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Abstract

Background: Jargon aphasia is a complex acquired language disorder which is characterised by fluent verbal output and usually accompanied by poor error monitoring. Written or graphemic jargon may or may not co-occur with spoken jargon. Intervention to address jargon behaviour is difficult to design due to the presence of poor self-monitoring of errors.

Aims: This study investigated the potential underpinning language and cognitive systems in the production of jargon behaviour and the ability to monitor spoken errors. We propose that jargon behaviour – poor language monitoring and jargon output – arise from an intersection of impaired language and cognitive systems.

Methods: Six individuals with jargon aphasia participated in the study. A range of background language and cognition tests were selected. Experimental tests were designed to measure participants' abilities to monitor their spoken and written output.

Outcomes & Results: Only three of the six participants were able to complete the full assessment battery, with each participant demonstrating a different profile of results across the experimental language monitoring tests. Participants who were better at monitoring their speech (AJ, AE and LS) scored on the higher end of tests on access to auditory discrimination and repetition. Results from the background cognitive tests identified a range of cognitive impairments including difficulties with attention, problem solving and sequencing.

Conclusions: Participants with relatively well-preserved skills in auditory discrimination and repetition were better at monitoring their spoken output. This suggests that language competence has a contribution to self-monitoring. All participants were found to have previously unidentified significant cognitive deficits. The significance of this is discussed in relation to language monitoring skills and potential treatment approaches.

Key words: jargon aphasia; self-monitoring; language; cognition

Introduction

'Jargon aphasia' is the term typically used to describe the impaired expressive language symptoms of people who present with fluent unintelligible output, of which they usually appear to be unaware after stroke (Marshall, 2006). The terms 'jargon behaviour' or 'jargon output' may be more appropriate descriptions as jargon can range in presentation from fluent output of semantically unrelated or perseverative words to 'neologistic' jargon; where nonsense or 'made up' words are produced seemingly without awareness (Panzeri, Semenza & Butterworth, 1987). Although most commonly associated with Wernicke's aphasia, jargon output can be a feature of other fluent aphasias. It is defined in this paper as fluent, easily produced verbal output with excessive phonemic, asemantic (i.e. semantically unrelated errors) and neologistic errors which are incomprehensible to the listener. The different presentations of jargon output likely represent different underlying impairments driving the behaviour. A similar presentation has been noted in written output, termed "graphemic jargon" (Schonauer & Denes, 1994) or "jargonagraphia" (Cappa, Cavallotti & Vignolo, 1987; Shintani, Maeshima, Nakai, Itakura & Komai, 2001), though by comparison it is considered to be a rare manifestation of aphasia.

A remarkable feature of jargon output is that, in the presence of such overt and often unusual spoken (and sometimes written) errors, the speaker will often demonstrate a lack of awareness. This behaviour ranges from 'holding the floor' whilst producing errorful language, to denial of any communication impairment (Marshall, 2006). This study aimed to identify the underlying breakdown in both linguistic and cognitive processes which might contribute to self-monitoring of single word spoken errors. We hypothesised that impairments of cognitive functions, other than language, contribute to monitoring failures and communication difficulties in jargon output.

Theoretical Approaches to Language Self-Monitoring

The relationship between the production of jargon and the inability to monitor for spoken (and sometimes written) errors appears to be a close one. Monitoring requires the speaker to know what s/he wants to say and to recognise any deviation from the target. Lack of awareness of the impairment makes jargon output notoriously difficult to rehabilitate (Jackson-Waite, Robson & Pring, 2003; Lebrun, 1987) as people who are unaware of their difficulties are less likely to attend to the therapeutic processes (stimulation, experiences and activities) which might improve their impairment (Robertson & Murre, 1999). A deeper understanding of the processes required for monitoring spoken and written output could provide a possible benefit to treatment approaches. Theoretical approaches to understanding the ability to self-monitor language errors include the Perceptual Loop Theory (Levelt, 1983, 1989; Levelt, Roelofs & Meyer, 1999) and the Resource Limitation Hypothesis (Shuren, Smith Hammond, Maher, Rothi & Heilman, 1995). The Perceptual Loop theory proposes that error monitoring relies on intact language comprehension whereas the Resource Limitation Hypothesis considers the impact of attentional capacity in the ability to detect and repair linguistic errors.

Marshall and colleagues (1998) presented an alternative account for monitoring failure in the Production Hypothesis, where the ability to monitor spoken output depends on the demands placed on the output system. Both the Resource Limitation Hypothesis (Shuren at el., 1995) and the Production Hypothesis (1998) rely on findings from single case studies, indicating this is an area which requires further investigation for speakers with jargon output.

A further consideration for the persistence of such prominent linguistic errors in jargon output is whether the speaker with jargon has the linguistic capacity to correct those errors, even if they have been successfully identified as incorrect. Butterworth and Howard (1987) compared a large corpus of paragrammatic errors produced by both aphasic and non-aphasic speakers. They concluded that a range of error types were produced by both groups and frequently went uncorrected, although the error rate was considerably lower for the neuro-typical control participants. These control participants often failed to correct errors and neuro-typical listeners ignored errors to interpret the planned message; achieving fluency at the expense of accuracy. The speaker with jargon output could be aware s/he would be unsuccessful in correcting the error or could decide correcting the error would be too effortful or disruptive to conversational flow (Maher, Gonzalez Rothi & Heilman, 1994). In the absence of a better alternative, a person with jargon output may simply be doing the 'best job' s/he is capable of.

