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 $\textbf{Article} \hspace{0.2cm} \textit{in} \hspace{0.2cm} \textbf{Quarterly journal of experimental psychology (2006)} \cdot \textbf{May 2007}$ 

DOI: 10.1080/17470210601147598 · Source: PubMed

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### Commentary on Baddeley and Larsen (2007)

## The phonological store abandoned

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Baddeley and Larsen (2007) argue that a number of key findings reported by Jones, Macken, and Nicholls (2004) and Jones, Hughes, and Macken (2006) pointing to shortcomings of the phonological store construct arise from the store being abandoned with long lists. In our rejoinder we point out that Baddeley and Larsen use a procedure in which retrieval from the supposed phonological storage would not—according to their own theory—have been possible, and we present theoretical, empirical, and logical problems with their "store abandonment" argument and highlight a number of difficulties associated with the interpretation of suffix and prefix effects. We conclude that our data are still problematic for the phonological store construct and suggest that a reformulation of short-term memory theory needs to embody (or indeed focus exclusively upon) perceptual and effector systems rather than bespoke storage modules.

In two articles, we reported evidence that questioned the validity of the concept of a phonological store (Jones, Hughes, & Macken, 2006; Jones, Macken, & Nicholls, 2004). In their comment, Baddeley and Larsen (2007, hereafter "B&L") discuss several reasons for attenuating the impact of that evidence. In this rejoinder, we point out logical and methodological difficulties that make it far from clear what conclusions can be drawn on the basis of B&L's own two experiments, and we address B&L's particular criticisms of our studies, particularly the notion that we failed to consider the possibility that participants abandon the phonological store under certain conditions.

The phonological store concept—the key-stone of the working-memory model (Baddeley, 2002; Baddeley & Hitch, 1974)—is specified by several key propositions: encoding of verbal materials in "phonological" form; privileged, direct access to the store by auditory stimuli; discretionary, indirect access to the store via a grapheme-to-phoneme conversion process for visual-verbal stimuli; rapid loss of phonological representations through decay (within roughly 3 s); revivification of phonological representations through a recirculatory rehearsal process; and loss of information in the store through "interference" based on (phoneme) similarity.

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Dylan Jones is also an Adjunct Professor at the Department of Psychology, University of Western Australia. This work was supported by a grant awarded to the authors by the United Kingdom's Economic and Social Research Council (RES-062-23-0011). Thanks are due to John Marsh for a critical reading of an earlier draft of this article.

These constructs map onto an array of empirical referents, the most important of which in the present context are: the phonological similarity effect (PSE; the impairment in serial recall when items are "phonologically" similar) arising from the interference by similarity construct; the articulatory suppression effect (the impairment in serial recall due to concurrent, irrelevant articulation) that arises from the blocking of the indirect route to the phonological store and the preclusion of rehearsal; and the irrelevant speech effect (the disruption of serial recall by to-be-ignored speech) exemplifying both the "direct access" and the interference-by-similarity constructs.

In Jones et al. (2006; Jones et al., 2004), a pivotal interaction between phonological similarity, articulatory suppression, and modality of presentation was reassessed. Predictions from the phonological store concept suggest unequivocally that suppression should, by its action of impeding indirect access to the store, impair the usual PSE with visual but not auditory presentation (the direct access mechanism being immune to articulatory suppression). And indeed, just as others have done (Baddeley, Lewis, & Vallar, 1984; Murray, 1968; Peterson & Johnson, 1971) this is what we found.

