentences are the specific focus of the "treatment of underlying forms" (TUF) approach developed by Cindy Thompson and colleagues, who have demonstrated it to be effective for improving both sentence comprehension and production in agrammatic aphasia (e.g. Thompson, Ballard & Shapiro, 1998; Ballard & Thompson, 1999; Thompson, Shapiro, Kiran & Sobecks, 2003 for a summary of a series of studies using this approach). Importantly they have also found that treatment of complex structures (e.g. object-relative constructions) can result in generalization to simpler, linguistically-related structures which have not been treated (e.g. wh-questions), but not vice versa (Thompson et al., 2003). Therapy involves explicit teaching of the steps for deriving the target noncanonical form from the active form of a sentence using written versions of the sentence. After training of each item, the individuals with aphasia are asked to identify verbs and their arguments in the noncanonical version of the sentence. As mentioned above, results from efficacy studies for this approach are promising but, as with other approaches, therapy targets a limited set of sentence structures, and materials used are necessarily a specific set of sentences selected by the clinician rather than the therapy targeting sentences which the patients themselves would like to produce. This may be problematic where an individual needs motivation to engage in therapy and where flexibility in choice of items trained in therapy would be beneficial in that respect.

Shape Coding

Shape Coding was developed for use with children with Specific Language Impairment (SLI)[1]. This approach teaches language explicitly and codes the syntactic components of a sentence using shapes and colours. The system codes thematic roles (e.g. agent, theme), syntactic dependant relations (e.g. subject-verb), grammatical categories (e.g. nouns, verbs)

and morphological inflections (e.g. present progressive and regular past tense endings). Shape Coding is based on the theory that children with SLI have difficulty linking lexical items to their corresponding syntactic positions (van der Lely, 1994). It also uses evidence from previous studies which demonstrate that the use of visual coding is an effective approach with children with SLI (e.g. 'Colourful Semantics' (Bryan, 1997)). Shape Coding was developed as an extension of these previous visual coding approaches, to include more complex structures and verb-morphology such as wh-questions, passives, conjunctions, tense, aspect and noun-verb agreement. It also provides additional information about the hierarchical structure of language as shapes can be placed inside each other.

The effectiveness of Shape Coding in intervention with children has been demonstrated in a randomised controlled trial by Ebbels, van der Lely and Dockrell (2007). They found significant improvement in the verb argument structure use of nine children with SLI in spontaneous speech following therapy. When compared to the control group, the children receiving therapy were more likely to include obligatory arguments and to allocate arguments to the correct syntactic positions. In addition to predicate-argument structure, efficacy studies have shown this system to be effective in the treatment of difficulties with grammatical morphology (Kulkarni et al., 2014) and coordinating conjunctions (Ebbels, Maric, Murphy & Turner, 2014).

It is possible that Shape Coding may address some of the limitations of therapy approaches previously used with individuals with agrammatic aphasia. In contrast to the therapy approaches mentioned above (e.g. Webster et al., 2005), Shape Coding does not require written language in order to understand what is required in the different constituents of a sentence; instead it provides a prompt which may build on the visual strengths of an individual with aphasia (e.g. Byng et al., 1994). Other therapies include visual prompts (e.g. coloured lines denoting the syntactic class of a component as in Byng et al (1994)), but these appear to be consistently attached to either the prompt picture or the written form of the sentence required. In Shape Coding, while the shapes are often used in conjunction with written sentences, the visual prompts themselves provide the sentence frame supporting the production of spontaneous utterances. This provides greater flexibility in therapy than is available in approaches such as TUF (Thompson et al., 2003), as the clinician can use the support system to elicit richer language from the person with aphasia in terms of what they are interested in. As a consequence, therapy activities need not be restricted to picture description (as in, for example, Rochon et al., 2005) as the use of the frame allows individuals to be creative and to produce sentences more complex than "who does what to

whom" by adding additional arguments as well as, for example, adjectival and prepositional phrases. Furthermore, the inclusion of morphological inflections in the coding system provides an opportunity for an individual to focus on verb morphology should that be appropriate. This tends not to be included in other approaches (e.g. VNeST, where morphology and inflection are not required (though not discouraged) in therapy; Edmonds, Mammino & Ojeda, 2014).

The current study aims to utilise the strengths of the Shape Coding system which thus far has been limited to therapy studies with children in order to evaluate whether it can enable two men with chronic agrammatic aphasia to produce more complete utterances and bring about an increase in functional communication. The specific questions posed in this study were therefore:

- Can the participants learn to use Shape Coding to produce more complete sentences in structured tasks?
- Do the effects generalise to less constrained tasks and to functional communication?

METHOD

Participants

Two participants with aphasia took part in the study. Participants were native English speakers who presented with non-fluent aphasia following stroke with impaired noun and verb retrieval. Neither suffered from any additional cognitive impairment (e.g. secondary to dementia or learning disabilities), and neither had vision or hearing difficulties which could affect participation in therapy. AS had been previously exposed to Shape Coding, having taken part in a pilot study the year before. TW was new to Shape Coding. They were recruited from a London based community clinic for people with acquired communication difficulties, where both had been attending therapy groups.

TW

TW was a 50-year-old right handed man, who at the time of the study was four years post stroke. He left school at age 16 and was working as a driver when he had a right-sided stroke followed one month later by a left-sided stroke. TW had good mobility in his right arm and leg, but reported that he had lost some sensation on that side and so wrote with his left hand. His primary language was English. He had been a bilingual German speaker, but reported that he had lost much of his German since his stroke. He did not wear glasses, but had a mild

right-sided visual field defect, which meant that he sometimes missed rapidly presented stimuli on his right-side. TW had normal hearing on pure tone audiometry, but had problems hearing speech in background noise.