Attention and Aphasia

People with persistent jargon output often present with bilateral hemispheric damage (Brown, 1981; Robson, Pring, Marshall & Chiat, 2003; Rubens & Garrett, 1991), which is likely to produce damage to multiple cognitive systems, including attention and language (Weinstein & Lyerly, 1976). Investigating the contribution of attentional deficits as a factor in the production of poorly monitored jargon would have implications for the rehabilitation process. Attention is considered a prerequisite for learning (Robertson, 1999) and the presence of an attention impairment is usually an indicator of a poor rehabilitation prognosis (Lambon Ralph, Snell, Fillingham, Conroy & Sage, 2010; Marshall, Grinnell, Heisel, Newall & Hunt, 1997). There has been a growing amount of literature acknowledging the importance of attention deficits and their impact on aphasia (Butler, Lambon Ralph & Woollams, 2014; Campbell & McNeil, 1985; Fillingham et al., 2006; Halai, Woollams & Lambon Ralph, 2017; Maher et al., 1994; Murray, 1999). Clinicians are aware that manipulating the communication environment (such as reducing background noise) can improve the linguistic competence of the person with aphasia, with a number of studies positively correlating divided and sustained attention deficits with aphasia (Erikson, Goldinger & LaPointe, 1996; Murray, Holland & Beeson, 1998; Tseng, McNeil & Milenkovic, 1993) to support the rationale for such intervention. For example, Erikson et al.(1996) compared ten aphasic speakers with ten control subjects on both sustained and divided attention tasks. Although no significant difference in performance was seen on the sustained attention task (discriminating non-linguistic auditory stimuli), the speakers with aphasia showed a poorer performance when having to divide attention between a card-sorting task and the auditory discrimination task. Non-linguistic tasks were selected to differentiate whether decreased attentional capacity was due to auditory processing or an inability to properly allocate attention. They concluded that attention was a basic determinant of auditory processing. However, it was unclear to what degree language comprehension was necessary to complete the dual task condition and therefore how that interacted with the results.

Petry, Crosson, Gonzalez Rothi, Bauer and Schauer (1994) suggested that an impairment of attention contributed to the severity of an aphasia and further studies by Fillingham and colleagues have linked poor attentional abilities with a poor response to language impairment therapy (Fillingham et al., 2006; Fillingham, Sage & Lambon Ralph, 2005). The production of spoken (and to some degree, written) language is a continuously 'on-line' demand. We must be able to maintain attention on the topic of conversation, the listener reaction and needs whilst monitoring language simultaneously. On-line and off-line conditions have been known to impact differently on the demand being placed on the attentional system. On-line monitoring conditions (i.e. judging the accuracy of language output as it is being produced) have been considered as placing a greater attentional demand on language and cognitive systems. Off-line monitoring conditions (i.e. being asked to judge the accuracy of spoken output once it has been produced, either via a recording or listening to someone else repeating back the error) have been viewed as requiring fewer attentional resources which may benefit a participant's ability to monitor his/her language output (Murray, 1999; Shuren et al., 1995; Tseng et al., 1993).

Tseng et al. (1993) proposed that speakers with aphasia had an 'attention allocation deficit' which resulted in the within-subject variability frequently observed in the clinical setting (though infrequently investigated under controlled conditions). They compared nine speakers with aphasia to eighteen non-brain damaged controls on both single and dual task test conditions, where subjects were required to make semantic judgements and/or monitor phonemic errors. Participants with aphasia were more likely to be sensitive to the dual task condition and subsequently display slower reaction times. They also performed significantly worse on the single task condition of monitoring phonemes. Tseng and colleagues (1993) used this small group study as support for their hypothesis that speakers with aphasia had difficulties allocating their limited attentional resources. However, they did not consider a language-based explanation which might have helped them to understand why phoneme monitoring alone was impaired. Such a specific monitoring difficulty could have been considered a selective impairment in a more traditional model of linguistic processing. McNeil et al. (1991) and Tseng et al. (1993) both proposed that aphasic symptoms could be explained in terms of damage to more general cognitive systems and this view might particularly hold in the case of jargon aphasia and poor self-monitoring of errors.

Study Hypothesis

Jargon output is a relatively poorly understood linguistic impairment. The role of self-monitoring and contributions of non-linguistic cognitive skills may have implications which could support the design of improved treatment**.** This study aimed to investigate the hypothesis that underpinning cognitive systems have a potentially significant contribution to jargon output and may influence a speaker's ability to monitor his/her spoken errors. We propose that jargon behaviour – poor language monitoring and jargon output – arises from an intersection of impaired language and cognitive systems.

Method: Study Design

This study used a case series method to investigate the language, cognition and self-monitoring skills of single spoken words of six participants with jargon output. Standardised tests were utilised to investigate language and cognition skills as well as three experimental monitoring tests to investigate the ability to monitor spoken output for each participant.