However, the point of departure from the received view of these results comes when the details of the data are uncovered: In Jones et al. (2004) it was shown that, with seven-item auditory lists, the surviving PSE is confined to recency, and, moreover, this vestige of the PSE can be removed by introducing a redundant end-of-list suffix (characterized as an effect of acoustic-based auditory perceptual organization, not phonology, see Nicholls & Jones, 2002). In Jones et al. (2006), we showed that with shorter, five-item, auditory lists, the PSE does indeed survive suppression throughout most of the list. Critically, however, this survival could also be blocked by the introduction of redundant items at the list-initial (a prefix) and list-end boundary (a suffix). That these redundant items acted upon acoustic, not abstract, phonological processes was bolstered by the observation that their impact was markedly reduced when presented in a different voice from the to-be-remembered items (Jones et al., 2006, Exp. 3). We also reviewed the evidence on errors in motor production and found that the PSE could more easily be accounted for in terms of errors in motor (speech) planning (Ellis, 1980) than by a phonological store construct. This led us to the view that there were two "phonological" similarity effects, neither of which necessarily relies on an exclusively "phonological" level of representation: One is due to errors in speech planning and production; the other is due to acoustic similarity (particularly its effect on perceptual organization of lists). We argued that a phonological store was unnecessary. In their article, B&L enjoin us to regard our effects as being of limited generality on the grounds that as the list length is reduced by just one item from seven (Jones et al., 2004) to six (B&L) there is, at least under conditions of articulatory suppression, a fundamental shift in the character of serial recall: A shift occurs from a nonphonological to a phonological strategy. We turn first to point out some problems with B&L's interpretation of their own data.

# Are B&L's experiments a valid test of their theory?

B&L show that, with list lengths of six, the PSE survives suppression with auditory but not visual presentation. They showed that this survival was apparent throughout the list, not just in recency as was found with seven-item lists by Jones et al. (2004). Even if we take this finding at face value (but see below), they are not in contradiction with those reported in Jones et al. (2006) insofar as we also found this pattern with five-item lists. However, the critical additional step taken in Jones et al. (2006)—which B&L did not take—was to deploy the use of suffixes and prefixes to ascertain whether this pattern was acoustically based as opposed to phonologically based. In support of the acoustic account, the survival of the PSE was abolished in the presence of a redundant

prefix and suffix in the same voice as the to-beremembered items (Jones et al., 2006, Exp. 2)<sup>1</sup>.

An additional problem is that the particular procedure of B&L's experiments means that they could not have, in any case, been tapping the action of the hypothetical phonological store: They used a procedure in which articulatory suppression was required during both a 6-s presentation period and a 10-s retention interval and attribute the PSE that they observe to the action of the phonological store. In their article, B&L state that the phonological store is only "capable of holding information over a period of seconds" in the absence of rehearsal (B&L, p. 497). Whilst this claim is entirely consistent with previous characterizations of the store-"[t]races within the store were assumed to decay over a period of about two seconds unless refreshed by rehearsal" (Baddeley, 2002, p. 86)—B&L's use of a setting in which rehearsal was (putatively) prevented during both presentation and a 10-s retention interval must mean that the phonological representations in the store would have decayed long before participants were free to start recalling. Thus, if the time-limited character of phonological storage is taken as an established tenet of the working-memory model, the delay in B&L's experiments means that they are not equipped to address the critical issue in question—namely, whether a PSE occurs throughout the list for auditory stimuli when rehearsal is prevented.

In neither of their experiments did B&L include conditions in which participants were free to rehearse (i.e., "no suppression" conditions). Aside from the problem with the delay that they employed, there are no means by which to verify, empirically, whether the articulatory suppression instruction was effective. It is possible to argue that the effectiveness of the suppression manipulation is demonstrated by the fact that there was no PSE in their visual condition. However, to

account for their observation of an inversion of one of the most easily reproduced features of verbal memory—the modality short-term effect—B&L argue that in the visual condition participants may have made "greater use of supplementary, visual or possibly semantic codes, which may be more readily accessible with visual presentation" (p. 502). Alas, this leads to a logical dilemma: It is not possible to tell whether the PSE disappeared in this condition because participants were suppressing or because the use of a visual/semantic code would preclude the emergence of a PSE regardless of whether participants were suppressing.

