"My Mind Is Doing It All": No "Brake" to Stop Speech Generation in Jargon Aphasia

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Objective: To study whether pressure of speech in jargon aphasia arises out of disturbances to core language or executive processes, or at the intersection of conceptual preparation.

Background: Conceptual preparation mechanisms for speech have not been well studied. Several mechanisms have been proposed for jargon aphasia, a fluent, well-articulated, logorrheic propositional speech that is almost incomprehensible.

Methods: We studied the vast quantity of jargon speech produced by patient J.A., who had suffered an infarct after the clipping of a middle cerebral artery aneurysm. We gave J.A. baseline cognitive tests and experimental word- and sentence-generation tasks that we had designed for patients with dynamic aphasia, a severely reduced but otherwise fairly normal propositional speech thought to result from deficits in conceptual preparation.

Results: J.A. had cognitive dysfunction, including executive difficulties, and a language profile characterized by poor repetition and naming in the context of relatively intact single-word comprehension. J.A.'s spontaneous speech was fluent but jargon. He had no difficulty generating sentences; in contrast to dynamic aphasia, his sentences were largely meaningless and not significantly affected by stimulus constraint level.

Conclusions: This patient with jargon aphasia highlights that voluminous speech output can arise from disturbances of both language and executive functions. Our previous studies have identified three conceptual preparation mechanisms for speech: generation of novel thoughts, their sequencing, and selection. This study raises the possibility that a "brake" to stop message generation may be a fourth conceptual preparation mechanism behind the pressure of speech characteristic of jargon aphasia.

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Jargon aphasia is well-articulated and fluent but unintelligible speech (Alajouanine et al, 1952). Patients with jargon aphasia may have a variety of language symptoms. Many patients produce verbal substitutions in which the substituted word is related to the target in either meaning (semantic jargon) or sound (phonological jargon). In many patients, target words are so phonologically distorted as to become nonwords (Butterworth, 1985; Panzeri et al, 1987). It has been proposed that some nonwords are not easily interpreted as distortions of real words but appear to be neologistic constructions (neologistic jargon) (Butterworth, 1979, 1985; Moses et al, 2004).

In addition to these specific speech characteristics, patients with jargon aphasia show the "pressure of speech" that Alajouanine (1956, page 27) described as "logorrhea, quick utterance, uncontrolled expression" that "showed indisputably the lack of *voluntary* influence." Alajouanine further argued that propositional and volitional forms of speech return as jargon "regresses." Butterworth (1979) suggested that once patients "start up the production mechanism … it operates unchecked" (page 135).

In a model of speech production, Butterworth (1980, 1992) proposed that "each level of the speech generation process requires a separate 'control module' comprising four functions: initiate, operate, check, and terminate" (as quoted in Robinson, 2013). This approach has been used to explain repetitive speech in parkinsonism (Benke and Butterworth, 2001; Benke et al, 2000) and somewhat resembles accounts of subprocesses of executive function or control (for a recent review, see Stuss, 2011). The volitional aspect of speech generation, propositional speech, is the focus of our study.

In contrast to the vast quantity of speech characteristic of jargon aphasia, dynamic aphasia is severely reduced *voluntary* propositional speech (Costello and Warrington, 1989; Gold et al, 1997; Luria, 1966, 1970, 1973; Robinson et al, 2006). Investigations of patients with dynamic aphasia have led to the specification of some of the mechanisms in the message-generation stage of propositional language production. Levelt's (1989, 1999) model of spoken language attempts to specify these mechanisms. His model proposes that the *conceptual*

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preparation stage is responsible for the voluntary generation of the conceptual structures for which words exist.

Several of our studies have shown that the left inferior frontal region plays a crucial role in the selection of conceptual propositions, while other bilateral frontal and frontostriatal areas play a crucial role in the generation of novel concepts and their subsequent sequencing (Robinson, 2013; Robinson et al, 1998, 2005, 2006, 2015b). Notably, propositions are new to a specific situation (ie, are novel) and are generated at will, in contrast to nominal language, which includes naming and repetition, and is more automatic and constant across contexts.

We can think of these findings in the context of Butterworth's suggestion that the conceptual preparation level of the speech generation process is a "control module" with the functions *initiate*, *operate*, *check*, and *terminate*. The generation of novel concepts could be a form of the *initiate* function; sequencing of concepts, a form of the *operate* or *check* function; and selection of concepts, another *initiate* or *operate* function.

One approach to understanding jargon speech has focused on single-word error analysis, rather than the vast quantity of a person's speech. For example, Butterworth (1979) proposed that word finding difficulties lead to the production of neologistic fillers. He also proposed that perseveration of phonemes gives rise to neologisms and unintelligible speech. Nonword error analysis has suggested that phoneme frequency (Robson et al, 2003) and phoneme perseveration (Eaton et al, 2010; Moses et al, 2004) are important factors in the generation of nonwords and inappropriate words. Real word error analysis has even revealed a reverse frequency effect in one patient (Marshall et al, 2001). Strikingly, phonological processes can largely be intact despite almost purely unintelligible phonemic jargon speech (Hanlon and Edmondson, 1996). These impairments are at the level of single-word production rather than at the message or conceptual generation level.

A second approach to understanding jargon speech assumes that patients' speech generation mechanisms are largely intact, but the mechanisms for controlling and monitoring speech output are impaired. The earliest observations focused on patients' lack of awareness (anosognosia) of their speech errors as a key contributor to jargon aphasia (Kinsbourne and Warrington, 1963; Panzeri et al, 1987). However, some individuals with jargon aphasia show partial awareness that they are making speech errors (Lebrun, 1987). Even if patients are aware of their speech errors, the rarity with which they try to self-correct before speaking has been interpreted as a monitoring deficit (Hanlon and Edmondson, 1996; Sampson and Faroqi-Shah, 2011).

In this study we describe the voluminous propositional speech of J.A., a patient with jargon aphasia, and relate it to classic aphasia and other propositional speech deficits, particularly dynamic aphasia. We report J.A.'s residual core language skills and poorly constrained generative language. We consider possible explanations for jargon aphasia at the level of lexical deficits and voluntary conceptual preparation for speech generation. We suggest that this case opens the possibility of characterizing another control mechanism at the early message-generation stage of spoken language.