Recruitment

Recruitment of participants was done via bi-monthly Aphasia Interest meetings at the University of Manchester, for Speech and Language Therapists working with people with aphasia in the North West, using the following inclusion criteria:

- The presence of fluent asemantic (i.e. unrelated word errors), neologistic and/or perseverative verbal output which is incomprehensible or 'empty' of content for the listener;
- Neurologically stable (three or more months post-onset);
- And no co-occurring progressive neurological condition.

Participants were not excluded on the basis of age or whether they were actively receiving therapy for their cognitive or language deficits. Referred patients were then screened using the Boston Diagnostic Aphasia Examination (Goodglass et al., 2001) and consented in to the study if appropriate. A total of 14 referrals were accepted, of whom 6 participated in the study. Of the 8 participants not included in the study, 2 did not have jargon output and 5 declined to participate. A further participant was excluded once the battery of assessments for language, cognition and self-monitoring were completed, due to his inability to participate in any of the experimental self-monitoring assessments. We therefore report on the assessment findings of six participants.

Participants

(Table One around here)

The six participants ranged in age from 61 to 86 years (mean 74.33, St. Dev. 8.76), all of whom had English as their first language. There were five males and one female; all were right handed. Scan results were available for all six participants. All six participants had a primary diagnosis of CVA (confirmed by CT scans). Time post-onset of injury varied from 3 to 45 months (mean 15.29, St. Dev. 14.13) and all participants were considered to be neurologically stable. Whilst we enquired whether participants required aids for hearing, they did not undergo hearing tests, which we acknowledge as a limitation of this study. AJ was the only participant with a bilateral hearing loss for which he wore aids.

The Boston Diagnostic Aphasia Examination (BDAE) Short Form was used to ensure that the participants met the diagnostic criteria for jargon output. Five of the participants (RS, AJ, AE, DM and RK) were classified Wernicke's aphasia type. LS did not fit in the Wernicke's aphasia profile. Most of his connected speech was perseverative (e.g. "I'm alright, I'm alright, are you alright?") and was therefore not categorised as 'paraphasic' errors. However, his speech output was still considered to be jargon in nature due to its well-articulated form, long phrase length (of 7 or more words in an utterance) and 'empty' content. Sentence repetition was minimally impaired for LS and he scored poorly in auditory comprehension tests. LS was classified as Transcortical Sensory Aphasic due to his relatively well-preserved repetition skills in the presence of well-articulated speech and poor comprehension. The heterogeneity of the participants most likely reflects the different underlying impairments which may contribute to jargon output.

Data Collection: Assessment Schedule

Each assessment session lasted from 60 to 90 minutes, carried out once a week, with participants completing the schedule over 7 to 10 sessions. Testing took place in the participant's home, in a quiet room, on a one to one basis. Language, cognition and experimental tests for language self-monitoring abilities were alternated to prevent the participant becoming disinterested. Whenever a participant signalled he/she was tired, testing was abandoned that week and rescheduled to the next week.

Principles of 'aphasia friendly' communication (Kagan, Winckel & Shumway, 1996) were adhered to in order to prevent any receptive language difficulties interfering with assessment administration, although we acknowledge that some of the limitations of working with this population meant that these attempts were not always successful. Written and pictorial prompts were used to assist with task instructions. Repetition and demonstration of task practice items were also repeated as necessary to help each participant follow assessment instructions. Where a participant could not reliably follow instructions for the administration of an assessment, the assessment was terminated and the rest of the testing scheduled administered in turn.

Background Language Tests

Eight language assessments were completed by each participant to explore and quantify the degree of language impairment for speakers with jargon aphasia. Assessments selected included the three picture version of the Pyramids and Palm Trees Test (Howard & Patterson, 1992) and the 96 Synonym Test (Jefferies, Patterson, Jones & Lambon Ralph, 2009) to investigate semantics; The Cambridge 64 Item Naming Test (Bozeat, Lambon Ralph, Patterson & Hodges, 2000) to measure spoken and written picture naming skills; PALPA 1 Same-Different Discrimination Using Nonword Minimal Pairs and PALPA 2, Same-Different Discrimination Using Word Minimal Pairs Aphasia (Kay et al., 1992) to investigate auditory discrimination skills; PALPA 31 Imageability and Frequency Reading and PALPA 36: Nonword Reading (Kay et al., 1992) to measure reading aloud skills; and PALPA 9 Auditory Word and Non-Word Repetition (Kay et al., 1992) was used to investigate the participants' ability to repeat words and non-words. The words are identical to those used in PALPA 31, Imageability and Frequency Reading (Kay et al., 1992) to allow a direct comparison of the ability to repeat and read words. The Cookie Theft Description task (Goodglass et al., 2001) was also completed to gather a sample of connected speech.

Any score two standard deviations or more below the mean was considered impaired. Where spoken language output was required (spoken naming, reading aloud, repetition and picture description tasks), responses were classified according to whether they were asemantic paraphasias (real word errors unrelated to the target e.g. 'parrot' for 'cherry'), phonemic paraphasias (defined as more than 50% of the correct phonology of the target), perseverations or neologisms (less than 50% of the target word). Written errors were also classified, with the addition of any written error where the word had 50% or more of the shared graphemes of the target word being categorised as a graphemic error. Recordings of the spoken naming assessment were made for use in the Experimental Tests.