### Abandoning the loop?

The key aspect of our results that remains highly problematic for the phonological store construct is that the survival of the PSE with auditory lists under suppression is abolished throughout the list in the presence of either a suffix (Jones et al., 2004) or a suffix in combination with a prefix (Jones et al., 2006). B&L's explanation of this finding is that even with five-item lists, if two redundant items are added, the task becomes too difficult, and participants abandon the use of the phonological store in favour of some other, possibly visual or semantic, code (even though the added items are to be ignored). More generally, it has been argued that when performance is overall below around 50%, the phonological store is abandoned (e.g., Baddeley, 2000). While it may seem appropriate to invoke the idea of limiting the compass of the action of the phonological store in this way, a considerable weakness of the idea is that it is not predicted on theoretical grounds. That is, the idea does not flow from any of the propositions that comprise the phonological loop model but is invoked post hoc as a means of accommodating data that would otherwise compromise the veracity of that model.

<sup>&</sup>lt;sup>1</sup> It may be worth noting that B&L seem to have misinterpreted the results of Jones et al. (2006) when they state that "it is only in this latter study [Experiment 3 of Jones et al., 2006] that the crucial interaction is totally confined to the recency portion of the serial position curve" (B&L, p. 499). In fact, in Experiment 3 of Jones et al. (2006), the similarity effect is apparent throughout the list but is also obliterated throughout the list with the addition of a prefix and suffix.

The store abandonment argument also suffers from other weaknesses. First, there are inconsistencies between expositions of the phonological store abandonment argument in terms of the causal relationship between store abandonment and low levels of performance. On one account, a low level of performance causes participants to abandon the phonological store: "it [phonological coding] tends to be abandoned when performance drops below a critical point" (Larsen & Baddeley, 2003, p. 1262). However, on another account, the causal arrow is reversed: "when it [the phonological loop] is not available, as reflected by the absence of a PSE, performance level is reduced" (Baddeley & Larsen, 2003, p. 1301). Clearly, these two standpoints are incompatible, and without an unambiguous version of the hypothesis, it becomes difficult to conceive of how it might be tested empirically.

Second, B&L's argument that the phonological store might have been abandoned in the presence of two redundant items in the Jones et al. (2006) study in favour of a nonphonological code (e.g., visual and/or semantic) is, presumably, based on the fact that the level of recall performance was relatively low (around 50%) in that condition. The argument therefore rests on the assumption that nonphonological codes are systematically less effective than phonological codes. However, there are reasons to doubt such an assumption. For example, Hanley and Bakopoulou (2003) found that participants instructed to encode to-be-remembered items using a semantic code was a better, not poorer, strategy than that using a phonological code. Indeed, that this is the case forms the basis of B&L's account of the inverted modality effect observed in their studies. Thus, if participants switched strategies in response to the presence of a prefix and suffix to use a visual and/or semantic code, performance should have been better, not poorer, in that condition than in the control (i.e., no prefix-and-suffix) conditions.

Finally, it is worth noting that the store abandonment argument leads the phonological store theory close to circularity. A notion that forms the backbone of the theory is that the presence of a PSE indicates the existence and use of a phonological store. The crux of the problem is that to argue

that the absence of a PSE indicates that the store was not used is a case of "denying the antecedent", making it unacceptable logically. In short, once the absence of the signature of the store (the PSE) can be attributed to the store being abandoned, it becomes difficult to falsify the phonological store theory. Identifying an independent index of store abandonment (or the use of nonphonological coding) would seem to be crucial if the abandonment argument is to be acceptable.

### Interpretation of suffix and prefix effects

B&L argue that the presence of a suffix and/or prefix in the studies of Jones et al. (2006; Jones et al., 2004) led to the abandonment of the phonological store. Their position pivots critically of they way they account for suffix and prefix effects. With regard to the suffix effect, they argue that there are two qualitatively different forms. One is a recencybased (and hence nonphonological) effect that appears to correspond to our own acoustic-based account (2006; Jones et al., 2004) and which disrupts the recall of the last one or two items in an auditory list. The second form of suffix effect disrupts recall of the entire list (presumably by disrupting the use of the phonological store), is not so concentrated at recency, and is disruptive because it delays recall. B&L argue that it is the former "recency-based effect that has formed the basis of the crucial interaction in the studies by Jones et al." (p. 502). We are somewhat confused by this suggestion because: (a) this is precisely our argument; the suffix (and prefix) in our studies affected the survival of the PSE under suppression by altering the effectiveness or use of acoustic order encoding not phonological coding; and (b) elsewhere B&L argue that the suffix (in combination with a prefix) abolished the PSE by promoting the abandonment of the phonological store, not by affecting acoustic coding. Aside from this apparent contradiction, there are also several, more general, problems with B&L's two-component view of the suffix effect:

1. No independent evidence for two suffix effects. Within a series of eight experiments, Bloom and

- Watkins (1999) reassessed the effect of suffix length reported by Baddeley and Hull (1979), which forms the basis of B&L's delay account and showed that a long suffix (e.g., Abergavenny) is only more disruptive (of prerecency items) than a short suffix (e.g., Rhyl') if the no-suffix and suffix conditions are blocked (Baddeley & Hull, 1979). When the more typical procedure of having the suffix and no-suffix conditions intermixed within a block of trials (which, critically, was the case in the studies of Jones et al., 2006, and Jones et al., 2004), "lengthening the suffix had no discernible influence on either the preterminal or terminal components of the suffix effect" (Bloom & Watkins, 1999, p. 1467);
- 2. Is the suffix effect phonological or nonphonological (i.e. acoustic)? The suffix effect in the critical conditions in the Jones et al. (2006; Jones et al., 2004) studies (i.e., auditory, under suppression) was restricted to recency (the last one or two items; see, for example, Figure 2B of Jones et al., 2006). Thus, even if we were to accept that there is both a nonphonologically based and a phonologically based suffix effect where the latter operates throughout the list and by delaying recall, the suffix effect in Jones et al.'s (2006; Jones et al., 2004) studies is—as B&L seem to agree—of the nonphonological (i.e., acoustic) type. Indeed, Baddeley and Hull (1979) showed that what they refer as the nonphonological-based suffix effect—which affects only terminal items—is reduced as a function of suffix length (but again, this effect only occurs under blocked conditions; Bloom & Watkins, 1999);
- 3. Strategy versus storage effects. B&L's suggestion that the suffix (and indeed the prefix) in our studies disrupted phonological coding is not only in conflict with the suggestion that it affected the acoustically driven recency effect, but it is also at odds with the contention that the suffix led to short-term phonological memory being abandoned. That is, a suffix that depresses performance by forcing the use of an apparently less effective, nonphonological, coding strategy is clearly not the same thing as a suffix that depresses recall by impairing the actual use of short-term

- phonological memory (for a similar point in relation to the PSE, see Page & Norris, 2003);
- 4. Delay was controlled for in Jones et al. (2006). Even if the delay account were true, it is unlikely to apply to the data of Jones et al. (2006): Participants were free to respond once they saw a visual signal that occurred 50 ms after the final to-be-remembered item regardless of whether that item was followed by a suffix. Even if participants had waited until the offset of the suffix in the "with-suffix" trials, the initiation of recall would have been delayed by just 1 s. All of which begs the question: If participants abandon the store when delayed for 1 s, why do they not abandon the store when delayed for 10 s as was the case in the experiments of B&L?

In interpreting the prefix effects, B&L cannot appeal to the idea that a prefix that need not be produced delays recall. B&L therefore argue that because "computational models of the phonological loop" incorporate the notion of "limited encoding resources", it is plausible to assume that a prefix would make demands on these resources and hence disrupt phonological coding (or lead to phonological coding being abandoned). However, B&L speculate that their phonological-based prefix and suffix effects will only come into play if these items are acoustically similar to the to-be-remembered list. Thus, there is here a conflation of phonological- and perceptual-based prefix and suffix effects. Moreover, B&L have to use separate explanatory constructs for prefix and suffix effects while empirically their action is strikingly similar.

