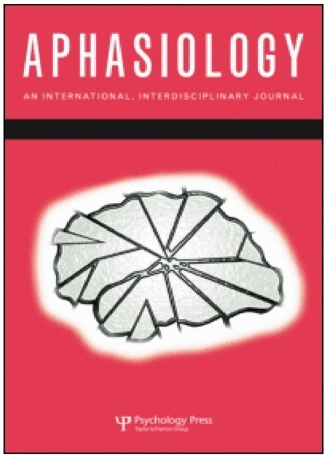

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The use of cueing to alleviate recurrent verbal perseverations: Evidence from transcortical sensory aphasia

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The use of cueing to alleviate recurrent verbal perseverations: Evidence from transcortical sensory aphasia

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Background: Previous studies have demonstrated that stimulus factors, including item frequency, presentation rate, stimulus repetition, and semantic relatedness, can influence the rate of recurrent verbal perseverations. These manipulations alter the balance of activation between current targets and past responses, suggesting that perseverations arise when the activation of a previously presented item overrides the weak processing of a new stimulus. By this view, cues and sentence contexts that bias inter-item competition towards the target and away from earlier responses should dramatically reduce the frequency of perseverative errors. However, the influence of these factors on perseverations has not been previously investigated.

Aims: To examine the effect on perseverative rate of altering the activational balance between past and present responses using both intrinsic and extrinsic stimulus manipulations.

Methods & Procedures: This study examined repetition, reading, and picture naming in a highly perseverative patient with transcortical sensory aphasia.

Outcomes & Results: The patient's strong perseverative tendencies were impervious to the stimulus factors listed above but he was able to overcome these errors to produce more correct responses when he was provided with phonemic, word, and sentence cues. These environmental constraints had a similar effect on perseverations in reading aloud and picture naming, although active repetition was necessary for a cue to benefit reading, whereas passively hearing the cue was sufficient to improve picture naming.

Conclusions: This task difference is likely to reflect the greater reliance of picture naming on semantic processing, which will benefit from cues regardless of whether they are repeated. We propose that poor internal control of language production allowed perseverations to dominate our patient's output. External constraints in the form of cues/sentence contexts overcame this deficit, dramatically reducing the rate of perseverations.

A perseveration is "the inappropriate repetition of a preceding behaviour when a new adapted response is expected" (Cohen & Dehaene, 1998, p. 1641). Sandson and Albert (1984) developed a classification system, which divides perseverations into stuck-in-set, continuous, and recurrent categories. Stuck-in-set perseverations occur due to the maintenance of a particular behavioural framework. Continuous perseverations are characterised by the uninterrupted repetition of an ongoing behaviour when it is no longer appropriate. Recurrent perseverations are distinct

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from other perseverative forms, as response repetition occurs after a period of cessation: for example, in picture naming, a previous response may be produced after several correct trials.

Aphasic patients show a particularly high incidence of recurrent perseverative errors in both spontaneous and provoked speech (e.g., Sandson & Albert, 1984). During three verbal tasks, 83% of Wernicke's, 50% of Broca's, and 38% of anomic aphasic patients made one or more perseverations (Shindler, Caplan, & Hier, 1984). Healthy participants also make an average of 4% perseverative responses in neuropsychological tasks (Ramage, Bayles, Helm-Estabrooks, & Cruz, 1999).

It is generally accepted that perseverations occur when the activation of a previous response exceeds that of the target, although this imbalance could be attributed to either the excessive activation of past productions (Yamadori, 1981) or weak activation of target items (Cohen & Dehaene, 1998). An imbalance caused by excessive activation of previously produced items could be due to either residual activation of these representations (Vitkovitch & Humphreys, 1991) or a failure of inhibitory processes that ordinarily decrease the likelihood of their reproduction (e.g., Campbell & Arbuthnott, 1996). An additional hypothesis proposes that persistent activation of previously produced responses is a normal phenomenon of word production as demonstrated, for example, by the intrusion of phonological fragments at the point in a sentence when the item is no longer required (Dell, Burger, & Svec, 1997). Rather, a failure to activate the target sufficiently causes it to become overridden by previously activated representations that are decaying normally (Cohen & Dehaene, 1998; see also Martin & Dell, 2004; Martin, Roach, Brecher, & Lowery, 1998). The likelihood of a perseverative response in picture naming is an exponentially decreasing function of the lag (number of intervening trials) since it was last produced, suggesting that perseverations can arise even when there is relatively normal decay of earlier responses (Cohen & Dehaene, 1998). At the neurobiological level, perseverations may result from an acetylcholine deficit, which makes cells less sensitive to new inputs and therefore more likely to continue processing old inputs (Gotts, Incisa della Roccetta, & Cipolotti, 2002). This view of perseveration successfully anticipates that perseverative rate will be influenced by stimulus manipulations that alter the activational balance between past and present responses. This has been achieved in previous studies by varying aspects of the target items themselves, such as: stimulus modality, speed of presentation, target frequency, semantic relatedness, and stimulus repetition (referred to as "intrinsic stimulus factors" below). Studies that have manipulated these factors can be summarised as follows:

- *Stimulus modality:* The incidence of perseveration varies across tasks: perseverations in some participants have been found to be more common in reading than repetition (Halpern, 1965) and are more frequent in picture naming and sentence completion than reading (Moses, Nickels, & Sheard, 2004; Santo Pietro & Ridrodsky, 1982). The likelihood of producing a perseverative error depends on how tightly the stimulus specifies the response. Picture naming is most vulnerable to error, as phonological output is achieved via semantics resulting in the activation of a number of semantically related items that compete with the target. In repetition and reading, the target phonology is more precisely specified by the spoken/written verbal input, reducing perseverative error (Moses et al., 2004).