Background Cognitive Tests

Assessments were selected to investigate the attentional skills, problem solving abilities and access to complex action tasks for each participant. Subtests from The Test of Everyday Attention - Elevator Counting (to assess sustained attentional capacity) and Elevator Counting with Distraction (to assess divided attentional capacity) (Robertson et al., 1994); the Raven's Coloured Progressive Matrices (Raven, 1956) and the Naturalistic Action Test (Schwartz et al., 2002a) were selected. All cognitive tests inherently involved some element of receptive language skills by their instructions and so practice items and demonstrations of task instructions were utilised to elicit reliable results. Adaptations were made according to how each participant responded, to take account of their aphasic output. For example, responses for the TEA subtests were accepted from AE according to how many fingers she held up. Other participants, such as RS, used a written scale of numbers to indicate his response.

The Assessment of Naturalistic Action (Schwartz et al., 2002a) was carried out to investigate cognitive difficulties (such as poor self-monitoring or reduced attentional capacity) in a non-language environment. This was done by measuring each participant's ability to carry out 'naturalistic actions'. Naturalistic actions are defined as "learned sequences of movements, typically involving objects, which comprise habitual means of achieving nested goals" (Schwartz et al., 2002b, p 312). Tasks include making toast and coffee, wrapping a gift as a present and making up a child's packed lunch box and pack a school bag. Distracter items are presented during each of the tasks (e.g. mustard and butter, toothbrush and pen)

The NAT provides a final quantitative score and each subtest provides qualitative information. As well as scoring points for managing each task, points are deducted according to the type and number of errors made (such as using distracter items or omitting task instructions). Errors were classified in the following way:

(1). Omissions – where a test instruction or object use was omitted. For example, tearing the wrapping paper rather than using scissors.

(2). Object Misuse – where the correct object was selected but used incorrectly. For example, stirring coffee with the spoon upside down.

(3). Distracter Selection – where one of the distracter items was selected instead of the target object (e.g. selecting secateurs for scissors).

(4). Perseveration – Where the participant perseverated in use of an object.

Experimental Tests

Three monitoring tests were devised to investigate participants' abilities to monitor single word spoken output. All required a yes/no response from the participant. Practice items were used to explain test instructions. Written and pictorial support was available to assist those participants who struggled to indicate yes/no reliably by speech alone. Both on-line and off-line monitoring conditions were investigated. On-line monitoring was assessed by asking the participant to immediately assess if their attempt at naming was correct after producing the word. Off-line monitoring was assessed by asking participants to listen back to their production whilst looking at a picture of the target. It was considered that participants with limited attentional abilities might perform better in off-line testing conditions, as it has been proposed that on-line spoken monitoring (judging whether language is correct as you speak) demands more attentional resources (Murray, 1999; Shuren et al., 1995; Tseng et al., 1993). All six participants completed the on-line monitoring tests, but only three were able to complete the off-line monitoring tests. The three spoken monitoring tests were:

(1). On-line spoken monitoring: This was tested by asking the participant to make a yes/no decision about whether they had correctly named an item immediately after producing it (using responses from the Cambridge 64 Naming Test (Bozeat et al., 2000), administered as part of the background language battery). Participants were encouraged to produce one-word answers for each picture stimuli. Spoken items were recorded to ensure reliable phonemic transcription and for use in the off-line test condition.

(2). Off-line Spoken Monitoring – Participant's Own Response: A tape recording of each participant's speech was prepared for this test. It consisted of 32 correct target words and 32 of their own errors. As the test required 32 correct spoken responses, only participants who demonstrated sufficient ability to repeat (a score of 40 or over on Auditory Word Repetition: Imageability and Frequency, Kay et al., 1992) could take part in the off-line spoken monitoring tests. Participants were recorded repeating the picture names. Correct and incorrect responses for the tape were selected at random. Participants listened back to this tape recording of their own speech and had to indicate if what they heard matched the picture.

(3). Off-line Spoken Monitoring – Examiner's Response: The participant was shown a picture and asked to listen to the examiner producing a word, correctly or incorrectly, and then make a yes/no decision about its accuracy. Incorrect words were based on those produced by the participant in test condition (1). This test used the same randomised set of 32 correct spoken words and 32 erroneous words as used in the off-line monitoring test of the participant's own response (test 2), to allow a direct comparison of results. Lip reading was not permitted.

Data Analysis

Profiles of individual performances across the language and cognitive tests were made, using comparisons from the published standardised norms. A McNemar Chi Square test was used to compare participants' ability to repeat words and read them aloud. A Binomial 2 tailed test was used to check for the significance of test scores above chance level for the experimental tests which required a yes/no response.

Ethical Approval

This study was approved under MRec ethics guidance (reference 01/8/94). Consent was obtained using the 'aphasia friendly' consent forms, using materials from the 'Supported Conversation for Adults with Aphasia' resource pack (Kagan et al., 1996).