CASE REPORT

J.A. is a 71-year-old retired court usher living in London, United Kingdom. He was born left-handed but was trained at school to write with his right hand and became predominantly right-handed for all activities (Edinburgh Handedness Inventory; Oldfield, 1971). After undergoing surgery for a cerebral aneurysm, he came to us because of marked expressive dysphasia with fluent jargon.

J.A.'s first signs of illness were two transient seizures 6 weeks before his surgery. He had the first seizure after finishing his lunch. He suddenly slid down in his chair and looked as if he were gasping for breath. The seizure lasted for a few minutes. He reported that during the seizure his thoughts were out of control, but they returned to normal within a minute after the seizure ended. Later that day he had a recurrence of the same symptoms, plus foaming at the mouth for 5 minutes. Again, he recovered quickly.

He was evaluated at the National Hospital for Neurology and Neurosurgery, Queen Square, London. Brain imaging showed a right-sided mass and edema in the adjacent temporal and occipital lobes. A cerebral angiogram revealed a large 1.7-cm aneurysm at the right middle cerebral artery bifurcation. The lesion was reported to have a wide neck and to incorporate the M2 branches. The superior aspect of the lesion had a locule. The aneurysm was not thrombosed and there was no evidence of significant aneurysmal wall calcification.

J.A. underwent a craniotomy for clipping of the aneurysm. The neurosurgeon noted that under the right frontal lobe, the sylvian fissure was widened and the giant aneurysm was visible. The aneurysm had dissected and caused a 4.5-mm temporal lobe occlusion; the surgeon applied a temporary 10-mm clip to the bleed. Although the distal M2 branches were well delineated, the surgeon had some difficulty applying a temporary clip at this location because the clip slid onto the neck of the aneurysm. The surgeon applied a temporal lobe clip, opened the aneurysm, removed the thrombus, and finally applied two permanent clips.

On the first day after surgery (Day 1), J.A.'s Glasgow Coma Score was 12 and he was noted to have left-sided visual inattention. He was started on intravenous phenytoin because of confusion that was thought to represent a subcortical seizure. A computed tomogram showed a small subdural hematoma with a mild midline shift. By Day 4, J.A.'s Glasgow Coma Score was 14.

On Day 15 he showed a marked expressive dysphasia with fluent jargon. A follow-up computed tomogram on Day 18 showed a right-sided subdural hematoma with hypodensities, involving predominantly the white matter but also the gray matter throughout the right middle cerebral artery territory, including the deep white matter structures (Figure 1). At this time, the patient had a neurologic and neuropsychological examination that was normal apart from showing the cognitive impairments described below.

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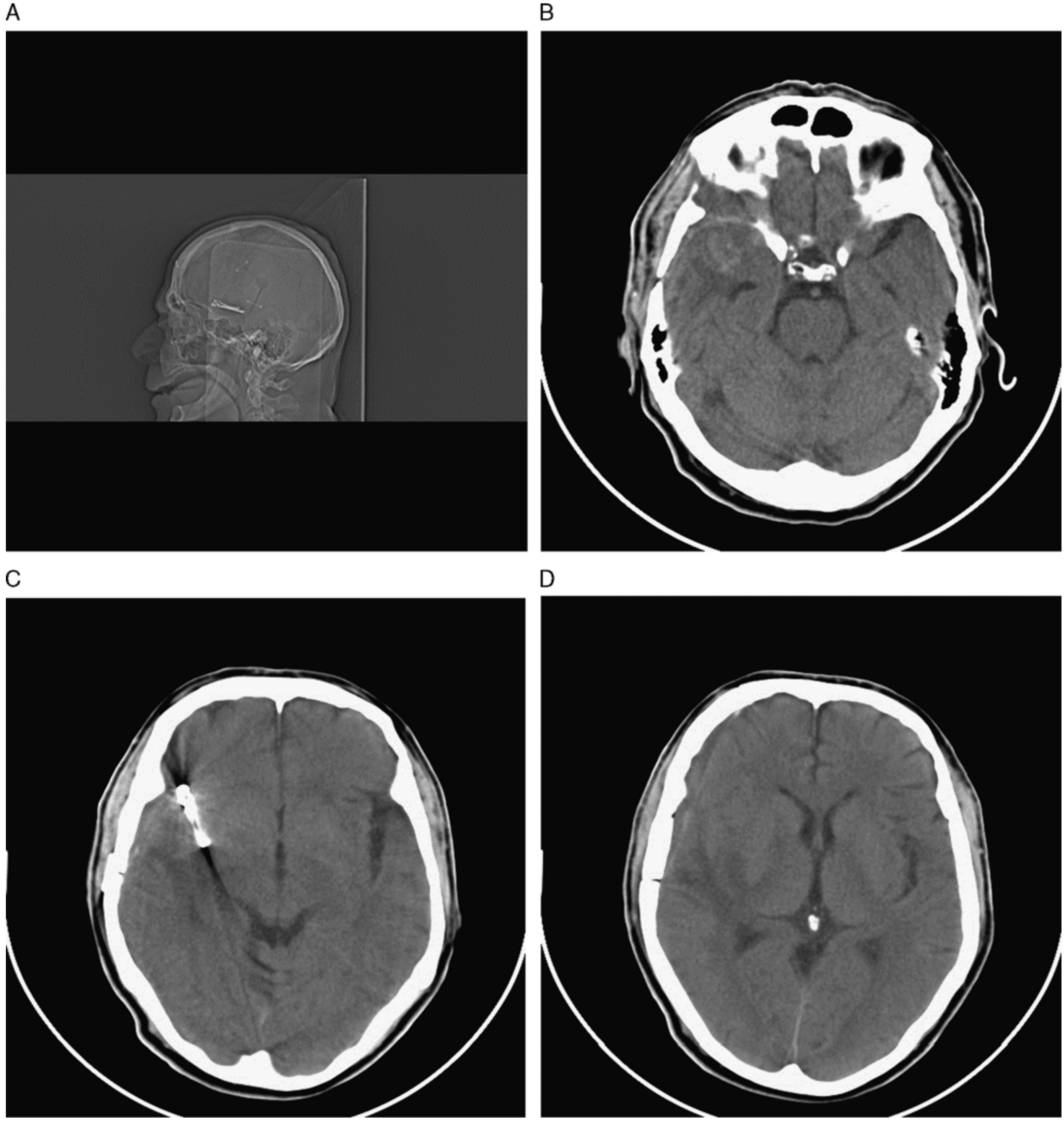

FIGURE 1. Patient J.A.'s computed tomogram of the head on postsurgical Day 18. Panel A: Localizer image. Panels B–D: Axial images in sequential order from inferior (B) to superior (D) show clipping of the aneurysm in his right middle cerebral artery.