On the Western Aphasia Battery (WAB; Kertesz, 1982) TW was classified as having severe Broca's aphasia with an aphasia quotient of 46.4%. He understood conversations on familiar topics and current events, often using situational cues to help him follow what was being said. On the Comprehension of Spoken Sentences subtest of the Comprehensive Aphasia Test (CAT; Swinburn, Porter & Howard, 2005), he scored 14/32 demonstrating difficulties understanding complex sentences (embedded sentences, reversible sentences and prepositional phrases). TW had reasonable functional reading skills, although difficulties in this modality mirrored his auditory comprehension (Comprehension of Written Sentence subtest of the CAT: 18/32). He was able to read single words and sentences for meaning, but had difficulties extracting factual and inferential information from longer text. On the Reading Comprehension Battery for Aphasia (RCBA-2: LaPointe & Horner, 1998) he scored 73%. Both his spoken and written output consisted mainly of single nouns. Verbal dyspraxia meant that speaking was effortful and often produced in short bursts. Despite these difficulties, TW was an enthusiastic communicator who initiated interactions and made effective use of facial expressions and pantomime to get the message across with familiar conversational partners. He often chose not to speak to unfamiliar people or people who didn't expect him to speak, relying instead on others means of communication.

AS

AS was a 54 year-old right handed man, who at the time of the study was five years post stroke. He had continued education to Masters Level and was working as a librarian when he had a left middle cerebral infarct, which resulted in a right-sided hemiplegia, aphasia and severe dyspraxia. AS had normal hearing, vision that was corrected by wearing glasses and wrote with his non-preferred hand. On the WAB he was classified as having severe Broca's aphasia with an aphasia quotient of 54.6%. AS was able to follow spoken instructions, but sometimes needed to hear them several times before he fully understood what he had to do. He understood most conversations on familiar topics, current events and topics related to particular interests. However, he sometimes interpreted utterances in a narrow way and found it difficult to think flexibly around a topic. On the Comprehension of Spoken and Written Sentences of the CAT, he scored 22/32 on both subtests, demonstrating some difficulties understanding complex sentences (embedded sentences, reversible sentences and

prepositional phrases). AS had functional reading skills; he could read headlines and get the gist of short, simple newspaper articles. On the RCBA-2 he scored 94%. In formal testing, AS was able to name pictures of objects and actions. However, in spontaneous speech he struggled to produce these words and to link them into sentences. Because of his dyspraxia, he sometimes was unable to initiate speech without a prompt. He was able to produce social phrases with effort but reasonable articulatory accuracy, but had more difficulty with longer words and those containing consonant clusters (e.g. *street* and *black*). AS often wrote down words he was unable to say. Like TW, he was an effective and keen communicator who used gesture, facial expression, drawing and writing of key words to supplement his speech. He also chose to speak only to familiar people.

A multiple baseline approach across participants was used to evaluate the effects of Shape Coding on these two participants. The design consisted of three phases: 1) baseline, 2) treatment (Shape Coding therapy sessions twice weekly for one hour over four weeks: a total of eight hours of therapy), 3) post treatment probes.

Outcome measures

Both participants underwent a series of baseline assessments which were repeated three times over a period of two weeks prior to therapy. Single word lexical retrieval was evaluated with the Object Action Naming Battery (OANB; Druks & Masterson, 2000). Participants' ability to produce appropriate predicate argument structure was evaluated using Thematic Roles in Production (TRIP; Whitworth, 1996), which uses picture stimuli to elicit production of verbs with one-, two- and three-argument structures (see Thompson et al (2007) for a useful outline for the classification of verbs by argument structure). Sentence production was also evaluated using an informal task, in which the participant was given individual verbs (presented orally) and asked to generate a sentence for each verb. Stimuli were forty-nine verbs divided into the following groups on the basis of the argument structure associated with the verb:

- 10 intransitive verbs (i.e. requiring one argument, e.g. *sleep, smile*),
- 9 transitive verbs (i.e. requiring two arguments, e.g. *admire, chase*),
- 10 ditransitive verbs (i.e. requiring three arguments, e.g. *give, put*),
- 10 verbs with optional one- and two-argument structures (e.g. *eat, drink*),
- 10 verbs with optional two- and three-argument structures (e.g. *borrow, invite*).

Three narrative tasks were included three times pre-therapy and once after treatment:

- Cinderella story – participants were asked to retell this fairy tale from memory, without picture prompts.
- The Dinner Party cartoon strip – originally taken from English language teaching material (Fletcher & Birt, 1983), this is a series of eight black and white cartoons which depict events relating to a dinner party. The speaker has sight of the pictures whilst telling the story.
- Mrs Doubtfire clip – participants watched a two-minute clip from the movie *Mrs Doubtfire* in which the title character completes a number of events (including cycling, reading, cooking and watching TV), and were then asked to recall what had happened in the clip.

Narrative attempts were audio- and video-recorded. Occasional prompts were provided in these tasks if the individual struggled to recall the narrative e.g. *Do you remember any of the bits in the house*) in order to enable the individual to continue with their narrative. Direct responses to these prompts were not included in the analysis.

The responses for all three narrative tasks pre- and post-treatment were transcribed and the narrative words extracted employing the principles of Quantitative Production Analysis (QPA; Saffran, Berndt & Schwartz, 1989), and total number of utterances for each narrative was determined. Given the nature and focus of the therapy, the primary measures of interest were whether participants showed gains post-treatment in:

1) verb retrieval – evaluated by verb token count (i.e. including all verb occurrences) and verb type count (i.e. only the first occurrence of each verb);

2) correct use of verb morphology – both in terms of tense and aspect (most often present progressive (i.e. *is* + *-ing*), evaluated in the sentence generation task;

3) percent of obligatory arguments produced;

4) number of thematically complete utterances – where thematic completeness is defined as the presence of the verb and all its obligatory arguments so that the sentence is syntactically and semantically appropriate.

All assessments both before and after therapy were carried out without the shapes available to the participants.