- *Speed of presentation:* A speeded response schedule of less than 2 seconds has been shown to elicit perseverations in healthy participants in both reading and picture naming (Moses et al., 2004, see also Vitkovitch & Humphreys, 1991). Although these results are not generalisable to patients, short stimulus–response intervals have been found to increase perseverations in aphasia (Santo Pietro & Ridrodsky, 1982; but see Gotts et al., 2002). When the inter-stimulus interval is long, earlier responses have a longer period of decay and are therefore less likely to override the target item as perseverative errors. Conversely, speeded response schedules induce competition between the target and previous responses that remain highly activated.
- *Target frequency:* Perseverations are more common when the target frequency is low for both healthy participants (Vitkovitch & Humphreys, 1991) and aphasic patients (Gotts et al., 2002; Hirsh, 1998; but see Halpern, 1965). High-frequency targets reside at a higher baseline level of activation and are therefore less vulnerable to competition from previously generated responses.
- *Semantic relatedness:* Perseverations in healthy participants and aphasic patients are often semantically related to the target (e.g., Hirsh, 1998; Vitkovitch & Humphreys, 1991). In picture naming, semantically related items compete with the target response and if one of these competitors has been previously produced, a perseveration may occur. However, not every study has observed an effect of semantic relatedness on perseverative rate (Gotts et al., 2002; Moses et al. 2004; Papagno & Basso, 1996).
- *Stimulus repetition:* Perseverative rate increases when stimuli are repeated (Gotts et al., 2002). If an item is presented several times, its residual activity rests at a higher level, making it easier to respond to but also allowing it to override weakly activated targets.

In summary, stimulus manipulations that bias competition towards new targets and away from previous responses have been shown to decrease perseverative rate. If perseverations arise when irrelevant past responses override weakly activated targets as proposed by Cohen and Dehaene (1998), extrinsic environmental constraints such as cues and sentence contexts should also have a profound impact on the frequency of perseverations. There is a long tradition of using cueing to alleviate word-finding difficulties in semantically impaired aphasic patients (e.g., Best, Howard, Bruce, & Gatehouse, 1997; Howard, Patterson, Franklin, Orchard-Lisle, & Morton, 1985; Patterson, Purell, & Morton, 1983; Wambaugh, 2003) as well as the use of miscues to decrease accuracy (Lambon Ralph, Sage, & Roberts, 2000). However, despite numerous investigations of the effect of intrinsic stimulus factors on perseverative rate, the effect of specific extrinsic cueing and sentence constraints on perseverative errors in particular has been largely neglected in the literature. External constraints might allow severely aphasic patients to overcome their deficient processing of new inputs by boosting target activation, preventing past responses from dominating response output. The present study examined the effect of intrinsic stimulus manipulations (target frequency, stimulus repetition, presentation rate, and semantic relatedness) and extrinsic environmental constraints (phoneme, word, and sentence cues) on the rate of perseverations in a transcortical sensory aphasic patient, LS. The output of this patient was dominated by perseverations across tasks and stimuli. In such a highly perseverative case, intrinsic stimulus manipulations may fail to override the strong tendency to perseverate. However, extrinsic cues and contexts that boost the activation of the target so that it exceeds that of previous responses should markedly reduce the likelihood of perseveration. In addition, miscues and irrelevant sentence contexts might interfere with the balance between any residual processing and weakly activated targets, thus increasing the rate of perseverative errors. We made use of the excellent repetition and sentence completion abilities of patient LS to provide cues and sentence contexts that were congruent or incongruent with the target response.

LS's preserved repetition occurred in the context of fluent speech and extremely poor comprehension. This aphasia profile is known as transcortical sensory aphasia (TSA; Albert, Goodglass, Helm, Rubens, & Alexander, 1981; Alexander, Hiltbrunner, & Fischer, 1989; Goldstein, 1948). Reading and naming may also be impaired in TSA, although not necessarily in every case (see Heilman, Rothi, McFarling, & Rottman, 1981). TSA has often been explained in terms of a disconnection from Wernicke's phonological area to lexical-semantic processing centres (e.g., Boatman et al., 2000; Coslett, Roeltgen, Gonzalez Rothi, & Heilman, 1987; Heilman et al., 1981; Lichtheim, 1885). While this could underpin LS's poor *verbal* comprehension, he showed comparable deficits on non-verbal semantic tasks such as picture association tests and environmental sound–picture matching. We have proposed that LS's comprehension problems across modalities can be explained parsimoniously in terms of a failure of semantic control, concomitant with executive deficits (Jefferies & Lambon Ralph, 2006). This might result in the production of many perseverative responses (as well as other unrelated errors). By this view, LS's perseverative tendencies should vary according to the demand a task places on semantic control.

We compared perseveration in reading and picture naming using the same items. Few studies have directly compared these tasks in aphasia despite the potential of this comparison to uncover the underlying causes of perseverations. Moses et al. (2004) proposed that their healthy participants made more perseverations in picture naming than reading because output is more tightly specified by orthography in reading, while picture naming is more dependent on semantic memory, a source of response ambiguity—a hypothesis that has been strongly supported in the literature (e.g., Lambon Ralph, Cipolotti, & Patterson, 1999; Morton & Patterson, 1980; Potter & Faulconer, 1975). If patient LS perseverates on trials in which the input only weakly stimulates the target response, he should also show this disadvantage for naming over reading. In addition, we contrasted the active repetition of cue words with passive listening. Hearing cue words—giving rise to semantic processing without phonological output—might be sufficient to reduce LS's perseverations in a predominately semantic task like picture naming, whereas active repetition might be required to influence reading aloud, which is more independent of semantics.

CASE REPORT

LS, a 71-year-old male retired mechanic, had a CVA in March 2001. An MRI scan revealed extensive left hemisphere damage in frontal, occipital, and parietal cortex (see Figure 1). In spontaneous speech, LS was fluent but anomic. He had good repetition but poor naming and comprehension, indicating transcortical sensory aphasia (see Table 1). He was echolalic in conversation and markedly perseverative in a variety of tasks (see below and Appendices A, B, and C for example responses).