COGNITIVE ASSESSMENT

Author G.A.R., a senior neuropsychologist, gave J.A. a cognitive assessment during postsurgical Week 3. By this time he had been moved to the National Hospital's post-acute rehabilitation ward, where he could be tested in the Department of Neuropsychology. We conducted experimental tests during Weeks 5 and 6. J.A. and his medical team gave consent to participate in both assessments. The study was approved by the National Hospital for Neurology and Neurosurgery and the Institute of Neurology Joint Research Ethics Committee, University College London Hospitals NHS Trust.

Cognitive Baseline Tests

The cognitive baseline tests measured J.A.'s nonverbal intelligence, visual memory, visual perception, and executive function. His low average performance on the Coloured Progressive Matrices test (Raven, 1976) (19/36,

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10th to 25th percentile) suggested mild intellectual decline from his optimal premorbid function, which we estimated to be within the average range given his education and occupation. His performance on visual recognition memory tests was mildly impaired (Warrington, 1984, 1996) (Faces 19/25, 10th percentile; Pictorial 29/30, > 10th percentile). His visual perceptual skills were normal (Incomplete Letters Test; Warrington and James, 1991) (18/20, > 5% cut-off).

Apart from a good ability to copy Luria's graphomotor sequence, J.A. did poorly on tasks sensitive to executive dysfunction. Thus, he showed impairment on a Go-No Go task (Luria's rhythm tapping) and Luria's bimanual alternating hand sequence task (Lezak et al, 2004; Luria, 1973). His word fluency was severely reduced for both phonemic and semantic tasks (< 1st percentile on the Controlled Oral Word Association Test; < 10th percentile for animals) (Spreen and Strauss, 1998). We note that J.A.'s reduced word fluency may be explained by the language disturbance detailed below. In sum, J.A. had well-preserved visual perception but significant frontal executive difficulties (including inhibitory failure) and mild impairments in nonverbal intellectual and visual memory.

Language Baseline Tests

Language baseline tests measured J.A.'s speech production (repetition of digits, letters, words, and sentences), phonological perception, naming ability, comprehension, reading and writing, phonemic and semantic word fluency, and spontaneous speech (complex scene descriptions). His language baseline scores are listed in Table 1 and described below.

Repetition

J.A.'s speech repetition skills were severely impaired for all tests: single digits, letters, words, and sentences (Cipolotti, 2000; McCarthy and Warrington, 1984). His single-word repetition errors were phonological (eg, skirt → *scanty*), semantic (eg, England → *Australia*), and perseverative (eg, green → *Ireland*, several trials after Ireland had been presented; then, two items later, gray → *green)*. When repeating sentences, J.A. tended to produce plausible grammatical structures but with semantic jargon (eg, He mended the plug → *The Maynard, the Maynard was the paper*; Deaf as a post → *Doth dove of a stroke*).

Phonological Processing

Although J.A. required extra practice items to grasp the task demands, his phoneme discrimination was almost flawless (Psycholinguistic Assessments of Language Processing in Aphasia; Kay et al, 1992). His high score indicates that his speech perception skills were intact and did not contribute to his repetition or output difficulties.

Oral Naming

J.A.'s picture naming skills were impaired and he rarely confined his responses to the target name (Oldfield Picture Naming Test; Oldfield and Wingfield, 1965). For examples of the types of errors that J.A. made, see Figure 2. He made phonological and semantic paraphasias (Figure 2A), circumlocutions (Figure 2B), and responses containing stories with only a vague semantic relationship to the target (Figure 2C).

Word Comprehension

J.A.'s word comprehension skills were mixed. His performance on the Pyramids and Palm Trees Test (Howard and Patterson, 1992) was intact for the versions with pictures and written words, but just below the cut-off for the version with spoken words. He did poorly on the short version of the British Picture Vocabulary Scale (Dunn et al, 1982) and at almost chance level for low-frequency items on the Word Synonyms Test (Warrington et al, 1998). His weak performance on the synonyms test may reflect word comprehension difficulty for low-frequency items.

His sentence comprehension skills were impaired (Test for the Reception of Grammar; Bishop, 1983).

Reading and Writing

J.A.'s spoken reading ability was poor for single high-frequency words (Schonell Graded Word Reading Test; Schonell, 1942). He read passages slowly and inaccurately, despite relatively preserved sentence structure. For example, we asked him to read aloud: "Good morning, brother," said Tom, "have you any message for the King of the Golden River?" J.A. said (underlined words are obvious errors or jargon), "*Good morning fortune*" *said Tom,* "*have you any letters for the let of the log not the garden*."

His ability to write sentences to dictation was impaired. In general, he retained sentence structure, but with perseveration and paragraphias (eg, Down in the dumps → *Down of the dumbed;* He taught French → *Far down Frenck*). When asked to write a spontaneous story, he used good sentence structure but the content was semantic jargon with occasional neologisms (eg, "*The possibles are anymore Mrs Mascowe. I come sown until come coming to when to year 45 years to a come people. So it sit glease misplart. John was to care darkly*").

Word Fluency

J.A. was severely impaired on phonemic fluency tasks on F, A, and S, as well as semantic fluency tasks for animals, foods, countries, and politicians (Spreen and Strauss, 1998). To compare his word quantity and errors across the phonemic and semantic tasks, we devised a semantic "composite" made up of three categories (food, countries, and politicians), similar to the phonemic task that contains three conditions (F, A, and S). Table 1 shows J.A.'s scores for the semantic "composite" and the standard category of animals, in addition to the phonemic task. We scored words as correct if they were appropriate to the task rule (eg, *sugar* for "S" and *cat* for "animals"), regardless of whether the word was part of a phrase or sentence that was inappropriate to the task (eg, the *cat* that was black).