Both participants also completed the Amsterdam-Nijmegen Everyday Language Test (ANELT; Blomert, 1992) before and after therapy, in order to evaluate their communicative abilities in conveying a spoken message in response to everyday scenarios (e.g. rescheduling a doctor's appointment).

All assessments were transcribed and/or scored separately by researchers who were not involved in the therapy and they were blinded as far as the order of data collection. Agreement between raters in terms of identification of verbs, arguments and thematic completeness ranged from κ = .570 - .991 across the tasks. All disagreements were discussed by the raters and a consensus reached for analysis.

The face recognition task from the Camden Memory Test was included as a control measure, but TW performed at ceiling both before and after therapy, and AS showed gradual improvement in the task before therapy.

Treatment

Full details of the Shape Coding system can be found in Ebbels (2007). In this study, treatment consisted of eight, one-hour therapy sessions which followed three phases: 1) learning the code 2) supported sentence production with Shape Coding prompts 3) supported conversation with Shape Coding prompts. Figure 1 provides an overview of the components of the therapy and the tasks used in therapy. Because of the nature of the therapy, there were no 'treated' items: none of the nouns or verbs included in the outcome measure tasks were targeted in therapy.

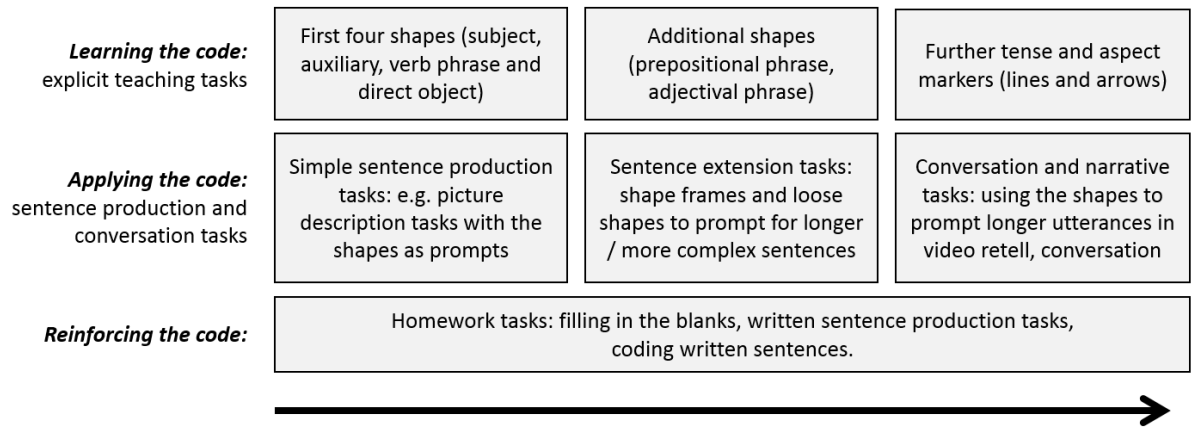

Figure 1. The components of Shape Coding intervention used in the study.

Learning the code

Participants were initially taught the colours and shapes for subjects and objects, auxiliary verbs and verb phrases. Once these had been learned (session one), the shapes for adjectival phrases and prepositional phrases were added (session two). The shapes were taught through modelling by the speech and language therapist (SLT) and joint tasks in which the participant

and SLT coded sentences together (i.e. drew shapes around words in example sentences) and wrote words into a shape 'sentence frame' to match a picture. There was minimal emphasis on tense in this therapy block, although the shape indicating the progressive form was used. Subject-auxiliary agreement was also highlighted. This explicit training was followed by a short function-based activity or conversation in which the new structure was applied in context. Figure 2 shows the Shape Coding system in use by one of the participants.

Figure 2. The Shape Coding system in use.

Supported sentence production with Shape Coding prompts

The majority of the therapy sessions were used for supported oral sentence production tasks, starting at a simple level (e.g. target: *the girl is eating*), becoming more complex as therapy progressed (e.g. *the girl is giving the boy a present*, *the man is eating an ice-cream in the park*). Target nouns and verbs were generally high frequency but were random in selection: there was no target list of either nouns or verbs for treatment. Therapy tasks were generally picture description tasks, although for some tasks the stimuli were single written verbs (e.g. *sweeping*). To make the target more salient, contrastive drills were completed where one element of a sentence was changed in turn, depending upon the structure being worked on. For example, *The man is walking* → *The man is running* → *The woman is running*.

Prompts were given in different forms (see Table 1 below), with more support being given at the start of the therapy block working towards less supported sentence production by the end of therapy. The prompting hierarchy described in Table 1 was not used rigidly, but was a method for stepping up or down in tasks according to the participant's needs. AS (who had the advantage of previous exposure to Shape Coding as well as slightly less impaired lexical retrieval) moved more quickly to level 3, realising that he could be more creative at this level as he was not constrained by a fixed shape frame, which he preferred. In contrast, TW benefitted from the higher level of support and structure of a fixed frame and stayed on this level for longer. Both participants had pens and paper available to them in all tasks and both used these frequently, writing single words or shapes to assist with sentence production.

Level of support	**Prompt**
1 (greatest)	Shape frame given with some of the words provided
2	Shape frame given, no words included
3	Shapes given, participants prompted to arrange them in the desired order themselves

Table 1. Prompting hierarchy used for Shape Coding therapy

Sentence production tasks became more complex as therapy progressed (especially for AS). This meant that rather than simple pictures being used (e.g. from the LDA Language cards 'Actions' set), composite pictures, narrative sequencing cards and videos were used in which there was more than one action to describe. Materials were selected which provided a clear representation of the structure being trained and, wherever possible, reflected the interests of the individual (e.g. AS had a particular interest in art; TW in football). TW continued to use the simple verb card stimuli for longer, and was more heavily supported in video and composite picture description tasks. He found these tasks much harder, tending to revert to single noun production (e.g. *car…. man… truck …*), rather than the thematically complete simple sentences he was able to produce in a more constrained task (e.g. *man is driving the car*).