Results

The results of the background language and cognitive assessments are shown in Table 2, ordered according to performance on PALPA 1: Same-Different Discrimination Using Nonword Minimal Pairs (Kay et al., 1992). Table 3 shows the experimental spoken monitoring test scores, with table 4 showing a comparison of on-line and off-line monitoring scores using a McNemar Chi Square test.

(Tables 2, 3 and 4 here)

Only three participants were able to complete all the language and cognition battery as well as the three experimental single word spoken monitoring tests. They were AE, LS and AJ.

- **AE** demonstrated some impairment at non-word auditory (56/72) and word (20/72) discrimination but performed at the higher end on semantic tests (P&PT 40/52 and the 96 Synonym Test 76/96). She scored 64/80 on single word repetition and 39/80 on non-word repetition suggesting a reliance on contributions from her semantic ability to repeat single words. She struggled with reading aloud words (3/80) and non-words (0/80). This suggests she had some intact ability to convert phoneme to phoneme (from auditory input to spoken output) but grapheme to phoneme conversion was severely impaired. Interestingly, AE was better at written naming when compared to spoken naming (27/64 compared to 3/64; McNemar, 2 tailed, p=0.06-0.09) indicating she still had access to some orthographic knowledge. AE was consistent in her predominant error type, consistently producing neologisms across expressive language tests. AE demonstrated attentional impairments on the Test of Everyday Attention (Robertson et al., 1994), falling below the 5th percentile on the divided attention test. However, she scored 6/7 on the sustained attention test and, overall, performed the best from the other participants in the case series. She fell between 25th and 50th percentile on Raven's Matrices (Raven, 1956). She performed abnormally on the NAT (Schwartz et al., 2002a), making a variety of uncorrected errors which increased as the task complexity increased. AE performed at ceiling in the on-line spoken monitoring test condition (test 1 – 64/64). AE demonstrated competency to monitor her own single word spoken output in experimental test 2 (60/64) and scored at ceiling on test 3 (64/64), off-line spoken monitoring of the examiner's response. AE showed no effect whether she was required to monitor on-line or off-line (McNemar, 2 tailed, $p>0.06$).

- **LS** demonstrated intact word auditory discrimination (PALPA 1 - 53/72 and PALPA 2 - 66/72). He was also able to accurately repeat words (77/80) and nonwords (71/80).   He performed below the controls on the semantic battery tests (P&PT 31/52 and 96 Synonym Test 44/96), indicating poor access to semantics. However, despite his ability to repeat, other forms of expressive language resulted in fluent, perseverative jargon output, with spoken naming ability at 7/64 (Bozeat et al., 2000). LS produced asemantic paraphasias and perseverative errors in spoken output tasks.   LS performed at floor for written naming (0/64) and was unable to read any words or non-words aloud, suggesting severely impaired access to orthography. LS demonstrated attentional impairments on the Test of Everyday Attention (Robertson et al., 1994), falling in the 1st percentile. He also demonstrated poor non-verbal reasoning on the Raven's Matrices (Raven, 1956), scoring below the 10th percentile. He scored 5/18 on the NAT (Schwartz et al., 2002a), making a variety of uncorrected errors across the tasks.   Perhaps given LS's ability to repeat and discriminate words, it is unsurprising that he performed reasonably well across the three experimental monitoring tasks, with scores of 48/64 for on-line monitoring; 46/64 for off-line monitoring of his own speech; and 59/64 for off-line monitoring of the examiner's speech. All three of LS's spoken monitoring scores were significantly different from chance (Binomial, 2 tailed, $p<0.01$). LS was significantly better at monitoring the examiner's spoken output (McNemar, 2 tailed, $p<0.01$) than his own spoken output.
- **AJ** demonstrated difficulties with auditory discrimination of words and nonwords (56 and 50 out of 72 respectively). He scored 45/52 on the Pyramids and Palm Trees Test (Howard & Patterson, 1992), just 4 points below the 'cut off' but scored 47 on the 96 Synonym Test (Jefferies et al, 2009), indicating some difficulties accessing semantics. AJ was by far the strongest participant in the group in terms of reading aloud ability (48/80 for words and 11/80 for non-words) and demonstrated comparative strengths in repetition ability (51/90 words and 49/80 non-words). AJ scored 16/64 for spoken picture naming and 4/64 for written picture naming. He produced differing jargon output in single word tasks (neologisms) in comparison to sentence level output (predominantly asemantic paraphasias). In cognition testing, he was the strongest performer on the Raven Matrices (Raven, 1956) but scored in the 1st percentile on the Test of Everyday Attention (Robertson et al., 1994). He scored 7/18 on the NAT (Schwartz et al., 2002a), with performance consistently worsening as the tasks grew in complexity. In the experimental monitoring tests, he scored highest when monitoring the examiner's speech (59/64) and the lowest when monitoring his own speech offline (32/64 i.e. chance level (Binomial, 2 tailed, $p>0.06$)). AJ was the only participant to require hearing aids which may have impacted on his ability to hear his own recorded voice. When asked to monitor his own speech on-line, he scored 43/64. AJ was significantly better at monitoring the examiner's speech off-line, in comparison to his own speech on-line (McNemar, 2 tailed, $p<0.01$). He was significantly better at monitoring his own speech on-line than off-line (McNemar, 2 tailed, $p<0.01$).