Overall, for all seven 1-minute word fluency tasks, J.A. produced only 23 appropriate words. Moreover, he

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TABLE 1. Patient J.A.'s Language Baseline Scores

	Score
Repetition[1]	
Single digits	4/10
Single letters	1/10
Single high-frequency 1- or 2-syllable words	11/30
Sentences	1/20
Phonological processing	
Phoneme discrimination[2]	69/72
Oral naming	
Oldfield Picture Naming Test[3]	10/30
Comprehension	
Single digits: spoken-to-written digit matching[4]	9/10
Single letters: spoken-to-written letter matching[4]	5/15
Single words:	
Pyramids and Palm Trees Test:[5]	
3 pictures	49/52 (> cut-off)
1 written word, 2 pictures	48/52 (= cut-off)
1 spoken word, 2 pictures	46/52 (impaired < cut-off)
Short British Picture Vocabulary Scale[6]	22/32 (< 5th percentile)
Word Synonyms Test[7]	29/50 (< 5th percentile)
Sentences: Test for the Reception of Grammar[8]	Impaired
Reading	
Single words[9]	1/20
Text[1]	Poor
Writing to dictation	
Sentences[1]	0/20
Word fluency	
Phonemic: FAS total correct[10]	6 (<1st percentile)
Unrelated words	30
Semantically related words	6
Nonwords	5
Perseverations	4
Semantic:	
Animals total correct[10]	6 (<10th percentile)
Unrelated words	22
Semantically related words	3
Nonwords	2
Perseverations	4
Composite (3 categories) total correct	11
Unrelated words	39
Semantically related words	27
Nonwords	3
Perseverations	0

[1]Cipolotti, 2000; McCarthy and Warrington, 1984. [2]Kay et al, 1992. [3]Oldfield and Wingfield, 1965. [4]Bevan et al, 2003. [5]Howard and Patterson, 1992. [6]Dunn et al, 1982. [7]Warrington et al, 1998. [8]Bishop, 1983. [9]Schonell, 1942. [10]Spreen and Strauss, 1998.

produced a much higher number of incorrect words: 91 words unrelated to the task (eg, *who's the greatest in world* for "animals"), 36 words related to the task (eg, *green grocer* for "food"), ten nonwords, and eight perseverations (for task-specific details, see Table 1). He produced equally high numbers of unrelated words on the phonemic and semantic tasks. By contrast, and perhaps unsurprisingly, he generated the most semantically related words for the semantic tasks, with few nonwords and perseverations.

Spontaneous Speech

J.A.'s spontaneous speech was marked by semantic jargon, neologisms, occasional paraphasias, and marked pressure of speech. He initiated conversation constantly and easily; he often required prompting to stop speaking.

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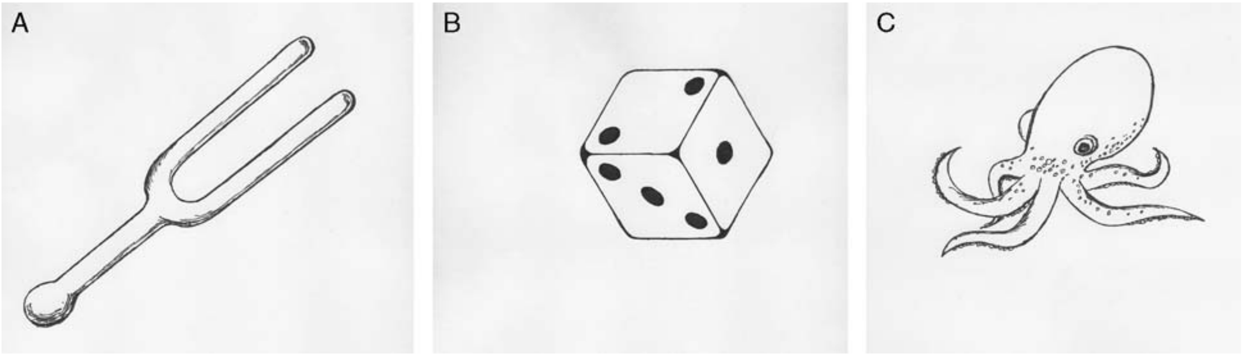

FIGURE 2. Examples of J.A.'s picture naming errors.
Panel A: When shown a picture of a tuning fork, he responded with phonological and semantic paraphasias: "*Tang fu isn't it they go boing boing boing*."
Panel B: He responded to a picture of a die with circumlocutions: "*Yes the wage I never own it so I have seen people cheat I've seen it in James Bond films throw*."
Panel C: He responded to a picture of an octopus with a story that bore only a vague semantic relationship to the stimulus: "*Sea the sea it's funny it's stupid you see I can remember some things here what is this bloody rubbish what good is that well the first thing I see is Edward Ryan and law two of them on the skin down there he came up with a very long neck the woman on the—it is scientific these things … I think Edward G. Robinson and Edward G. Robinson fruiting to this care field what's on this stuff and she was hanging on this stuff and she grabbed it*."
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However, the content of his spontaneous speech was rarely relevant to the context or our questions. We could not elicit automatic speech from a verbal command, but he spontaneously counted from 1 to 10 and recited the alphabet.

We elicited his spontaneous speech by asking him to describe two complex scenes: "Beach" (Warrington, 1989) and "Cookie Theft" (Goodglass and Kaplan, 1972; for a discussion of spontaneous speech measures, see Law et al, 2015). We showed each scene to J.A. for 1 minute and asked him to "describe everything you see going on in the picture." His descriptions of both scenes were fluent, with good sentence structure; however, they contained occasional neologisms, relatively few content words, and semantic paraphasias. For example, his description of the Cookie Theft scene (each word shown in brackets is our best guess at his intended word): "*He is saying* [doing?] *things that are dangerous especially with the couch* [stool?] *like that. He is going to stand on it and it is going to come to the kimme line* [kitchen?] *and she over there does not call. I know what it is all about she does not talk* [walk?] *on it all they do is the step over something and we will be interested in something the chair and something we imaging might fall about* [down?]."

We used the Quantitative Production Analysis method (Berndt et al, 2000) on a 2-minute spontaneous speech sample from J.A. This let us compare his speech production with that previously reported for patients with dynamic aphasia (Bormann et al, 2008; Crescentini et al, 2008; Raymer et al, 2002; Robinson et al, 1998, 2005, 2006, 2015b) and the sample of patients with nonfluent aphasia and healthy controls reported by Berndt and colleagues (2000). As shown in Table 2, J.A. differed from the other groups most strikingly in his speech rate, which was even faster than the controls. His overall proportion of verbs and closed class words was similar to the controls and the patients with dynamic aphasia.