As well as sentence production tasks, some grammaticality judgement tasks were included to reinforce elements such as thematic completeness and subject-auxiliary agreement. Homework tasks were given after each therapy session. These were generally

writing tasks, reinforcing work that had been done in that day's therapy session (either filling in the blanks in a Shape Coding frame, or adding shapes to a written sentence).

Supported conversation using Shape Coding prompts

In the second half of AS's therapy block part of each session was spent on supported conversation tasks with shape coding prompts, for example discussing works of art which he was interested in, or what he had done over the weekend. The shapes were used in these situations to prompt fuller sentence production (e.g. as loose shapes which AS arranged himself). AS quickly demonstrated an awareness that he needed more knowledge of tense marking, in particular for talking about past events (therapy tasks having generally focused on the present progressive). Although subsequently one session was completed using Shape Coding to support past tense production, it was felt that more time was needed than the study allowed to explore this fully.

TW found Shape Coding much harder to employ in less constrained tasks such as story re-telling or composite picture description. Consequently, more time was spent on structured tasks to consolidate skills at this level and he did not take part in supported conversation with Shape Coding prompts during this eight-week therapy block.

RESULTS

For both of the participants, there was variation in performance in some assessments across the three pre-therapy assessment points. Stability of scores across the pre-treatment period was evaluated using Cochran's Q test, where appropriate. Where performance was found to be stable, pre-therapy and post-therapy results were compared using McNemar's Test for related samples, using scores from the final assessment session before therapy. Below we provide the full set of assessment results for each participant with the number of McNemar Tests carried out and the significant results of these indicated. Significant and marked numerical differences are also presented in the text, with figures used to illustrate these findings where appropriate.

Participant TW

Full assessment results for TW can be seen in table 2. Overall, he showed improvements in all four measures of interest included (verb retrieval; correct use of verb morphology; percent of obligatory arguments produced; number of thematically complete utterances) after the

eight sessions of Shape Coding therapy. However, these gains were restricted to the constrained tasks, and were largely not mirrored in the narrative tasks.

		pre-therapy sessions				
		1	**2**	**3**	**post-therapy**	
Object Action Naming Battery (OANB)						
Objects (total=81)		61	59	63	71	§†
Actions (total=50)		10	8	8	25	§†
Thematic Roles in Production (TRIP)						
Nouns (% obligatory arguments)	intransitive	71.4	28.6	71.4	85.7	
	transitive	45	25	30	65	
	ditransitive	6.7	13.3	13.3	33.3	
	overall	35.7	21.4	31	57.1	§†
Verbs	intransitive	57.1	57.1	57.1	71.4	
	transitive	60	50	50	80	
	ditransitive	0	0	20	40	
	overall	45.5	40.9	45.5	68.2	§
Completeness	intransitive	42.9	14.3	57.1	57.1	
	transitive	20	10	10	70	
	ditransitive	0	0	0	0	
	overall	22.7	9.1	22.8	50	§‡
Sentence Generation task						
% obligatory arguments	intransitive	50	65	85	85	
	transitive	18.4	47.4	23.7	55.3	
	ditransitive	13.3	10	23.3	33.3	
	overall	23.9	38.6	37.5	54.6	
% thematically complete	intransitive	50	55	50	70	
	transitive	5.3	31.6	5.3	42.1	
	ditransitive	0	0	0	0	
	overall	22.5	34.7	24.5	44.9	
% morphologically complete	intransitive	20	8.3	50	55	
	transitive	0	21.1	5.3	26.3	

	ditransitive	10	0	0	10	
	overall	12.2	14.3	22.5	34.7	§‡
Cinderella narrative						
verb type	intransitive	2	0	0	1	
	transitive	2	1	1	2	
	ditransitive	0	0	0	0	
	overall	4	1	1	3	
% obligatory arguments	intransitive	50	-	-	0*	
	transitive	50	0*	50*	50	
	ditransitive	-	-	-	-	
	overall	50	0	50*	42.9	
% thematically complete	intransitive	50	-	-	0	
	transitive	0	0	0	0	
	ditransitive	-	-	-	0	
	overall	25	0	0	0	
Dinner Party narrative						
verb type	intransitive	0	1	1	2	
	transitive	1	3	3	3	
	ditransitive	0	0	0	0	
	overall	1	4	4	5	
% obligatory argument	intransitive	-	100*	100*	33.3	
	transitive	50*	16.7	12.5	33.3	
	ditransitive	-	-	-	-	
	overall	50	28.6	22.2	33.3	
% thematically complete	intransitive	0	100*	100*	33.3	
	transitive	-	0	0	0	
	ditransitive	-	-	-	-	
	overall	0	25	25	11.1	
Mrs Doubtfire narrative						
verb type	intransitive	2	2	1	3	
	transitive	1	1	3	5	
	ditransitive	0	0	0	0	
	overall	3	3	4	8	

% obligatory argument	intransitive	33.3	0	0	33.3
	transitive	12.5	0	0	25
	ditransitive	-	-	-	-
	overall	18.2	0	0	26.3
% thematically complete	intransitive	33.3	0	0	33.3
	transitive	0	0	0	0
	ditransitive	-	-	-	-
	overall	14.3	0	0	9.1

* Only one verb produced

NB: TW produced no ditransitive verbs in any of the narrative tasks in any testing session

§ Pre-therapy 3 and post-therapy results compared using McNemar's Test for related samples

† Statistically significant difference between final pre-therapy and post-therapy assessment ($p<.05$)

‡ Difference between final pre-therapy and post-therapy assessment approaching significance

Table 2. Full assessment scores for TW

OANB

Analysis revealed stability in performance pre-treatment and a difference between scores pre- and post-therapy both in the number of nouns ($p = .021$) and verbs ($p < .001$) successfully produced by TW, with better performance post-intervention (see table 2).