Participants DM, RK and RS were excluded from the offline experimental tests (2 and 3) as they could not reliably repeat. Repetition of correct picture names was necessary to create the test materials for these experimental tests.

- **DM** demonstrated comparative strength in his ability to access semantics, scoring 46/52 on the Pyramids and Palm Trees test (Howard & Patterson, 1992) and 68/96 on the 96 Synonym Test (Jefferies et al, 2009). His access to phonological forms was impaired in both auditory discrimination tasks (31/72 PALPA 1 and 32/72 PALPA 2) and for repetition of words and non-words (0/80 for both tests). He was unable to name any pictures reliably in spoken form (0/64). DM produced neologisms when attempting to repeat or read aloud. In other spoken tasks, he tended to perseverate on spoken naming ("eleven" and "seven" were his usual responses). DM did demonstrate some intact access to written word forms, scoring 22/64 on written picture naming. DM was scored in the 50th percentile on the Raven's and the 1st percentile for the elevator test with distraction. He scored 6/7 on sustained attention. He was less successful in the NAT, scoring 1/18. DM scored 21/64 on the online spoken monitoring test, where a chance score was 32.
- **RK** presented with relative strengths in semantic knowledge on the Pyramids and Palm Trees Test (47/52), but less so on the 96 Synonym Test (34/96). He had impaired auditory discrimination skills (PALPA 1 24/72; PALPA 2 25/72) and struggled greatly to produce any accurate repetition or reading aloud of words and non-words. He performed between the 25th and 50th percentile on the Ravens. He scored 4/7 on the sustained attention test but in the 10th percentile on the divided attention test of the TEA. Interestingly, he achieved the highest score in the case series on the NAT with a score of 10/18, despite performing poorly on language and cognitive testing. RK scored just 1/64 in the online monitoring test, indicating his 'yes' bias (i.e. on all but one occasion he judged that he had produced the word correctly). RK made consistent neologistic errors when writing or speaking a picture name. When corrected on a spoken error, RK would usually respond with, "That's what I said".
- **RS** scored within the control range on the 96 Synonym Test (Jefferies et al., 2009) with a score of 94 but he performed below the normal cut off point (n=44.5) in the Pyramids and Palm Trees Test (Howard & Patterson, 1992). He was unable to participate in auditory discrimination test, indicating he could not follow the instructions and was unable to accurately repeat any words or non-words. Despite this, he demonstrated the highest scores within the group on spoken and written naming (19 and 35/64 respectively), perhaps indicating his relatively well-preserved access to semantics. He also presented with cognitive impairments in the Ravens (scoring in the 25th percentile) and attentional deficits in sustained attention (4/7) and divided attention (5th percentile) in the TEA. He scored 6/18 on the NAT and 22/64 on monitoring his spoken output online.

Discussion

Summary of Findings

The profile of poor receptive language skills was consistent with previous literature on jargon aphasia (Marshall, 2006). These results imply that jargon output can differ according to whether it is single word or multiple word output, and whether the word is being named from a picture stimulus, repeated or read aloud. The range of spoken jargon output across the case series varied (i.e. from predominantly neologistic output in the case of AE to perseverative in LS), making the participant group heterogenous, especially with regards to LS who was the only participant not to be classified as a Wernicke's aphasic with the BDAE. It is likely that jargon behaviour is underpinned by different profiles of language and cognitive skills.

Participants who were better at monitoring their speech (AE, AJ and LS) performed better on the language tests which assess access to auditory discrimination and repetition skills. The contribution of these abilities to discriminate auditory input and the ability to monitor speech is a logical relationship. However, cases such as LS (with relatively intact ability to discriminate auditory input and repeat) suggest that speech monitoring relies on contributions from other systems as well as phonology. The relationship between access to semantics and monitoring of language output was less clear. For example, in the case of RS, who scored the highest on the semantic language tests, he was the only participant to demonstrate a bias towards a 'yes' response in the on-line monitoring test. RS was also the highest scoring participant in the NAT (Schwartz et al., 2002a), perhaps reflecting his ability to access semantic information. However, all participants made uncorrected errors in the NAT, suggesting that self-monitoring errors may go beyond single word production. In other words, could monitoring errors in non-language tasks signify that non-language domains are involved in error monitoring abilities? The variation across cognitive abilities could be of significance to monitoring abilities. All participants presented with impairment of attention which could have contributed to their jargon behaviour.

Hartsuiker and Kolk (2001) defined the speech monitoring system as "the process of inspecting one's own speech and taking appropriate action when errors are made" (p.113). All participants in this study demonstrated deficits in language monitoring tasks, including AE, who scored at ceiling in two of the spoken word monitoring tasks (test 1 – online; test 3- offline monitoring of the examiner's speech) but had deficits in monitoring her own speech offline. All participants who were poor at monitoring their speech online (test 1) were poor at monitoring their own speech offline (test 2). According to Hartsuiker and Kolk (2001) these results indicated that participants were unable to adequately inspect their speech or take appropriate corrective action.