In summary, J.A. spoke a vast quantity of meaningless "semantic" jargon with occasional neologisms and phonological paraphasias, in the context of reading and naming deficits and severe repetition but relatively good comprehension of high-frequency words. In terms of classical aphasiology, J.A.'s disorder falls somewhere

TABLE 2. Spontaneous Quantitative Speech Production in Patients with Different Types of Aphasia

	Jargon Aphasia (Patient J.A.)	Dynamic Aphasia[1] (n = 7)	Nonfluent Aphasia[3] (n = 29)	Healthy Controls[3] (n = 12)
Speech rate (words/minute)	196.0	23.4 (8.0)[1]	39.0 ± 19.6	160.8 ± 37.0
Proportion of verbs	0.46	0.41 (0.03)[2]	0.37 ± 0.10	0.48 ± 0.06
Proportion of closed class words	0.54	0.43 (0.18)[2]	0.41 ± 0.11	0.54 ± 0.04

[1]Patients reported by Bormann et al, 2008; Crescentini et al, 2008; Raymer et al, 2002; Robinson, 2013; Robinson et al, 1998, 2005, 2006. [2]Patients reported by Robinson et al, 1998, 2005, 2006. [3]Controls reported by Berndt et al, 2000.

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between a mild Wernicke aphasia and a conduction aphasia.

Two weeks after our clinical assessment, during postsurgical Weeks 5 and 6, we conducted experimental tests to learn more about two aspects of J.A.'s language:

- His residual language skills and relatively preserved comprehension
- His propositional language-generation impairment characterized by the large amount of meaningless output

METHODS: EXPERIMENTAL INVESTIGATION

Semantic Processing: Repetition, Reading Aloud, Oral and Written Naming, and Word Comprehension

Because J.A.'s language impairment was so severe, we studied his repetition, reading aloud, naming, and comprehension skills using a set of very common, high-frequency words in the A (≥ 50 but < 100 occurrences/million words) and AA (≥ 100/million) categories (Thorndike and Lorge, 1944) (for further details, see our earlier studies Bevan et al, 2003; Cipolotti, 2000; and Robinson and Cipolotti, 2001). The stimuli were 50 color pictures, ten each from five categories: maps, body parts, colors, animals, and objects.

In the repetition task, we spoke each target word aloud and asked J.A. to repeat it. In the reading aloud task, we showed him the target words, each printed in large letters on a separate card, and asked him to read them aloud. In the oral and written naming tasks, we showed him each picture separately and asked him to speak or write the name of the item in the picture.

To assess his word comprehension skills, we gave him two tasks: spoken word-picture matching and written word-picture matching. For both tasks we showed him the pictures in arrays of five from the same category, and either spoke the name of the target item or showed it in large print on a separate card. We asked him to point to the picture that matched the word.

He had no time limits for any of these tasks. We scored his responses as correct or incorrect.

Conceptual Proposition Generation: Word and Sentence Generation

We gave J.A. word and sentence-generation tests that we had previously designed specifically to study the selection mechanism in propositional language generation. We had given these tests to patients with dynamic aphasia and to controls (for more details, see Robinson, 2006, 2013; Robinson et al, 1998, 2005, 2006, 2015b). To facilitate comparison with J.A., we include the results from those patients and controls in this report.

For all of our word and sentence-generation testing in our earlier studies, as well as the tests that we gave to J.A., we recorded the number correct and the response time, measured with a stopwatch. Because we were focusing on message generation rather than single-word retrieval or syntax, we defined the number correct with reference to generation ability. Thus, we scored any verbal response (word or sentence) as correct, regardless of syntax and meaning, but we also noted the content. We defined response time as the time from the end of stimulus presentation to the time J.A. started to generate a response.

Sentence Generation from a Single Word

We spoke a single word to J.A. and asked him to produce a whole sentence containing that word. Of the 45 words, 15 were proper nouns and 30 were common nouns. Because a proper noun has only one or a few referents, it should activate a dominant ("prepotent") conceptual proposition (eg, *Gandhi* would likely prompt "Gandhi was an Indian pacifist"). By contrast, a common noun has many referents and thus should activate many conceptual propositions that would compete with each other for selection (eg, *glass* might prompt "I drink water from a glass," "We have stained glass in the hall," and "The glass shattered in the storm") (for details of stimulus construction, see Robinson et al, 2010). We presented the stimuli to J.A. in random order.

Sentence Generation from a Pair of Words

We spoke a pair of words to J.A. and asked him to say a complete sentence that incorporated both words. Of the 30 word pairs, 15 were high in association (eg, spider-web) and 15 were low-association (eg, spider-dog). We classified the pairs as high or low in association based on the Free Associative Norms (Riegal, 1965). Word pairs with high interword associations strongly activate a dominant conceptual proposition and weakly activate other propositions. Pairs with low interword associations activate many conceptual propositions that compete with each other for selection. We presented the stimuli to J.A. in random order.

Generation of a Single Word to Complete a Sentence

From the Bloom and Fischler (1980) completion norms, we selected 128 "sentence frames" with the final word omitted. The sentence frames that we chose were evenly divided, with 32 each of very high constraint, medium-high constraint, low constraint, and very low constraint.

The four levels of constraint were defined by the highest probability of a dominant response being produced. For example, we chose very high-constraint sentences to have only one or a few possible completion words, each with a very high probability of being the dominant word produced. Thus, few alternative completion words would compete for selection. A sample very high-constraint sentence: "Water and sunshine help plants ___." At the other extreme, we chose very low-constraint sentences to have many possible completion words so that many words would compete for selection and each word would have a very low probability of being produced. A sample very low-constraint sentence: "There was nothing wrong with the ___." (For further details, see Robinson et al, 2005.)

We spoke each sentence frame to J.A. and asked him to say one appropriate word to complete the sentence meaningfully. Our oral instructions emphasized that he was to produce "only one word," and we repeated this instruction

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throughout the task. We recorded the total number of sentences to which J.A. responded. We calculated the number of words that he generated for each sentence (no words, one word, one to nine words, ≥ ten words) and the total number of words generated for all 128 sentence frames. We also coded whether or not his responses were meaningful to the sentence frame, and we categorized every word he spoke as a content word (noun, verb, adjective), another word (eg, function word), or a neologism. We gave J.A. this task twice: during postsurgical Week 5 and 10 days later during Week 6. Both times we told him to say "only one word"; during the Week 6 retest, we also placed a written version of this instruction in front of him throughout the task.