Sentence production tasks

In the TRIP, TW's performance post-therapy was superior to scores that he achieved at baseline (see Figure 3). These increases were observed in noun and verb retrieval and production of thematically complete utterances across all predicate-argument types (with the exception of thematic completeness for three-argument verbs). Analysis showed that although difference in performance relating to retrieval of verbs was not significant ($p = .125$), there was a significant difference between scores for retrieval of nouns (i.e. obligatory arguments; $p = .004$) and the difference for thematic completeness ($p = .070$) approached

significance. Again there were no significant differences between scores achieved pre-therapy, suggesting a stable level of performance in that period.

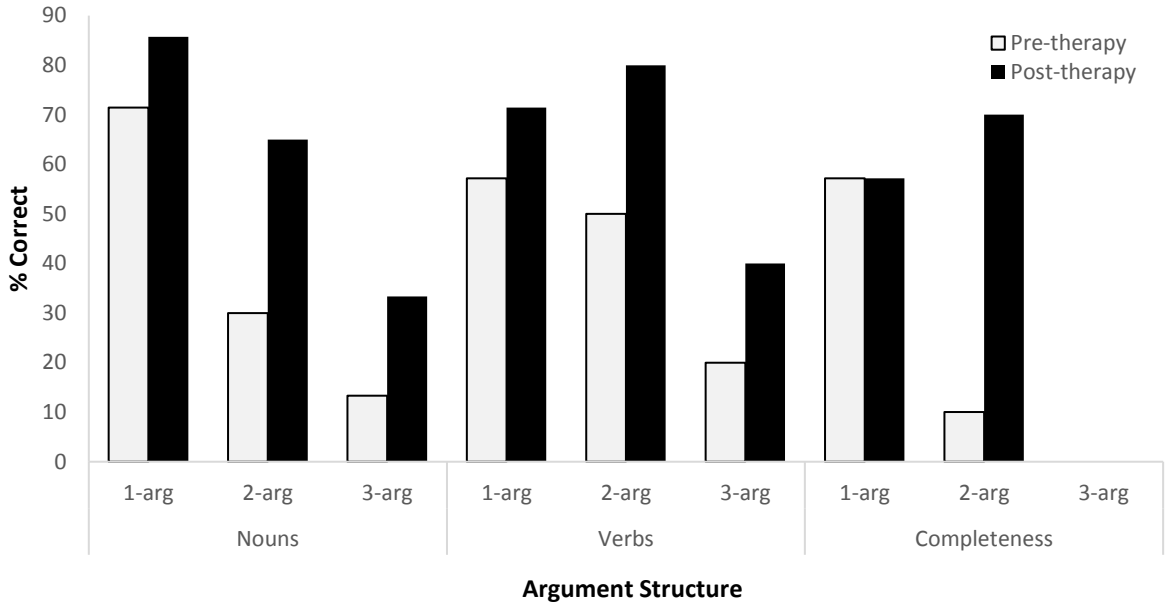

Figure 3. Comparison of TW's performance on Thematic Roles in Production between pre-therapy (session 3) and post-therapy

In the sentence generation task the percentage of obligatory arguments produced increased after treatment (37.5% pre-therapy; 54.5% post-therapy). Although TW produced more complete utterances post-therapy (44.9%) than his best performance pre-therapy (34.7%), Cochran's Q analysis revealed scores across the three pre-therapy sessions were not sufficiently stable to carry out a McNemar test to evaluate this difference.

As in the TRIP, TW did not produce any thematically complete utterances including three-argument verbs either before or after therapy, though after therapy there were only two verbs for which he wasn't able to generate any arguments (compared with five in his best performance before intervention).

Verb morphology: TW produced more complete utterances which included the correct form of the verb post-therapy, a difference which approached significance (p = .057). For example, *The girl is climbing* as opposed to *The boy climb* and *Animal is feeding* rather than *The dog is feed dinner*.

Narrative tasks

In the narrative tasks, TW produced relatively few verbs either pre- or post-therapy. Table 2 shows an increase in the number of different verbs that TW was able to generate in the Dinner Party and Mrs Doubtfire tasks (i.e. describing a picture, and a video clip). This improvement is not observed in the Cinderella task where there are no visual prompts.

He generated only one thematically complete utterance both pre-treatment (*lady running*) and post-treatment (*dinner is cooking*). However, the data represented in Table 2 suggest that there were some benefits in this respect, with a higher percentage of obligatory arguments produced in two of the tasks post-therapy.

There is some evidence that TW was attempting to put what he has focused on in therapy into practice as he begins more utterances in the same way, with the subject followed by 'is' either intended as an auxiliary or main verb – though he doesn't complete most. For example, *Cinderella is…*; *salmon is…*; *dinner is cooking*; *the boy is….*

Amsterdam-Nijmegen Everyday Language Test

TW's results for the ANELT showed identical scores pre- and post-therapy (11.5) for level of verbal communicative abilities. His responses to the items both before and after intervention were typically characterised by some verbal output supported by frequent use of gesture. For example, in response to item 6:

> *You are in the chemist and you find this [present glove] lying on the floor. What do you say?*
> Answer: *Gloves* ((gestures waving a glove around to show people)) *Who? Gloves.*

Participant AS

Full assessment results for AS are provided in table 3. Most marked improvements after therapy were the number of obligatory (and optional) arguments generated both in the sentence generation task and in the narrative tasks.