Limitations of the study

To implement a self-monitoring process, the participant was required to identify an error, search for the correct and corresponding element, and finally replace the error with the correct target word. This lengthy process could be too demanding for an aphasic speaker with a limited capacity for attention. Participants AE, LS and AJ who performed relatively well in the spoken monitoring tests could have benefited from the design of the tests. Indeed, by the nature of the test design, only participants who had sufficiently intact ability to discriminate and accurately repeat auditory stimuli could participate in the off-line monitoring tests. Therefore, participants who were able to participate in the full test battery were those with the necessary language skills to monitor their output. Testing of participants' monitoring abilities was done in one-to-one testing conditions in a quiet room. Participants were given explicit instructions and demonstrations regarding the test requirements. Hence the test design itself might have assisted participants' ability to monitor. The experimental tests made the monitoring process an overt and explicit one, with participants being given clear instructions to judge their own speech. If attentional deficits were an underpinning skill in language monitoring, the experimental task design might have helped to allocate attentional resources to the required task. The findings of this study might not have reflected the true severity of the monitoring deficits.

The recruitment process meant that a number of potential participants (n=5) declined to participate in the study. In this way, the recruitment of participants was selective and may have excluded participants with jargon aphasia and intact self-monitoring skills. Furthermore, due to the experimental nature of the self-monitoring tests, there were no control data and some participants were unable to participate, resulting in an incomplete set of data. A larger case series would enable further investigation in to how cognitive and language impairments might interact.

This study tested single word output only, lacking a real-world validity to everyday language use. More extensive testing of language monitoring in connected speech would also contribute to our understanding of how monitoring relies on contributions from both language and cognition systems. In the case of AE, who scored highly on spoken monitoring tests, but continued to produce uncorrected spoken jargon at sentence level, one might consider whether the production of jargon and lack of self-correction was due to her inability to provide a corrected version of the target words. This may lend support to Maher and colleagues (1994) view that any attempts to correct spoken errors would result in disruption to the conversational flow (Maher, Gonzalez Rothi & Heilman, 1994). Or it may be the case that single word monitoring, performed in explicit experimental conditions, relies on different mechanisms from that of monitoring conversational output.

Discussion

All participants presented with attention deficits and 5 participants presented with monitoring deficits at the single spoken word level. Failure to detect and correct responses could be considered as 'normal' behaviour, with the aim of maintaining conversational flow, as many neurologically normal speakers accept and 'ignore' spoken errors (Garrett, 1991). The number of errors and the quality of errors made by participants in this study were striking. If participants were willing to sacrifice accuracy for fluency and a conversational turn (no matter how erroneous), it would be expected that they would have performed more consistently across each monitoring test condition. Instead, the data show that most participants, except for

AE (who performed at ceiling or almost ceiling in all three experimental tests) were better able to monitor their speech depending on the test condition. The Resource Limitation Hypothesis (Shuren et al., 1995) predicted that speakers with aphasia were unable to speak and monitor simultaneously due to a reduced attentional capacity. In the case of this study, we would expect off-line monitoring testing conditions to require fewer attentional resources and subsequently allow for more accurate error detection. However, LS showed no significant difference when monitoring his own speech on-line and off-line. Furthermore, AJ was significantly better at monitoring his own speech on-line than off-line.

The relationship between language competency and self-monitoring skills is implicated from the results of this study: AJ, AE and LS demonstrated the highest range of scores for monitoring online spoken output and all scored on the higher end of tests of auditory discrimination and repetition. In this respect, the findings appear straight forward – access to auditory discrimination and repetition is associated with the ability to monitor speech errors. However, there are many people with aphasia with poor access to auditory discrimination and repetition but who still demonstrate awareness and attempt to correct their phonology. All participants were found to have previously unidentified significant cognitive deficits, including difficulties with attention, problem solving and sequencing, suggesting further research in to the language and cognitive impairments which result in the distinctive production of jargon behaviour is implicated.

The identification of both language and cognitive deficits in this case series might also have some implications for therapy. This study presented six participants with severe aphasia who had no previously identified cognitive impairments. The presence of significant cognitive impairment had been suggested as impacting greatly on prognosis (Galski, Bruno, Zorowitz & Walker, 1993) and patients with jargon aphasia have been notoriously difficult to treat (Jackson-Waite et al., 2003; Lebrun, 1987). All participants had some degree of cognitive deficit, which would result in an increased burden on their ability to engage in remediation therapy. Hinckley and Carr (2001) proposed that compensatory therapy, such as encouraging non-verbal means of communication, actually *increased* the cognitive burden on the impaired speaker. The majority of previous therapy for jargon aphasia has focused on compensatory methods (Jackson-Waite et al., 2003; Robson et al., 2001; Robson et al., 1998), which might shed light on why the success rate of therapy was relatively poor.