For each of the word and sentence-generation tasks, the critical comparison was between stimulus types, comparing performance for each patient on high- and low-constraint items using the nonparametric chi-square test of independence (significant results, $P < 0.05$). Thus, we compared high-constraint stimuli (which place no or minimal demands on selection) to low-constraint stimuli (which place considerable demands on selection): proper nouns versus common nouns, high-association word pairs versus low-association word pairs, and very high/high-constraint sentence frames versus low/very low-constraint sentence frames.

RESULTS: EXPERIMENTAL INVESTIGATION

Language Processing of High-Frequency Items: Repetition, Reading Aloud, Oral and Written Naming, and Word Comprehension

J.A. showed profound impairment on the reading aloud and written naming tasks for the 50 high-frequency stimuli, and less severe impairment on the repetition and oral naming tasks (Table 3). By contrast, his scores on the two comprehension tasks showed virtually intact function, and he was flawless on the task of written rather than spoken words. These results confirmed relative preservation of J.A.'s word comprehension despite his rather widespread aphasia. We saw no effects of category: When we combined the six transcoding tasks, the percentage of correct responses fell within a narrow range: countries = 53%, body parts = 52%, colors = 52%, animals = 58%, and objects = 48%.

We categorized J.A.'s errors on these tasks as shown in Table 3: phonological errors (words and neologisms); orthographic errors, all of which were neologisms (eg, *narse* for neck); semantic errors that were concrete substitutions (eg, *horse* for cow) or associations (eg, *read* for lips); perseverations of words or neologisms; other unspecified errors (eg, *hollowy* for pig); and no responses. The majority of J.A.'s errors were semantic for oral output tasks and neologisms for reading and written naming tasks.

Conceptual Proposition Generation: Word and Sentence Generation

Sentence Generation from a Single Word

J.A. was able to generate a response for almost every stimulus, and he performed equally well for all stimulus types (chi-square test, $P > 0.05$) (Table 4). His response times were fairly prompt in relation to the controls (Robinson, 2006). J.A.'s mean response time for proper nouns = 2.6 seconds, standard deviation = 1.2; and for common nouns = 3.7 seconds, standard deviation = 3.6.

TABLE 3. J.A.'s Performance on Transcoding of High-Frequency Single Items

			Naming		Comprehension	
	Repetition	Reading Aloud	Oral	Written	Spoken Word-Picture	Written Word-Picture
Correct responses on 50 trials (%)	32 (64%)	2 (4%)	25 (50%)	9 (18%)	40 (80%)	50 (100%)
Error types						
Phonological:						
Word	1	0	4	0	0	0
Neologism	2	0	3	0	0	0
Orthographic:						
Neologism	NA	4	NA	27	NA	0
Semantic:						
Substitution	4	0	12	5	10*	0
Association	8	0	2	0	0	0
Perseveration:						
Word	1	11	10	2	[5]*	0
Neologism	0	33	0	4	0	0
Other	2	0	2	0	0	0
No response	0	0	1	3	0	0

*J.A. made 10 semantic errors, of which 5 were also perseverations because his response was correct for the previous item.
NA = not applicable.

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TABLE 4. Sentence Generation Tasks: Percentage Correct for Patient J.A., 4 Patients with Dynamic Aphasia, and 35 Controls

	Jargon Aphasia	Dynamic Aphasia				
	J.A.	A.N.G.[1]	C.H.[2]	M.C.[3]	K.A.S.[4]	Controls[5]
Generation of a sentence from a:						
Single word						
Proper noun	100	93	73	94	100	99.8
Common noun	97	39	33	60	93	99.6
Word pair						
High association	100	73	NT	93	100	99.6
Low association	100	13	NT	73	100	99.3
Generation of a single word to complete a sentence:						
Total	100*	72	73	83	97	98.3
Very high constraint	100	NT	92	98	87	99.4
Medium-high constraint	100	NT	79	NT	100	NT
Low constraint	100	NT	69	NT	100	NT
Very low constraint	100	NT	53	60	100	97.3

*J.A. scored 100% both times he was tested. Rather than the requested one word/response, however, he gave a mean of 9.7 words, few of them meaningful.

[1]Robinson et al, 1998. [2]Robinson et al, 2005. [3]Robinson, 2013. [4]Robinson et al, 2006. [5]Robinson, 2006.

NT = not tested.

By comparison, the controls' mean response time for proper nouns = 2.4 seconds, standard deviation = 1.7; and for common nouns = 2.6 seconds, standard deviation = 1.6.

In sharp contrast to the patients with dynamic aphasia, all of the sentences that J.A. generated were at best only partly meaningful, and all were longer than ten words. In fact, for many sentences we had to interrupt J.A. to stop his flow of words. Vastly different was patient K.A.S. with dynamic aphasia, who had a mean sentence length of 5.2 words for proper nouns and 5.5 words for common nouns (Robinson et al, 2006).

Sentence Generation from a Word Pair

J.A. was able to respond for all word pairs regardless of stimulus type (chi-square test, $P > 0.05$) (Table 4). However, most of his responses were either meaningless or only tangentially related to the word pair, and he omitted one or both target words for 40% of the high-association and 30% of the low-association pairs. For example, for the low-association pair "spider-dog," J.A. responded, "*The spider was cruel the spider was crawled up greenhouse place*."

His mean response time was 5.1 seconds (standard deviation = 3.7) for high-association word pairs and 7.9 seconds (standard deviation = 5.1) for low-association word pairs. For comparison, the controls in Robinson (2006) had mean response times of 2.6 seconds (standard deviation = 1.8) for high-association word pairs and 3.9 seconds (standard deviation = 2.7) for low-association word pairs. Again, J.A. generated sentences longer than ten words for 67% of the word pairs; by contrast, patient K.A.S. with dynamic aphasia averaged 8.3 words (Robinson et al, 2006).

Generation of a Single Word to Complete a Sentence

J.A. generated a response for every sentence frame both times we tested him, regardless of constraint level (chi-square test, $P > 0.05$) (Table 4).

Week 5. The first time he was tested, J.A. produced more than one word to complete 90% of his sentences. In fact, he was able to limit himself to a single word for only 15 of the 128 sentences. By contrast, taking the four patients with dynamic aphasia collectively, if they completed a sentence at all it was almost always with a single word (Table 5). Thus, at 9.7 words per sentence, J.A.'s mean response length was ten times the mean response length of the patients with dynamic aphasia.