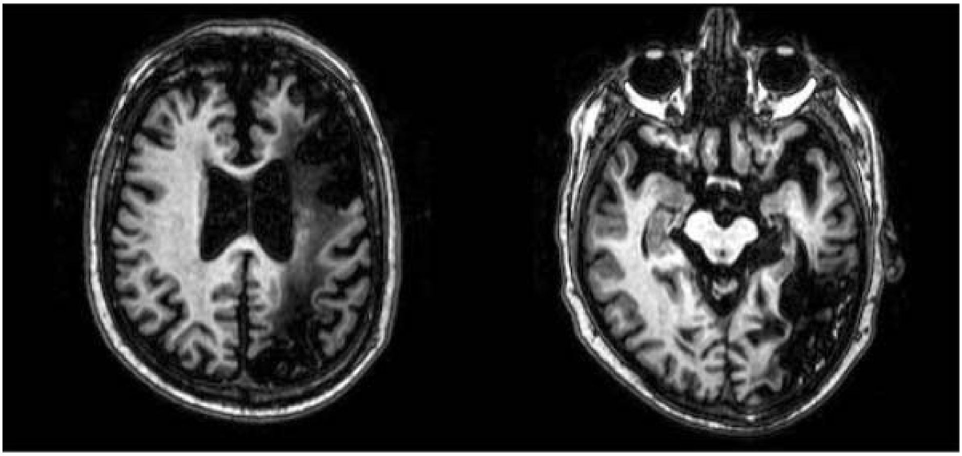

Figure 1. MR scan of LS's lesion affecting frontal, occipital, and parietal regions in the left hemisphere.

Background tests show that LS had particular difficulty with tasks tapping executive/attentional processes, suggesting that his general ability to self-monitor was poor (see Table 1).

The following investigations assessed the effect of intrinsic stimulus factors on accuracy and perseverative rate in repetition, picture naming, and reading aloud

TABLE 1
Background neuropsychological test scores

	Test	*Max*	*LS*
Fluency	BDAE fluency percentile		90
	Cookie theft (words per minute)		30*
Repetition	PALPA 8 non-word repetition	30	27
	PALPA 9 word repetition	80	77
Semantic	BDAE comprehension percentile		13*
	Pyramids and Palm Trees pictures	52	31*
	Pyramids and Palm Trees words	52	39*
	Word–picture matching	64	37*
	Category fluency (8 categories)		13*
	Letter fluency (letters F, A, S)		8*
Attention/executive	WCST (no. categories)	6	0*
	Raven's Coloured Progressive Matrices	36	16*
	Digit span forwards (max length)		4*
	Digit span backwards (max length)		1*
Visual/spatial (VOSP)	Screening	20	18
	Object decision	20	11*
	Position discrimination	20	16*
	Number location	10	8
	Cube analysis	10	4*

* denotes impaired performance. BDAE (Boston Diagnostic Aphasia Examination; Goodglass & Kaplan, 1983); PALPA (Psycholinguistic Assessments of Language Processing in Aphasia; Kay et al., 1992); Pyramids and Palm Trees Test (Howard & Patterson, 1992); WCST (Wisconsin Card Sorting Task; Milner, 1964; Stuss et al., 2000), Raven's Coloured Progressive Matrices (Raven, 1962), Digit span (Wechsler Memory Scale; Wechsler, 1987), VOSP (Visual Object and Space Perception Battery; Warrington & James, 1991).

tasks. Task type, frequency, and lag were investigated first, followed by stimulus repetition, presentation rate, and semantic relatedness. Subsequently, extrinsic cues and sentence contexts were used to increase the level of constraint applied to word production, both towards and away from the target response, to a degree beyond that possible via intrinsic stimulus manipulations. The analyses focussed on perseverative errors both for reasons of clarity and because they strongly dominate LS's errors (e.g., 52% of errors were perseverative in baseline reading, 49% in naming). In all analyses a perseveration was defined as the part or full repetition of a previous response either immediately or following several intervening trials. Production of a previously given cue word was also considered perseverative. The remaining errors were mostly whole words that were unrelated to the target (37% reading, 31% naming), with a very small number of additional omission, semantic, and phonological errors. In picture naming, for example, "kangaroo" was produced when given the picture of unrelated item pineapple, even though "kangaroo" had not been produced previously or given as a target stimulus (see Appendix A). The same unrelated errors were true of reading, where, for example, LS produced "brush" instead of target stool (see Appendix A). Non-perseverative error rates mirrored the fluctuations of correct responses across conditions and therefore will not be reported explicitly in the analyses.

INTRINSIC STIMULUS FACTORS: BASELINE TASKS, FREQUENCY EFFECTS, AND LAG ANALYSIS

Method

LS attempted to name 64 pictures from the Snodgrass and Vanderwart (1980) set, and to read aloud and repeat the same object names. In each trial of the repetition task, items were tested immediately after auditory presentation and again following a 10-second filled delay in which the patient counted aloud. Practice trials were administered before the test items in order to ensure that LS understood the "count and repeat" method. In all three tasks, the effect of target frequency was considered and lag analysis was used to assess the inter-trial interval between responses and their perseverations.

Results

Task comparison. As discussed in the Introduction, few studies have directly compared reading aloud and picture naming in aphasia, although comparisons in healthy participants have shown that picture naming is more vulnerable to perseverative responding under a speeded response deadline (Moses et al., 2004). The following analysis will compare immediate and delayed repetition with picture naming and reading aloud.

Accuracy was greatest for immediate repetition, poorer for delayed repetition (McNemar Exact $p = .001$), worse still for reading (reading vs delayed repetition, McNemar Exact $p = .001$) and lowest for picture naming (reading vs naming, McNemar Exact $p = .077$; see Table 2). Every task except immediate repetition showed a high perseverative rate. In delayed repetition, 94% of perseverations were previously presented stimuli (as opposed to previous incorrect responses). In picture naming this figure dropped significantly to 68%, $\chi^2(1) = 4.42$, $p = .04$. In addition,

TABLE 2
Accuracy and perseverative errors in different tasks

	Overall (N = 64)		*Low frequency (N = 20)*		*High frequency (N = 20)*	
Task	*Correct (%)*	*Perseveration (%)*	*Correct (%)*	*Perseveration (%)*	*Correct (%)*	*Perseveration (%)*
Immediate repetition	96	0	95	0	100	0
Delayed repetition	72	27	65	35	70	25
Reading aloud	22	38	20	15	40	45
Picture naming	8	39	5	25	15	35

Scores indicate percentage of trials.

reading elicited significantly fewer within-set perseverations (25% of perseverations) than naming, $\chi^2(1) = 9.09$, $p = .003$.

In naming, 16% of perseverations were semantically related to the target and 4% were phonologically related. In reading, 13% of perseverations were linked in meaning to the target and none was phonologically related. In delayed repetition, 11% were semantically related to the target response, while 0% of perseverations were phonologically related.