Conclusions

This study hypothesised that jargon behaviour (jargon output and poor self-monitoring) was underpinned by a combination of language and cognitive impairments. However, in the case of AE, who was able to successfully monitor single word output, it may be that a profile of 'jargon behaviour' requires further investigation. The investigation of self-monitoring skills beyond the single word would add to our knowledge of the potential language and cognition profiles of jargon behaviour. We examined whether monitoring systems were specific to spoken output, and whether monitoring was confined to the language system. There was a lack of consistency in performance both within participants and across the case series. The ability to monitor language output 'off-line' was not always easier for some participants. A future direction of research would be to ‘map out’ the contributions needed from the language and cognition systems required to result in different forms of jargon and monitoring impairment. A multidimensional approach to assessment (i.e. language and cognition abilities) would provide more specific and relevant intervention. In particular, the presence of attention deficits could be a contraindication to compensatory therapy. Further multidimensional approaches to jargon aphasia are required in order to fully understand this complex set of symptoms and more fully evaluate the optimal treatment approaches to working clinically with people who present with this highly disabling form of communication impairment.

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Word Count 6551

Table 1: Participant biographical details and neuroimaging summary.

Participant	**AE**	**LS**	**AJ**	**DM**	**RK**	**RS**
Age (years)	71	71	72	76	81	86
Gender	Female	male	Male	male	Male	male
Handedness	Right	Right	Right	Right	Right	Right
Medical diagnosis	CVA	CVA	CVA	CVA	CVA	CVA
CT/ MRI scan results	Bilateral lesions	Left temporal parietal frontal	Left frontal	Left temporal parietal	Left parietal	Bilateral lesions
Time post-onset (months)	13	45	20	7	10	3
Glasses	Yes	Yes (reading only)	Yes (reading only)	Yes (reading only)	Yes (reading only)	Yes
Hearing aid	No	No	Yes – bilateral	No	No	No
Occupation	Retired secretary	Retired salesman	Retired shift leader	Retired clerk	Retired engineer	Retired company director
Previous reported cognitive/ physical deficits	Right hemiparesis	Right hemiparesis	Right hemiparesis, depression	Right hemiparesis & hemianopia	Right hemiparesis	Right hemiparesis

Table 2: Language & cognition assessment scores

Participant	***Max***	***Range***	***Mean***	***SD***	**AE**	**LS**	**AJ**	**DM**	**RK**	**RS**
BDAE Classification					Wernicke	TSA	Wernicke	Wernicke	Wernicke	Wernicke
Pyramids and Palm Trees	*52*	*49-52*	*51.2*	*1.4*	40	31	45	46	47	44.5
96 Synonym Test	*96*	*89-96*	*94.50*	*1.76*	76	44	47	68	34	94
PALPA 1 Same-Different Discrimination Using Nonword Minimal Pairs	*72*		*70.79*	*2.90*	56	53	50	31	24	NA
PALPA 2, Same-Different Discrimination Using Word Minimal Pairs	*72*		*70.73*	*3.38*	40	66	56	32	25	NA
PALPA 31 Imageability and Frequency Reading	*80*		*79.40*	*1.00*	3	0	48	0	2	3
PALPA 36 Nonword Reading	*24*		*22.88*	*2.89*	0	0	11	0	0	0
PALPA 9 Auditory word repetition	*80*		*78.81*	*2.71*	64	77	51	0	3	0
PALPA 9 Auditory non-word repetition	*80*		*75.94*	*6.72*	39	71	49	0	0	0
Cambridge 64 Spoken Naming	*64*		*62.3*	*1.6*	3	7	16	0	3	19
Cambridge 64 Written Naming	*64*				27	0	4	22	3	35
Raven's Coloured Progressive Matrices – total score (percentile)	*36*				21 (25-50th)	16 (10th)	26 (75th)	26 (50th)	20 (25-50th)	15 (25th)
Test of Everyday Attention	*7*				6	3	3	6	4	4

- elevator counting										
- elevator counting with distraction – raw score (percentile)	*10*				6 (5th)	2 (1st)	4 (1st)	3 (1st)	4 (10th)	2 (5th)
Naturalistic Action Test – total score	*18*	*14-18*	*17.3*	*1.2*	7	5	7	1	10	6
Task 1 – toast & coffee	*6*		*5.57*		6	2	6	0	6	2
Task 2 – Wrap present	*6*		*5.86*		1	1	1	0	4	4
Task 3 – Pack lunchbox & school bag	*6*		*5.87*		0	2	0	1	0	0

Table 3: Experimental spoken monitoring test scores

Participant	***max***	**AE**	**LS**	**AJ**	**DM**	**RK**	**RS**
Spoken Monitoring							
- On-line	*64*	64	48	43	21	1	22
- Off-line participants' own response	*64*	60	46	32	NA	NA	NA
- Off-line examiner's response	*64*	64	59	59	NA	NA	NA

NA= Participant did not take part in the test

Table 4: A comparison of on-line and off-line monitoring scores

Participant	**AE**	**LS**	**AJ**
Spoken on-line (test 1) compared to spoken off-line participant's response (test 2)			
- Online Score	64	48	43
- Offline Participant Score	60 ns	46 ns	32*
Spoken on-line (test 1) compared to spoken off-line examiner response (test 3)			
- Online Score	64	48	43
- Offline Examiner Score	64 ns	59**	59**
Spoken off-line participant response (test 2) compared to spoken off-line examiner's response (test 3)			
- Participant Response	60	46	32
- Examiner Response	64ns	59**	59**

McNemar, 2 tailed, ns=not significant, *p<0.05, **p<0.01; NA= participant not able to perform tasks

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