Because the instructions specifically required J.A. to say a single meaningful word to complete each sentence, the majority of his responses were technically incorrect. For example, in response to the sentence frame "They went to the rear of the long ___," J.A. said, "*There was a team lingled place and you said what is this place now what is this place now then she was voting and you were voting things like this singular, this and that, that and that is popular that is missing that is what we do she was too singular and Angela said to me hmm look at those two they were there too last to do studying one and I said now loving in the sun I said is that compare oh we writing that lion is writing that lorry was writing that*." This response ended only when the examiner called a halt.

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TABLE 5. Task to Generate a Single Word to Complete a Sentence: Quality of Content Generated by Patient J.A. and Four Patients with Dynamic Aphasia

	Jargon Aphasia J.A.		Dynamic Aphasia			
	Week 5	Week 6	A.N.G.[1]	C.H.[2]	M.C.[3]	K.A.S.[4]
% of sentences for which the patient generated a response	100	100	72	73	83	97
% distribution of number of words generated for each sentence						
No response	0	0	27.5	25.0	50.0	0
1 word	11.7	53.9	71.4	73.4	50.0	96.7
2-9 words	32.8	46.1	1.1	1.6	0	3.3
≥ 10 words	55.5	0	0	0	0	0
Total number of words generated for all sentences						
Words per sentence	9.68	2.14	0.76	0.51	0.92	1.03
Meaningful response						
Yes	11.7	40.7	100	96.4	94.6	100
No	88.3	59.3	0	3.6	5.4	0
Word type						
Content word	35.1	62.5	100	100	100	100
Other word	55.4	25.5	0	0	0	0
Neologism	9.5	12.0	0	0	0	0

[1]Robinson et al, 1998. [2]Robinson et al, 2005. [3]Robinson, 2013. [4]Robinson et al, 2006.

The content of J.A.'s responses was of poor quality (Table 5). Although 90% of the words he used were real (the other 10% being neologisms), only 11.7% were meaningful to the sentence context. By contrast, the patients with dynamic aphasia responded entirely with content words (ie, no neologisms or other word types) and, apart from a few times that patient C.H. repeated a word in the sentence frame or produced two words, their responses were all meaningful to the context.

J.A.'s comments during this task made clear that he was aware of saying too many words. For example, one time when he was instructed to respond with "only one word," he said, "*You said it you see, that is why I said to you, you have got to keep it a few things something you got to keep that there is a few thousand, thousand, thousand so in other words my mind is doing it, it is doing it all*." Later in the same task, he said, "*I cannot do it, six or seven in one go, can I, you are talking about that compulsion again*."

Week 6. When we repeated the task 10 days later, J.A.'s performance improved significantly. He was able to limit his responses to a single word for about half of the sentence frames ($\chi^2_1 = 40.4$, $P < 0.001$) (Table 5). For the other half, his responses contained two to nine words. None exceeded ten words. He also improved his meaningful responses from 12% to 41%, and they contained a higher percentage of content words than other word types. This improvement may have been natural recovery; our testing strategy and reminders to him to limit his responses to "only one word" may also have increased his monitoring and led to some self-correction.

DISCUSSION

Our patient with jargon aphasia exhibited marked pressure of speech, resulting in a vast quantity of meaningless, uninterpretable speech. Like previously reported patients with jargon speech, J.A. had deficits in repetition, naming, reading, writing, and sentence comprehension (Eaton et al, 2010; Kinsbourne and Warrington, 1963; Sampson and Faroqi-Shah, 2011). His single-word comprehension skills were relatively preserved. We focused our investigation on J.A.'s vast quantity of seemingly *involuntary* speech. This phenomenon, first observed by Alajouanine (1956), has received little attention in patients with jargon aphasia.

Previous interpretations of jargon aphasia have suggested that word retrieval difficulties or perseveration may lead to the production of neologisms (Butterworth, 1979; Eaton et al, 2010; Moses et al, 2004). J.A. produced very few neologisms except when he read aloud, and his perseverations consisted mainly of real words (Tables 3 and 5).

Other studies have suggested that jargon aphasia may arise from a monitoring failure that manifests in a lack of awareness of speech errors and a failure to try to correct them (Marshall, 2006; Marshall et al, 1998; Moses et al, 2004). J.A. showed at least partial awareness of the inappropriateness of his speech. Again, during a single-word

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generation task, he commented that "*there is a few thousand…so in other words my mind is doing it… all…six or seven in one go*." Similarly, during the "animal" word fluency task, after he had said several inappropriate words, including a neologism, he commented, "*What a load of rubbish J.A.*" Strikingly, despite these expressions of self-awareness he could not reduce his vast quantity of inappropriate speech in the task. Only in one instance, when trying to say "bagpipes," did he self-correct (*bappipes*→ *bagpipes*).

We also note that on the task to say a single word to complete a sentence, J.A. improved from Week 5 to Week 6. Again, we can only speculate on whether the improvement came simply from general spontaneous recovery or from his greater awareness helping him to monitor himself better. Overall, nominal, perseverative, and monitoring difficulties play a role in jargon aphasia; however, they cannot account easily for the large volume of inappropriate speech.

Research on jargon speech has given little attention to volume of propositional speech. Our formal quantitative analysis showed that J.A.'s speech rate was comparable to or faster than that of controls (Table 2), and he required prompting to stop talking. His abundant propositional speech contrasted sharply with the severely reduced propositional speech of patients with dynamic aphasia. These patients require prompting to initiate (and sustain) conversation, and their speech rate is profoundly slowed (Bormann et al, 2008; Crescentini et al, 2008; Raymer et al, 2002; Robinson, 2013; Robinson et al, 1998, 2005, 2006) (Table 2).

J.A.'s speech tended to be incomprehensible and only vaguely relevant to the context; almost without exception, the speech of patients with dynamic aphasia was meaningful to the context. J.A. was able to generate a verbal response from common nouns and word pairs that were low in association. He had slightly slower response times than controls, possibly indicating some effect of constraint level. Patients with dynamic aphasia and a selection deficit typically failed at word pairs with low association (Robinson, 2013; Robinson et al, 1998, 2005).