Target frequency. Accuracy and perseverative rate were assessed in a comparison of the 20 most and 20 least frequent items from the 64 set of items in picture naming and reading aloud tasks. Frequency data were taken from the Celex database (Baayen, Piepenbrock & van Rijn, 1993), high-frequency items ranged from 12.57 to 387.88 (mean = 58.2) while low-frequency ranged from 0 to 3.52 (mean = 1.63). In contrast to other patients in the literature, frequency did not affect accuracy in any of the tasks and we did not observe more perseverations for lower-frequency items (see Table 2). For delayed repetition, the influence of frequency and imageability was assessed using an additional 62 items. Neither of these variables affected perseverative rate (high/low frequency: 55% vs 48% of trials; high/low imageability: 58% vs 45% of trials).

Lag analysis. The lag (number of intervening trials) between responses and their perseverations never exceeded one in delayed repetition. Reading and naming had significantly longer lag ranges of 41 and 40 respectively (mean = 10 and 7.6; Mann Whitney $U = 27$, $p < .001$). Figure 2 shows that the number of perseverative errors decreased exponentially as lag increased for both reading and naming.

Stimulus repetition, presentation rate, and semantic relatedness

Method. Stimulus repetition, presentation rate, and semantic relatedness factors were manipulated in a cyclical picture-naming task (see Jefferies, Baker, Doran, & Lambon Ralph, 2007). Twelve blocks of 36 items from six categories were used:

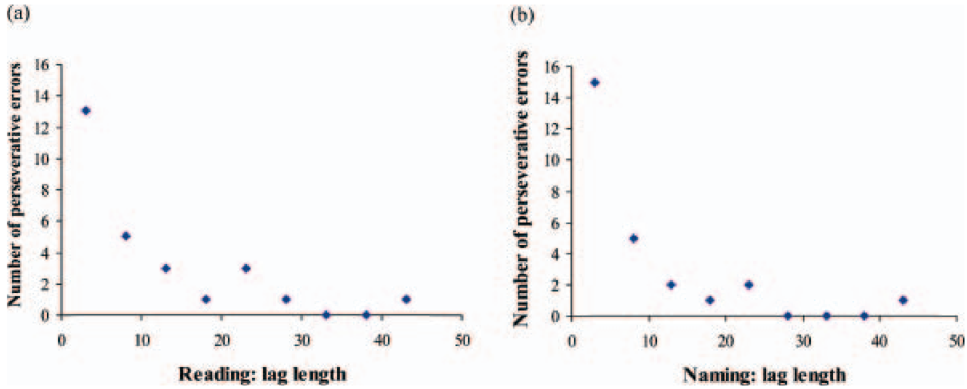

Figure 2. Perseverative lag length for the 64-item set. (a) Reading aloud. (b) Picture naming. The figures show the number of perseverative errors at each lag length (expressed as the number of intervening trials between a response and its perseveration).

foreign animals, fruit, birds, tools, vehicles, and musical instruments. Each category had six exemplars. The items were presented using e-prime software. At the beginning of each trial a fixation point appeared on the screen, followed by a picture. Five seconds were given for each item to be named; if a response was not given within this time the trial was terminated and an error was recorded. Blocks either consisted of related or unrelated items. In related blocks the items were all drawn from the same category, whereas unrelated blocks comprised items from different categories. Each block contained six individual items that appeared four times in a pseudorandom order. Items were either presented at a fast or slow rate, with response stimulus intervals of 0 and 5 seconds respectively. Every item was tested in all conditions and the order of testing was counterbalanced.

Results. Presentation rate and semantic relatedness had no significant effect on perseverative rate or accuracy. Correct responses were infrequent when presentation was both fast (8% correct) and slow (7%); around 70% of errors were perseverations in both conditions. Accuracy and perseverative rate were also comparable for related and unrelated blocks (7% and 8% correct respectively; 73% and 69% of errors were perseverative). There was no significant change in accuracy with item repetition (9% correct on first presentation and an average of 7% correct responses on the following three presentations). However, perseverations rose significantly from 49% of errors on the first presentation to 71% following stimulus repetition, $\chi^2(1) = 22.67$, $p < .001$.

Intrinsic stimulus factors: Summary

As detailed in the Introduction, several studies have shown that intrinsic stimulus factors can affect perseverative rate. Although stimulus repetition caused a significant increase in perseverations, LS's strong tendency to perseverate was otherwise impervious to the relatively weak impact of all other intrinsic factors. Hence, in the following analysis stronger extrinsic factors were used to manipulate accuracy and perseverative rate in reading aloud and picture naming. Although extrinsically administered cues have frequently improved accuracy in aphasic patients generally (e.g., Wambaugh, 2003) rarely, if ever, have they been used to target perseverative response types directly.

EXTRINSIC CUE AND CONTEXT FACTORS

Three experimental paradigms successively increased the constraint applied to the response in single word reading and picture naming. The cues were (1) the initial phoneme of each target, (2) word stimuli which were identical, semantically related or unrelated to the target word and either actively repeated or not, and (3) correct and incorrect sentence contexts.

Phonemic cueing

Method. Reading of the PALPA 53 items ($N = 60$; Kay, Lesser, & Coltheart, 1992) was compared with and without a phonemic cue in separate blocks. In the cued condition, the first phoneme of each item was spoken aloud by the experimenter immediately before each written word was presented.

Picture naming was examined under cued, miscued, and uncued conditions ($N = 140$). Simple line drawings were presented in the uncued (baseline) condition for the participant to name. In the cued condition, LS was given the first phoneme of the target word. In the miscued condition, he was given the initial phoneme of a semantically related word (e.g., knife + /f/ from fork). The three conditions were interleaved and every item was tested under each condition on separate trials in different testing sessions. As it is well established that cueing can increase accuracy in picture naming and reading aloud, with a consequent reduction in error rate, the effect of cueing on perseverative rate was assessed by examining the proportion of errors that were perseverative or otherwise.

Results. Phonemic cues improved reading accuracy from 0% (in the uncued baseline condition) to 12% (McNemar Exact $p = .07$). The rate of perseverations was also reduced from 62% to 30% of errors, $\chi^2(1) = 11.2$, $p < .001$.