	pre-therapy sessions			
	1	**2**	**3**	**post-therapy**

Object Action Naming Battery (OANB)						
	Objects (total=81)	77	75	81	78	
	Actions (total=50)	23	34	39	44	
Thematic Roles in Production (TRIP)						
Nouns (% obligatory arguments)	intransitive	85.71	100	100	100	
	transitive	85	90	40	95	
	ditransitive	80	86.7	73.3	100	
	overall	81	88.1	78.6	97.6	§
Verbs	intransitive	85.7	100	100	85.7	
	transitive	100	80	100	100	
	ditransitive	60	80	40	80	
	overall	72.7	86.4	68.2	90.9	§
Completeness	intransitive	85.7	100	100	85.7	
	transitive	70	80	70	90	
	ditransitive	40	40	20	40	
	overall	68.2	77.3	68.2	77.3	§
Sentence Generation task						
% obligatory arguments	intransitive	100	100	100	100	
	transitive	86.8	97.4	94.7	100	
	ditransitive	43.3	66.7	60	100	
	overall	75	87.5	84.1	100	
% thematically complete	intransitive	100	95	100	100	
	transitive	73.7	84.2	89.5	100	
	ditransitive	0	20	0	100	
	overall	69.4	75.5	75.5	100	§†
% morphologically complete	intransitive	75	85	85	100	
	transitive	52.6	79	100	84.2	
	ditransitive	60	80	90	90	
	overall	63.3	81.6	91.8	91.8	
Cinderella narrative						
verb type	intransitive	7	8	5	10	
	transitive	3	4	4	3	
	ditransitive	1	0	1	1	

	overall	11	12	10	14
% obligatory arguments	intransitive	55.6	90	100	85.7
	transitive	75	42.9	35.7	66.7
	ditransitive	66.7*	-	0*	66.7*
	overall	66.7	62.5	50	78.3
% thematically complete	intransitive	83.3	90	100	85.7
	transitive	80	14.3	50	33.3
	ditransitive	0*	-	0*	0*
	overall	56.3	62.1	60	72.2
Dinner Party narrative					
verb type	intransitive	2	3	5	3
	transitive	3	5	3	6
	ditransitive	0	0	0	0
	overall	5	8	8	9
% obligatory argument	intransitive	100	100	100	100
	transitive	87.5	60	70	78.6
	ditransitive	-	-	-	-
	overall	80	71.4	76.9	82.4
% thematically complete	intransitive	100	100	100	100
	transitive	50	40	40	60
	ditransitive	-	-	-	-
	overall	60	66.7	62.5	70
Mrs Doubtfire narrative					
verb type	intransitive	7	7	6	6
	transitive	6	5	5	7
	ditransitive	0	0	0	0
	overall	13	12	11	13
% obligatory argument	intransitive	22.2	14.3	28.6	66.7
	transitive	43.8	41.7	33.3	55.6
	ditransitive	-	-	-	-
	overall	36	31.6	31.6	59.3
% thematically complete	intransitive	22.2	14.3	28.6	66.7
	transitive	25	16.7	33.3	33.3

	ditransitive	-	-	-	-
	overall	23.5	15.4	33.8	50

* Only one verb produced

§ Pre-therapy 3 and post-therapy results compared using McNemar's Test for related samples

† Statistically significant difference between final pre-therapy and post-therapy assessment (p<.05)

Table 3. Full assessment scores for AS

There were no significant differences between AS's pre- and post-therapy performances on either subtest of the OANB; he performed near ceiling on the Objects subtest before therapy.

Sentence production tasks

There were no significant improvements in AS's performance on the TRIP after treatment, though there were small numerical increases in the number of verbs produced and the percentage of obligatory arguments (nouns) produced (see Table 3). AS scored at ceiling for stimuli involving intransitive verbs before therapy, so these increases reflect changes in the production of transitive and ditransitive verbs.

AS produced a higher percentage of obligatory arguments in the sentence generation task after treatment; the difference in this case is driven by an increase in the number of arguments produced for verbs requiring three arguments. He produced significantly more thematically complete utterances in the sentence generation task after therapy than before therapy (p = .021): in the post-therapy session, he produced complete utterances for all the verbs provided. There were minimal differences in performance across the three pre-therapy assessments.

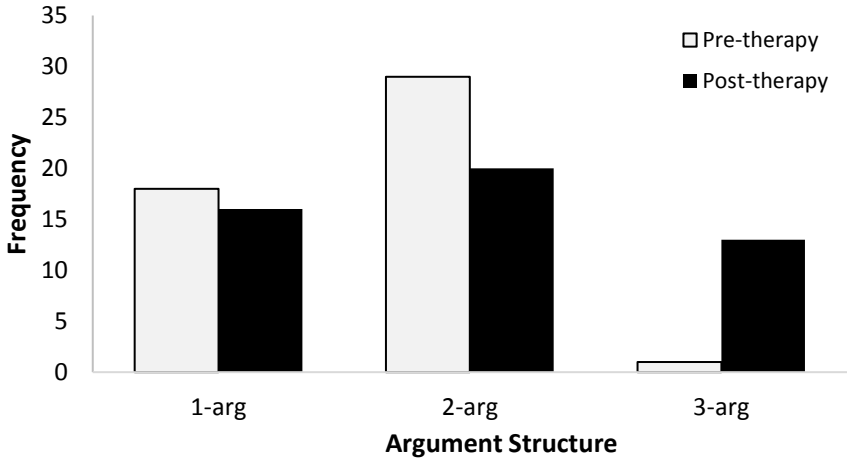

Figure 4. Comparison of AS's performance on the sentence generation task pre- therapy (session 3) and post-therapy

Further differences in performance pre- and post-therapy can be seen in AS's responses when he was presented with a verb either requiring three arguments or with an optional third argument (see Figure 4). In the former case, errors made in testing before therapy, where only two arguments were provided, were corrected post-therapy (see examples in Table 4). AS also produced more verbs with optional third arguments included after therapy, rather than just two as in the sentences he generated for the same verbs pre-therapy (see Table 4).