J.A. was also able to generate responses from very low-constraint sentences, another task typically failed by patients with dynamic aphasia and impaired selection. However, despite instruction to say single words on this task, J.A. produced many long sentences that were impossible to understand. Analysis of his spontaneous speech sample showed that he was similar to controls in both his quantity of words and proportion of content words. However, his specific combinations of words created meaningless content, characteristic of jargon speech. We note, however, that his pre-linguistic "message generation" mechanism was intact. In this he differed from the patients with dynamic aphasia, who had deficits in spontaneous speech and in the *generation* of novel thoughts (Robinson et al, 2006, 2015b).

The mechanisms that have been suggested for the conceptual preparation stage—generation, sequencing, and selection of novel concepts—were proposed to explain the markedly reduced propositional language of patients with dynamic aphasia. We hypothesized that an impairment in the mechanisms responsible for generating and sequencing novel concepts caused the dynamic aphasia of our patient K.A.S. (Robinson et al, 2006). Thus, K.A.S. was unable to generate potential messages that could be produced in conversation (for a recent example of problems with generation, see Robinson et al, 2015b). We found impairment to the selection mechanism to underlie the dynamic aphasia of our patients A.N.G. and C.H. (Robinson et al, 1998, 2005). Thus, A.N.G. and C.H. could speak when a dominant (prepotent) response was available and selection was not required, but they failed to speak when multiple competing messages were available. Recently, we found the dynamic aphasia of patient M.C. to be underpinned by deficits in all three mechanisms: generation of ideas, sequencing of ideas, and selection from among competing ideas (Robinson, 2013).

We cannot entirely rule out J.A. having a deficit in his ability to generate or select task-appropriate thoughts. Although the level of stimulus constraint that activated either a dominant response or multiple competing responses had minimal effect on J.A., his slightly longer response times to generate a sentence from stimuli that elicit multiple competing options (common nouns, low-association word pairs) suggest some influence of constraint level. Notably, though, in contrast to patients with dynamic aphasia, J.A. remained able to generate a sentence. We did not explicitly test his sequencing of ideas, but some deficit may be implicated in his occasional perseveration. However, we note that he did not perseverate when copying Luria's graphomotor sequence.

We propose a fourth mechanism as being crucial for the conceptual preparation stage of spoken language: the *termination processes*. This mechanism is part of the control systems for each of the levels in the sentence-generation process (Benke and Butterworth, 2001; Butterworth, 1980, 1992). In essence, this mechanism acts as a "brake" that stops or inhibits the generation of new messages (for a recent review and broader discussion of inhibition, see Aron et al, 2014). When operating normally, this mechanism would terminate the process of creating novel thoughts when a stream of relevant messages for the current focus has a natural end or when the situation demands a change or new topic of focus.

When this mechanism is damaged at the level of conceptual preparation, the speaker will have difficulty stopping new thoughts from being created, generated, and expressed as overt speech. Effects of damage may also be evident on specific word fluency tasks. Damage to this mechanism is unlike a failure to terminate at later stages of speech production; such a failure may manifest as perseveration of phonemes or single words. Recently, we (Robinson and Ceslis, 2014) reported the tangential and rhyming verbal output of a patient with probable dementia and prominent executive dysfunction; we attributed the patient's speech to a failure to terminate or inhibit verbal associations at the level of conceptual preparation for spoken language. This failure has some

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similarities to the jargon speech of J.A. We note that J.A. failed Luria's Go-No Go rhythm tapping task, indicating executive dysfunction and, specifically, loss of response inhibition.

An alternative to the termination processes explanation is the idea of semantic control (Jefferies, 2013). This theory suggests that efficient use of semantic memory requires an executive-semantic control system that governs task-based use of semantic concepts. Somewhat like the selection mechanism just discussed above, if the semantic control process were impaired, patients would show more jargon speech and uncontrolled output in low- rather than high-constraint tasks where some experimental constraint is applied. By contrast, a failure of a termination process would be evident in all self-generation tasks, regardless of high or low constraint and selection demands.

Upon closer scrutiny of J.A.'s long responses (> ten words) when he was supposed to say a single word to complete a sentence, we find that he gave long answers almost equally often for sentences with very high/high constraint and very low/low constraint. His similar performance for high- and low-constraint tasks supports the termination hypothesis rather than a specific semantic control hypothesis; however, further investigation should explicitly address these explanations.

The anatomic correlates of the mechanisms involved in generating and sequencing novel thoughts rely on the bilateral frontal and frontostriatal regions. The mechanism for selecting conceptual propositions from among competitors is supported by the left inferior frontal regions (Robinson et al, 1998, 2005). The fourth mechanism that we are proposing, termination processes, is also likely to be supported by frontal regions. A termination mechanism involves inhibition or a stop signal and online monitoring, processes usually thought to involve an "executive frontal" system and association with the right inferior frontal region broadly (Aron et al, 2014), and specifically for verbal suppression (Robinson et al, 2015a).

J.A. was naturally left-handed, he underwent neurosurgery for a right middle cerebral artery aneurysm, and he suffered right frontotemporal damage. This left him with executive difficulties, including an inhibition failure on a simple Go-No Go task. Based on the possibility that his aphasia was somewhere between a conduction and a Wernicke aphasia, we can speculate that his lesion included the posterior temporal lobe and/or the inferior parietal lobe, together with subcortical white matter, eg, the arcuate fasciculus (a suggestion from an anonymous peer reviewer). However, the lack of fine-grained imaging to localize J.A.'s lesion is a limitation of our case report, and the precise brain regions supporting termination processes will need further investigation.

In sum, pressure of speech in jargon aphasia can be viewed as a disorder of voluntary propositional language generation marked by a vast quantity of meaningless speech. We suggest that at least four mechanisms are involved in the early conceptual preparation stage for producing propositional speech at will. Deficits in the first three mechanisms have been observed in patients with dynamic aphasia, which is characterized by drastically reduced propositional speech. These patients have impaired ability to *generate* novel thoughts, to *sequence* novel thoughts, and to *select* among competing thoughts. Jargon aphasia is in stark contrast: Propositional speech flows quickly and continuously, and the failure is in stopping the generation of novel thoughts, that is, a failure in *termination processes*. Thus, jargon aphasia provides a source of evidence allowing us to address the crucial mechanisms involved in the conceptual preparation stage of propositional speech. Our study highlights that these mechanisms operate at the interface between language and executive function.

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