Picture-naming accuracy improved from 2% at baseline to 28% when correct phonemic cues were provided (McNemar Exact $p = .001$). There was no difference in accuracy between the uncued and miscued conditions (6% of responses correct). Perseverative rate (proportion of errors that were perseverative) was lowest when the target was correctly cued (37% of all errors) and highest when it was uncued (43%). The provision of correct cues caused a significant decrease in perseverative rate relative to the baseline (uncued) condition, $\chi^2(2) = 1.38$, $p < .001$.

Cue words with and without repetition

Method. This experiment used the 64 items from the Snodgrass and Vanderwart (1980) set described previously. Reading aloud and picture naming were examined under four conditions: without a cue (baseline), with an auditory cue that was the same as the target item, with a semantically related cue (e.g., the spoken cue "table" immediately before reading/naming the target "stool"), and with an unrelated word taken from outside the target category (e.g., "stool" preceded by "turkey"). Each item was tested under every condition in different test sessions, in a counterbalanced order. The different conditions were presented in a pseudorandom order so that it was not possible to anticipate in advance whether a particular cue was identical, related, or unrelated to the target. When a cue was not offered in the baseline condition, a short delay was inserted before stimulus presentation in order to keep timing constant in all conditions.

LS either actively repeated the cue words (using his intact immediate repetition) or he listened to audio recordings of the words without repeating them. On these trials, he was asked to point to male and female pictures to indicate the gender of the voice in the recording, ensuring that he attended to the cue words. Every item was tested with and without active cue repetition in different test sessions.

Results. LS's responses were coded as correct, perseverations of a previous response, perseverations of a cue, unrelated responses, and other errors (omissions and errors with a semantic or phonological basis). Perseverative responses were the most frequent error type made by LS and so are reported here along with accuracy rates. The remaining errors comprised mostly unrelated errors (described above) and a low proportion of other errors. In the following analyses perseverative responses are first considered as a proportion of all errors (as above). Where this does not show an effect they are also considered as a proportion of all responses (i.e., in relation to correct responses).

Reading and picture naming with cue repetition: When LS repeated the target word before reading it, 64% of responses were correct. Accuracy was substantially lower at 23% when no cue was given (see Figure 3a, McNemar Exact $p = .001$). Semantically related and unrelated cue words did not change the number of correct responses relative to baseline (i.e., when no cue was provided). These results were replicated for picture naming: LS produced significantly more correct responses when cued with the target word relative to baseline (McNemar Exact $p = .001$) but semantically related and unrelated cues did not affect accuracy (see Figure 3b).

Although there were no significant differences in the proportion of errors that were perseverative across the different conditions, the total number of perseverations decreased as correct responses increased when the target word was given as a cue. Therefore, perseverations were a smaller proportion of total responses when a cue identical to the target was provided compared to baseline performance; this was true of both reading (McNemar Exact $p = .004$) and picture naming (McNemar Exact $p = .006$).

Reading and picture naming without cue repetition: Picture-naming accuracy was significantly improved by cues that were identical to the target response, even when the cues were not repeated (McNemar Exact $p = .001$). Response accuracy for this condition was not affected by whether repetition was required or prevented (McNemar Exact $p = .86$, see Figures 3b and 3d). Furthermore, the requirement to actively repeat the cue word did not affect perseverative rate relative to passive listening to the same cue words, regardless of whether perseverations were expressed as a proportion of errors, $\chi^2(1) = 1.19$, $p = .28$, or as a proportion of trials (McNemar Exact $p = .36$). As above, semantically related and unrelated cue words did not change the number of correct responses or perseverations relative to baseline.

This pattern was not repeated in reading. When LS repeated a cue that was identical to the target, 64% of responses were correct. This fell significantly to 38% when the cue was not repeated (McNemar Exact $p = .005$, see Figures 3a and 3c).

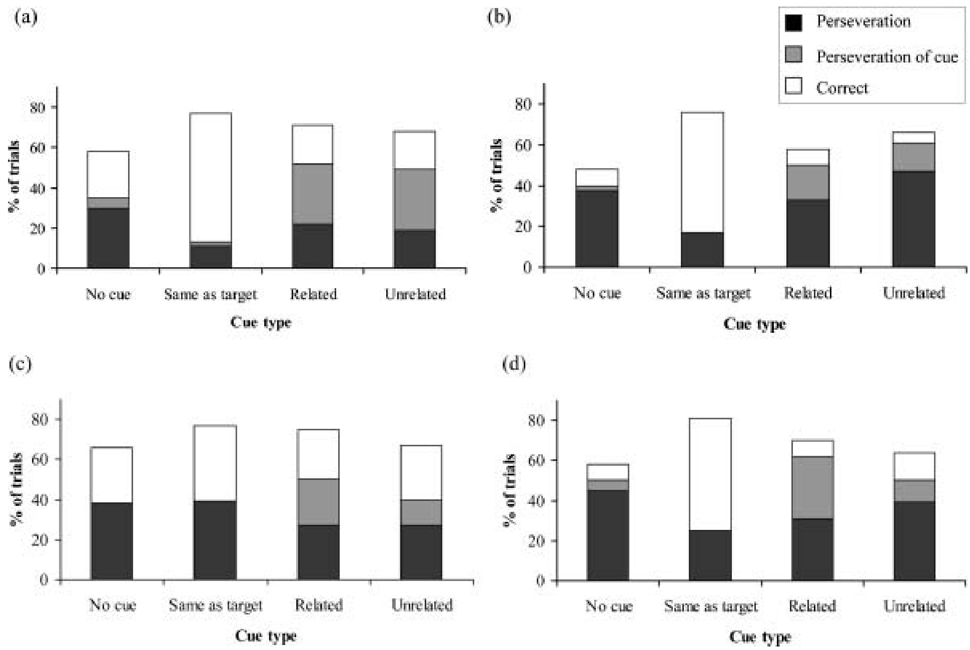

Figure 3. Picture naming and word reading with and without the repetition of cue words. (a) Reading with cue repetition. (b) Naming with cue repetition. (c) Reading without cue repetition. (d) Naming without cue repetition.

Active repetition of this cue also reduced the proportion of errors that were perseverative—30% compared to 63% without cue repetition; $\chi^2(1) = 6.01$, $p = .01$. Thus, unlike naming, reading only benefited from cues that were overtly repeated.