Pre-therapy	**Post-therapy**
The horse is showing the man	The man is showing the woman the watch
The man is putting pepper	The child is putting the food to the mouth
The man is lending a man	The man is lending money to the bank. Hah um rich man
The postman delivers the post	The postman is delivering the letter to the man
The girl is throwing a ball	The boy is throwing the ball to the girl
The man is borrowing money	The man is borrowing money from the bank

Table 4. Examples of AS's production of three-argument verbs in the sentence generation task pre- and post-therapy

Verb morphology: In contrast to TW, AS did not produce more complete utterances which included the correct verb morphology post-therapy, though isolated changes were observed. For example, *The boy is breaking the vases* as opposed to *I breaking the plate*.

Narrative tasks

AS's post-therapy performance for each narrative task was better than his best pre-therapy performance, both in terms of obligatory arguments produced and in terms of thematically complete utterances (see Table 3). Overall, improvements after intervention are most marked in the Cinderella task: in addition to the improvement in percentage of obligatory arguments, there is both an increase in the types of verb produced in this task and an improvement in type-token ratio (from 57.1-73.3% pre-therapy to 79% post-therapy). This contrasts with the other tasks (Dinner party TTR: 90% vs 83.3-100%; Mrs Doubtfire TTR: 70.6% vs 76.5-86.7%).

Though there were changes in the language produced in the Cinderella task, note that there was no marked difference in number of Correct Information Units conveyed (see Whitworth, 2010): with a best pre-therapy of 12, and 14 produced post-therapy.

In terms of predicate-argument structure, although gains in production of ditransitive verbs in the sentence generation task were not generalised to these tasks, as table 3 shows, there was an increase in the number of attempts at combining verbs with arguments, even though these were not complete. For example, in the Cinderella narrative after treatment, AS produces the following:

Fairy godmother ask Cinderella you um ball

Cinderella sweeping but prince decide to... Cinderella shoe and fit

These are structures that he did not attempt in any of the pre-therapy versions of the Cinderella story, and they perhaps show ambition in attempting to produce utterances more complex than simple SVO. Again, these changes in the Cinderella task are not mirrored in the other narrative tasks.

Amsterdam-Nijmegen Everyday Language Test

AS's performance on the ANELT post-therapy (25.5) was judged to be better than his performance before the intervention (21.5), though this difference was not found to be significant (Z=.779, p=.438). Specific improvements were observed in, for example, item 9:

You have just moved in next door to me. You would like to meet me. You ring my doorbell and say…

Pre-therapy: *Hello. I (reach?) next door*

Post-therapy: *Me, no I am neighbour. You meet me… soon?*

DISCUSSION

This study set out to investigate whether Shape Coding could improve the verbal output of two chronically agrammatic speakers. This goal was explored by considering each participant's (1) ability to produce more verbs, arguments and complete utterances in structured tasks, (2) generalization to less constrained tasks and (3) generalization to functional communication. Both participants reported a personal benefit from the treatment and showed positive changes in their spoken output as a result of therapy, although the extent of these changes differed. Furthermore, there was some suggestion that participants were referring to or using the shapes in daily life, even though there was no evidence that this led to improved sentence production.

After the intervention, TW showed improved performance in the production of obligatory arguments and in the number of thematically complete utterances he was able to construct in all structured tasks. These results are in line with those found by Ebbels et al. (2007) when trialling Shape-Coding with children who have SLI, that children were more likely to include obligatory arguments and to allocate arguments to the correct syntactic position after intervention. A shortcoming of the current study is that we were unable to include further assessment to establish whether improvements observed immediately post-therapy were maintained after a few months.

Although TW's performance in the structured tasks demonstrated that he had the language skills to produce more complete utterances in the narratives after therapy, these gains did not translate to the unconstrained tasks which may simply be because no therapy was carried out at this level. Another possibility is that difficulties in the narrative tasks were due to increased demand on cognitive processing in terms of sequencing of thoughts, which is not required in the constrained tasks. Marshall (2009) argues that expressing our thoughts requires cognitive preparation, and proposes that variations in performance that have been observed across different word classes and tasks suggest that difficulties experienced are not purely language-based. This argument could be extended to processing demands when ordering or structuring a lengthy response, for example telling a story involving several parts. Additionally, generating narrative from memory (as in the Cinderella and Mrs Doubtfire

tasks) is likely to be more difficult, as TW's less efficient language system means he is likely to encode narrative events poorly and as a consequence will have more difficulties reporting the logical sequence of events when retelling the story (Ellis, Evans & Hesketh, 1999). However, if these were the only factors for TW, we would expect to see improved performance in the description of the Dinner Party, as the pictures provide the structure to the story, in contrast to the description of the video or recounting the Cinderella fairy tale, but this was not the case.

Alternatively, TW's poorer performance in the unconstrained tasks may be because they give him more freedom to resort to using compensatory strategies such as gesture, writing and pantomime with which he can communicate very effectively in everyday conversation. This was also characteristic of TW's responses in the ANELT both before and after therapy. Despite the fact that TW understood that speech was required in all the tasks, the constraints embedded in tasks such as the sentence generation task seemed to help him to produce spoken language: improvements were found only where agrammatic compensation strategies were necessarily reduced by the nature of the task (i.e. producing a sentence with a given verb versus describing the events in a story). For individuals like TW, avoiding the use of compensatory strategies and restricting the output to speech only has been found to be effective for aphasia rehabilitation in approaches such as Constraint-Induced Therapy (Pulvermüller et al., 2001). The finding that avoidance of learned non-use of spoken language can lead to improvements in verbal abilities could provide an explanation for the overall pattern of improvements in this study. If, through the use of shapes as scaffolding, TW were encouraged to use his linguistic abilities rather than compensatory strategies, the gains in syntactic accuracy that were observed in the constrained tasks may also be found in narrative tasks.