Reading and picture naming in correct and incorrect sentence contexts

Method. LS attempted to name pictures and read single words aloud in three conditions: without a sentence context (baseline), with a constraining sentence cue and with a sentence miscue. In the cued condition, LS heard an incomplete sentence just before he was asked to read or name the target item. The target response was the noun missing from the end of the sentence; for example, "I ate my dinner with a knife and …" followed by naming a picture of a fork or reading the word "fork". In the sentence miscue condition, the target item was incongruent with the preceding sentence; for example, "I opened the lock with the …" followed by an unrelated item such as "camera". As an additional baseline, LS was also asked to complete the sentences without a target word/picture. Although a range of different responses are possible in all conditions, the (highly predictable) sentence cues offered relatively greater constraint on the response in comparison to picture stimuli. Each item ($N = 49$) was tested in every condition, in a counterbalanced fashion across different test sessions. The different conditions were interspersed making it impossible to predict whether a particular sentence context was correct or incorrect.

Results. Responses were coded as correct, perseverations, miscued responses (generated by incongruent sentences), unrelated errors, and other errors (omissions and semantic/phonological errors). Once again, a large number of unrelated responses were produced, but the analysis below focuses on correct, perseverative and miscued responses. Figure 4 demonstrates the distribution of these responses across the conditions. As above, perseverations are considered first as a proportion of errors and second as a proportion of all trials.

Reading: Baseline reading accuracy was 6%. This increased to 38% when a constrained sentence cue was provided (McNemar Exact $p = .001$). However, there was no difference in accuracy between uncued and miscued trials (10% correct;

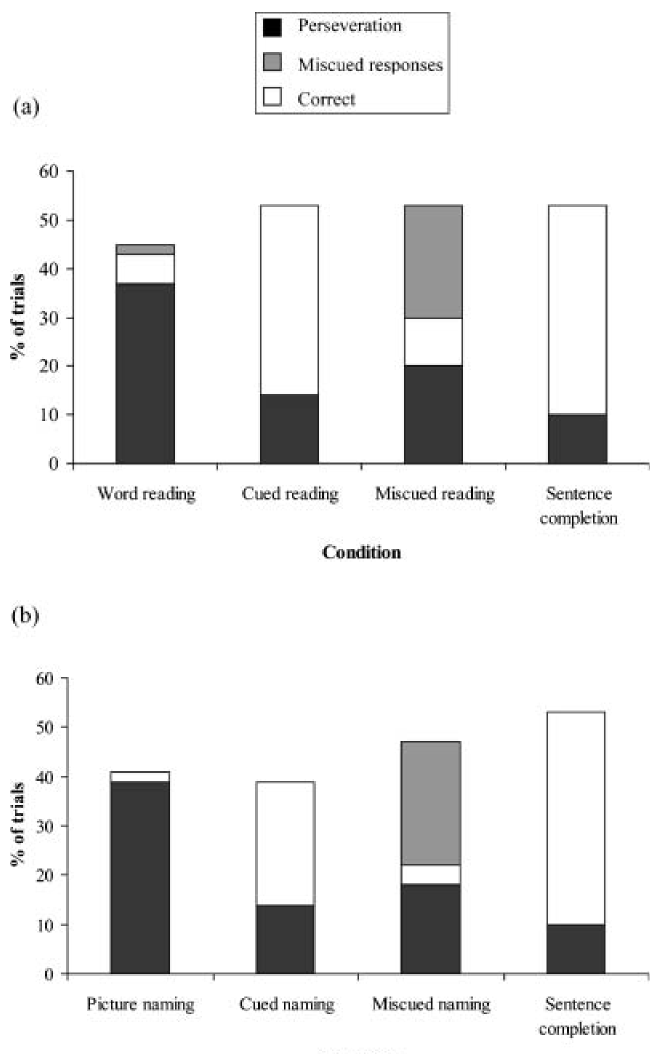

Figure 4. Picture naming and word reading with and without constrained sentence cues and miscues. (a) Word reading. (b) Picture naming.

McNemar Exact $p = .69$). In addition, cued reading accuracy did not differ from the completion of sentences without reading targets (McNemar Exact $p = .80$).

The proportion of errors that were perseverative did not differ for the uncued and correctly cued conditions, $\chi^2(1) = 2.05$, $p = .15$. As a proportion of all response types, however, perseverative errors were more frequent when words were read without a cue (37% of trials) compared with when they were read in a correct sentence context (14% of all trials; McNemar Exact $p = .03$, see Figure 4). There was no difference in perseverative rate between the constrained reading and sentence completion conditions, regardless of whether perseverations were considered as a proportion of errors, $\chi^2(1) = 0.27$, $p = .61$, or as a proportion of trials (McNemar Exact $p = .73$). However, perseverations were a somewhat smaller proportion of the total errors for miscued vs uncued reading, $\chi^2(1) = 2.82$, $p = .09$.

Picture naming: Uncued picture naming accuracy was very low (2% of trials correct) but rose to 24% when a constrained sentence was provided as a cue (McNemar Exact $p = .003$). Rather surprisingly, picture naming in the context of a sentence cue was less accurate than completion of the same sentences without a picture (McNemar Exact $p = .01$, see Figure 4).

Sentence cues reduced perseverations in picture naming from 40% of errors in the baseline condition to 19%, $\chi^2(1) = 4.2$, $p = .04$. There was no difference in perseverative errors between cued picture naming and sentence completion (18% of errors). Miscued naming also generated significantly fewer perseverations (23% of errors) compared with uncued naming, $\chi^2(1) = 5.94$, $p = .02$. This probably reflected the frequency of miscued responses in the incongruent sentence condition (22% of trials).

Extrinsic stimulus factors: Summary

Phonemic cueing increased accuracy and decreased perseverative rate in both reading aloud and picture naming, although miscues did not alter performance in comparison to baseline conditions. Although related and unrelated single-word cues did not affect accuracy or perseverative rate, active repetition of the target word cue did improve accuracy in both tasks and reduce overall error rate, including a gross reduction in the number of perseverations. This pattern was observed in naming regardless of whether the cue was actively repeated, but the facilitatory cueing effect was lost in reading when active repetition did not occur. Constraining sentence cues increased accuracy in comparison to baseline tasks for both reading and naming. While the facilitatory effect of sentence cues was global in reading, such that an increase in accuracy was mirrored by an overall reduction in errors (the majority of which were perseverative), the same cue type in picture naming caused a *specific* reduction in perseverations when considered as a proportion of all errors.

DISCUSSION

This study explored factors affecting the frequency of recurrent verbal perseverations in reading and picture naming in a highly perseverative transcortical sensory aphasic patient, LS. In addition to examining the impact of intrinsic stimulus variables in line with previous studies, we conducted novel investigations of the effect of extrinsic cues/contexts on perseverative rate.

Intrinsic stimulus variables

Previous studies have shown that perseverations can be reduced by manipulations such as the use of high-frequency items, which increase the target activation over that of past responses. Conversely, factors that impede the normal decay of previously generated responses, such as speeded presentation rate, stimulus repetition, and the use of semantically related items, can increase perseverative rate. In contrast to these findings, LS showed little effect of intrinsic stimulus variables. These manipulations may have been insufficient to influence his extremely strong predisposition towards perseveration.

Extrinsic cues and context

External constraints on output, such as phonemic cues, whole-word cues, and sentence contexts, did overcome LS's tendency to reproduce irrelevant past responses, increasing the accuracy of both picture naming and single-word reading. The effect of these constraints can be understood within the model of perseverative behaviour proposed by Cohen and Dehaene (1998). Cues and contexts that are congruent with the target and inconsistent with previously generated responses should help to boost activation of the target word above that of competitors that might be perseverated. LS only benefited from cues that tightly specified the target word to the exclusion of other competing responses. The phonemic cues were consistent with the target response and largely inconsistent with previously generated responses and semantically related competitors. The sentence contexts were highly constrained towards a single target word. Similarly, cue words were only beneficial when they were identical to the target response: semantically related cue words did not improve accuracy or reduce perseverations relative to the uncued condition perhaps because these words activated other associated items which competed with the target.

Single-word cueing had a global facilitatory effect on word production whereby the observed reduction in perseverative error was proportional to the overall decrease in error as accuracy increased. The same pattern was true of reading when constraint was applied with a sentence context cue, but not picture naming in which a specific reduction in perseverations as a proportion of the total error rate was observed. Provision of a sentence context cue causes a gradual increase in the activation of a number of semantically related items until a prepotent target response reaches firing level and the word is produced. By activating a specific set of semantically related representations above the resting activation, the sentence cue decreases the number of possible responses from which the target must be selected. The demand for control of semantic retrieval that characterises normal word production is therefore alleviated when a sentence context is provided. If perseverations arise from a lack of semantic control, one would expect sentence contexts to specifically reduce perseverations in picture naming, as it is dependent to a greater extent on a semantic route to output phonology than reading, which is more likely to proceed via orthography. Where word production proceeds in the absence of a constraining sentence context, a weakly activated target overexerts the patient's impoverished ability to control semantic retrieval and the correct response becomes overridden by residual activation from a previously produced response. Phonemic cues also caused a particular reduction in perseverative rate; however, a task-related difference was not observed, as the cues acted on phonology, which is integral to both reading and naming.

Phonemic miscues, unrelated words, and incongruent sentence contexts had little effect on accuracy in reading and picture naming. LS performed near floor in both the uncued and miscued conditions, suggesting that the target response achieved so little activation in the baseline condition that miscues designed to work against this activation were ineffective. However, the sentence miscues, which would have been strongly inconsistent with the residual activation of previously produced words, did reduce the rate of perseverations. The sentence miscues were presumably more effective at reducing perseverations than the unrelated single-word cues because the single words did not strongly specify an alternative response that was able to override LS's perseverative tendency.

An unexpected finding was that LS was more accurate at producing words from highly constrained sentences than from pictures even when the same sentences were provided as cues. The pictures may have been detrimental to LS's performance because they increased the number of responses that he could make. Even for healthy participants a picture of a fork, for example, might activate not only the object name but also a variety of other associated concepts/words (e.g., plate, food, lunch etc.). In contrast, the incomplete sentence "I ate my dinner with a knife and …" can only be completed with the target word. LS may have had difficulty constraining activation within his language system to focus appropriately on the target word: thus his poor picture naming might have resulted from poor semantic control and not a loss of relevant knowledge (further support for this view is described below). The stronger external constraints on output in the sentence completion task would have reduced the requirement for internal semantic regulation, perhaps explaining why cues/sentence contexts were so effective at reducing the frequency of perseverations.

In a recent study that included patient LS, we compared the nature of the semantic impairment in stroke aphasia and semantic dementia using a case-series design, in which the CVA group comprised mostly TSA patients and the remainder had less fluent speech and/or poorer repetition (Jefferies & Lambon Ralph, 2006). The two groups of patients obtained similar scores on a variety of semantic tasks despite having very different areas of brain damage (bilateral anterior temporal atrophy in semantic dementia and a mixture of left frontal and/or temporoparietal infarcts in the stroke group). However, the nature of the semantic impairment was qualitatively different in the two conditions. The patients with semantic dementia were highly sensitive to frequency/familiarity, made coordinate/superordinate semantic errors in picture naming, and showed substantial consistency when a set of items was assessed several times using different tasks, indicating a loss of amodal semantic knowledge. The stroke-aphasic patients were also consistent across different input modalities, but tasks requiring different types of semantic processing (e.g., word–picture matching and picture association tasks) did not correlate. The aphasic patients were insensitive to familiarity/frequency—instead, semantic performance was influenced by the ease with which relevant semantic relationships could be identified and distractors rejected. In addition, the picture naming of this group improved with phonemic cues and they made associative semantic errors, which the semantic dementia patients did not make (e.g., squirrel → "nuts"; glass → "ice"; lorry → "diesel"). All of these findings are consistent with the view that the aphasic patients' difficulties did not stem from a loss of semantic knowledge but instead resulted from an inability to appropriately regulate activation within the semantic system. They were inconsistent when comparing across different tasks because the semantic control requirements changed: even when they demonstrated knowledge of a concept in one task, they were unable to reshape the information for another test/situation. Their associative naming errors suggested that they had difficulty constraining their responses to the right part of semantic space and the provision of phonemic cues helped to overcome this deficit. Although further details are required regarding the nature of a failure of semantic control, it is nevertheless a concept that could shed light on the mechanisms underlying perseverative error.