The Shape Coding intervention has had a positive impact on TW's output, but he may need much more experience with the framework, consolidating skills at the sentence level, before he is able to apply the concepts and principles involved consistently and effectively in different communicative situations. In this study, TW received a total of eight hours of therapy delivered in two sessions per week over a four-week period. Effective therapies typically involve greater intensity and duration than that used in the current investigation. For example, in VNeST a set of target verbs are practised for 3.5 hours a week for 10 weeks. Intensive Language Action Therapy (Pulvermuller & Berthier, 2008) is also applied with high frequency, for example 30 hours within 10 working days. It could be that with greater intensity or duration, improvements would be made in communicative situations more

reflective of everyday life. Furthermore, in this study, output was produced post-therapy without Shape Coding support, and it is possible that the participants needed to use the framework as a prosthesis in order to show the full benefits.

In contrast to TW, AS had previous exposure to the Shape Coding framework having undergone a six-week block of therapy 18 months prior to the current study. This extra input seems to have proved crucial and the results indicate the amount of time it may take for an individual, having learned the framework, to make use of it. Findings indicated that the framework provided by Shape Coding enabled AS to produce much richer language after the intervention. This included producing more optional arguments in the sentence generation tasks, and an increase in the percentage of obligatory arguments produced across all tasks, including the unconstrained tasks. Improvements observed in the narrative tasks were relatively small and this may relate to the fact that we have relied on informal measures in the absence of published assessments for evaluating the kind of connected speech that we were interested in eliciting, though Cinderella is widely used as a tool for evaluating spoken language output in adults with aphasia. Gains were most marked in this task and the difference between this and the other narrative tasks may reflect most the different nature of tasks: re-telling the Cinderella narrative from memory (as opposed to describing a picture/video) may give more scope for creativity in terms of possible verbs.

It is possible that AS could make further gains with more intervention: Shape Coding may be used to target the production of narratives, in terms of planning not just sentences but the organisation of ideas across a narrative. In this study, therapy focused largely on pictorial stimuli and did not give the participants the opportunity to practise narrative skills, for example, the resolution of a problem. Individuals may need a gradual transition into other types of tasks and conversational exchange. Shape Coding should be viewed as a toolkit from which the therapist can select and adapt tools according to an individual client's needs. When time is limited for intervention, it may be most advantageous to target the type of language that is most useful to address. In the intervention carried out in present study, there was a heavy emphasis on the present progressive form of verbs. Other structures may be more functional; for example, the past tense form of verbs may be more valuable where improving narratives is a goal of intervention; working with imperatives may increase opportunities for individuals to prompt a response from another person.

We did not observe a significant change in the measure of functional communication used in this study (ANELT). This may be because a single, relatively short measure (the ANELT has 10 test questions) was not sufficient to pick up changes in communicative ability

as a result of the intervention. The Communicative Abilities in Daily Living - 2 assessment (CADL-2; Holland, Frattali & Fromm, 1998), for example, assesses functional communication skills across a greater range of scenarios and may have enabled the identification of specific areas of strength and weakness. We did not formally gather information on either participant's opinion of their abilities using, for example, the Communicative Effectiveness Index (Lomas et al., 1989), a self-rating scale of functional communicative ability. This information may have provided further insight into their perceived areas of strength and weakness, which may have been affected by therapy.

AS and TW both reported limited opportunities to communicate as many of their friends did not see them as conversation partners, which could provide some explanation for the results obtained. This limited experience of applying Shape Coding in functional settings outside of therapy likely decreased the extent of generalisation. However, AS's SLT provided anecdotal evidence that the shapes seemed to act as an ongoing scaffold to support his spoken output as he was observed to use gestured versions of the shapes (e.g. tracing the shape for 'adjective phrase') in conversation. Anecdotal findings also suggest that some carry-over into similar situations also occurred for TW and that trained skills were maintained. In aphasia group sessions which took place after the current study, TW drew the shapes of elements of the sentence he did not always produce, for example a diamond for the auxiliary and a small circle for the determiners, when describing composite pictures. Both have subsequently requested miniature versions of the shapes which they have attached to their key rings: the shapes seem to act as a reminder of the array of sentence elements that could be used, and they use these in group therapy sessions and when interacting with conversational partners. This suggests that Shape Coding provides a framework which can be used outside of SLT sessions: AS and TW may both be able to draw on their knowledge of the shapes which provide an awareness of what is possible in spoken language and which act as a kind of 'internal prompt' to producing that language. Other approaches tend to be restricted to the therapy session itself, with arguably less potential to be used outside the clinic setting. For example, VNeST has been demonstrated to have positive effects on lexical retrieval and syntax production in discourse tasks. However the materials themselves - cards containing target verbs, and wh-questions - are not easily transferable to use in everyday communicative settings where the speaker does not know in advance what they want to say. The *SentenceShaper*™ computerised communication system which allows users to re-order sentence fragments into longer structures has been shown to enable individuals to produce markedly more structured language, but the system itself is not easily used as a prosthesis in

ordinary conversations. Semantic feature analysis (see e.g. Massaro & Tompkins, 1992) may be used to encourage the speaker to have an internal framework in mind when attempting to produce a word, and this could be used to improve word retrieval in everyday communicative situations (e.g. Peach & Reuter, 2010), but this focuses only on the single word level and does not provide a framework for linking words together. Shape Coding may provide such a framework, though more research – and clinical work – is required to determine whether this is the case. A series of two case studies lacks the statistical power to enable strong claims to be made about the effectiveness of the intervention for this client group, and the participants' performance in the control task does not rule out improvements which may have been affected by spontaneous general recovery over the course of the study. However, these preliminary findings suggest that Shape Coding has the potential to be a fruitful approach. More research is also needed on the possible long-term effects of Shape Coding for adult clients, on who may be the most appropriate candidates for this approach and on how improvements can transfer into everyday language. However we suggest that our small-scale study shows encouraging signs that Shape Coding has the potential to be of real value to adults with agrammatic aphasia.

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FOOTNOTE

1. There is new consensus about the label and definition for the language disorder previously known as Specific Language Impairment: Developmental Language Disorder. However, we have retained the term SLI in the text as this is the one utilised by the studies to which we refer.