If LS had poor semantic control without a loss of semantic knowledge per se, in common with the other stroke aphasic patients in this study, the provision of external constraints in the form of cues/sentence contexts would have boosted his performance by allowing him to activate relevant knowledge that he still retained. If, in contrast, his knowledge was impoverished, as in semantic dementia, cueing might have had little effect because environmental constraints that specify the target more precisely will be of little benefit if the target itself is severely degraded.

Task differences

In line with the findings of previous studies (Moses et al., 2004; Santo Pietro & Ridrodsky, 1982), we found differences between reading and picture naming which showed that perseverations are sensitive to the type of processing required by a task. Although LS was highly perseverative in every task, accuracy followed the sequence immediate repetition > delayed repetition > reading > picture naming. In addition, perseverations were more frequent for reading/picture naming compared with repetition. These differences are likely to reflect the degree to which the input in a given task specified the required phonological output. Repetition is highly constrained by the tight coupling between auditory input and phonological output. There is also marked consistency between orthography and phonology which helps to constrain reading aloud. In contrast, picture naming proceeds via the semantic system and because of the unsystematic nature of the mapping between semantics and phonology, output is much less tightly specified. Consideration of task demands may also explain the other differences that we observed between repetition and reading/picture naming: LS's perseverations in delayed repetition were more likely to be previous targets (as opposed to responses that had not been targets) and were repeated at very short lags. These findings might reflect the strong and predictable connection between acoustic input and phonological output. Target words that LS heard on the preceding trial were strongly activated in the language system and were therefore able to override current processing, resulting in perseverative errors.

As noted above, LS was less accurate at naming pictures in a sentence context than he was at completing the same sentences alone without a picture, suggesting that the pictures generated additional response ambiguity. LS did not show this pattern in reading aloud: his accuracy was equivalent for sentence completion and constrained word reading. The written word stimuli did not introduce additional response ambiguity perhaps because reading output is largely specified by the links

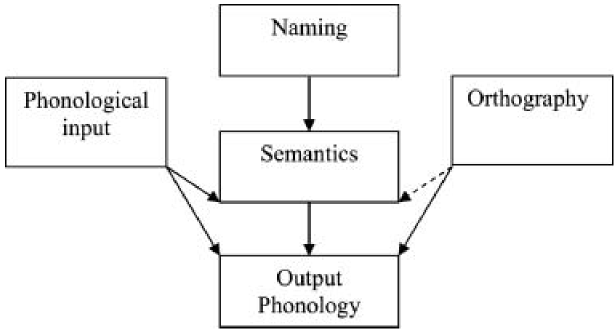

Figure 5. The language processing system.

between orthography and phonology and less reliant on semantic processing (see Figure 5).

Cue repetition effects. Cue words that were identical to the target response improved picture-naming accuracy and reduced perseverations regardless of whether they had been actively repeated or just heard. However, the same cues only significantly improved reading performance when they were repeated aloud; passive listening did not overcome LS's perseverative tendencies in reading. While both listening to and repeating cue words should facilitate the semantic processing of target words to broadly equivalent degrees, overt repetition should activate output phonology more strongly than passive listening. Picture naming is thought to be heavily reliant on semantic processing, whereas word reading benefits from an additional route from orthography to output phonology (see Figure 5). The asymmetry of reading and naming with and without overt repetition can be explained within this framework. Picture naming derived equal benefit from cues that were heard and actively repeated, as both conditions would have placed constraints on semantic processing. In contrast, reading was especially improved by overtly repeated cues that boosted the desired phonological output to a greater extent than passive cues.

In conclusion, we have demonstrated that phonemic, word, and sentence cues designed to bolster activation of the target word can overcome even very entrenched perseverative tendencies. We propose that these manipulations bias the competition between past and present stimuli in favour of the current stimulus in line with Cohen and Dehaene's (1998) explanatory framework. Patients such as LS, who have poor internal control of language processing, may fail to direct activation towards current targets and away from previous responses, which act as strong competitors. Cues that provide external constraints on processing are highly beneficial for such patients because they reduce the requirement for self-generated control. Although LS was perseverative in multiple tasks, there were differences between the tasks that were explicable in terms of the degree to which output was constrained by the stimulus. In addition, the effect of cueing varied across the tasks according to the way in which the cues were delivered (active repetition vs passive listening). Cues were most effective if they directly influenced the components of the language system that were most strongly engaged in the task. A specific reduction of perseverative responses in picture naming as a proportion of total error rate with externally applied sentence constraints is a finding unique to the present study and could provide a new approach to directly overcoming perseverative behaviour in the clinical setting.

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APPENDIX A

An example of baseline picture naming and reading aloud

Item number	*Target*	*Picture naming*	*Reading aloud*
1	Rabbit	Mouse	Rabbit
2	Sledge	Sleigh	House
3	Dustbin	Eye-glass, um a lamp	Dustbin
4	Frog	Elephant, no, tangerine	Frog
5	Tomato	Elephant, no	House, handbag
6	Lorry	The line	Kangaroo, cola
7	Cow	Cat, cow	Cow
8	Watering can	It's a /mju/	Watering can
9	Pineapple	Kangaroo	Water book
10	Bus	Mouse, no it's a hat	Book
11	Stool	Mouse or a hat	Brush
12	Dog	Breeder, breeding	Dog

12 stimuli taken from the Snodgrass and Vanderwart (1980) stimulus set.

APPENDIX B

An example of immediate and delayed repetition following a 10-second delay

Item number	*Target*	*Immediate repetition*	*Delayed repetition*
1	Gravy	Gravy	Gravy
2	Head	NR	Gravy
3	Care	Care	Care
4	Theory	Theory	Carey
5	Treason	Treason	Creason
6	Purpose	Purpose	Treason
7	Tally	Tally	Treason
8	Kite	Kite	Kite
9	Vow	Vow	Cow
10	Hand	NR	Cand
11	Man	Man	Man
12	Attitude	Attitude	Aptitude

12 stimuli taken from 62 items of varying frequency and imageability. NR indicates that no response was made by the participant.

APPENDIX C

Transcript of spontaneous speech produced by LS in the Cookie Theft Task (part of the Boston Diagnostic Aphasia Examination; Goodglass & Kaplan, 1983.)

"/The hand is carrying the feet/ it's mixing the bread/ hanging the letter/ watching the letter/ he's writing a letter/"