We argue that the survival of the "phonological" similarity effect under suppression at recency (and also at primacy with short lists) is explicable by recourse to principles of perceptual organization and that nothing further it bought by postulating a hypothetical memory store. An understanding of auditory recency begins with a characterization of an auditory to-be-remembered list in terms of a perceptual object or stream. The last item in the list represents a salient boundary to the auditory sequence, which forms a coherent auditory stream on account of the fact that its

constituent members share a common ground: They are spoken in the same voice, share a common timing, duration, and location in auditory space, and so forth (cf. Bregman, 1990). It is well known that acoustic changes superimposed on a common ground yield order cues that are processed obligatorily and preattentively, particularly for stimuli at the boundaries of a sequence (e.g., Bregman, 1990; Bregman & Campbell, 1971; Macken, Tremblay, Houghton, Nicholls, & Jones, 2003). We suggest that participants exploit such automatic order encoding to recover the order of auditory to-be-remembered items in a serial recall task. However, this strategy is only likely to be effective (or is at least likely to be more effective) for items at the list boundaries and when the sequence exhibits acoustic changes on a common ground, such as is the case with a "phonologically" dissimilar list (e.g., "r, k, l, h, q"), but not so much the case with a "phonologically" similar list (e.g., "c, b, d, g, t").

From this perspective, the action of a suffix can be readily explained without having to posit a shift in the character of serial recall as posited by B&L: The suffix impedes the use of automatic acoustic order encoding that otherwise supports performance at recency (likewise a prefix at primacy with short lists). Adding a redundant item to the end of the list displaces the last to-be-recalled event from the boundary and hence into a position where automatic order encoding will be less useful, thereby decreasing the likelihood that it will be recalled in its correct position. Having the correct last item in place also disambiguates those before it, so the effect of the suffix propagates back into the list. The suffix does not, therefore, act by lengthening the list. Indeed, adding two suffixes (of the same type) reduces rather than augments this effect (Crowder, 1978). This is again easily explained by auditory perceptual organization: The first of the duplex now shares more acoustic commonality with the suffix that follows it than it does with the list items. The duplex suffix is thereby perceptually partitioned and isolated from the list, allowing the last list item to recover its salience, and, correspondingly, it once again exhibits strong recency (for a detailed account, see Nicholls & Jones, 2002). Nor is the last list item overwritten by the suffix within a store: If the to-be-remembered list is accompanied by a sequence of sound that is acoustically similar to the suffix and hence "captures" that suffix into a stream separate from the list, then the suffix effect disappears (Nicholls & Jones, 2002). Mnemonic constructs—overwriting or interference by similarity (especially phonological similarity)—do not apply in the case of the suffix (or indeed the prefix); rather, its action is governed solely by the principles of auditory perceptual organization.

Part of the difficulty that B&L encounter in dealing with the suffix and prefix stems from the fact that such effects are not explicitly part of the working-memory formulation. One way out of this difficulty is to "bolt-on" a further module dealing with perceptual organization particularly as it relates to auditory input (or indeed a module intended to explain the phonological similarity effect through speech errors). This temptation should be resisted on the grounds that perceptual organization, in conjunction with an action-planning system, alone can account for the data neatly and with parsimony.

Exigencies of space do not allow us to discuss other difficulties with the phonological store construct; these are summarized in Jones et al. (2006; Jones et al., 2004) as well as elsewhere (e.g., Macken & Jones, 2003). In the same spirit, we note also that B&L's interpretation of the data of Murray (1968) is at odds with Murray's own interpretation. B&L argue that Murray's (1968) data are inconsistent with the results of Jones et al. (2004) in indicating an effect throughout the list. However, Murray (1968) explicitly states otherwise: "recall of the *final items* of nonarticulated auditory lists is affected by AC [acoustic confusability] ... the effects of AC were also marked on early items but only when rehearsal was permitted" (Murray, 1968, p. 683; emphases added).

### **CONCLUSIONS**

The major shortcomings of the B&L comment are manifold: From their description of the store their

experiments cannot be a test of the store theory, their methodology limits the interpretations that can be placed on the data, the logic applied to the "abandoning" of phonological storage is faulty, and their arguments in relation to prefix and suffix effects are inconsistent with a substantial body of work. We conclude that B&L fail to undermine either the validity of the Jones et al. (2006; Jones et al., 2004) data or their generality.

Original manuscript received 9 May 2006 Accepted revision received 31 August 2006 First published online 12 February 2007

### REFERENCES

- Baddeley, A. D. (2000). The phonological loop and the irrelevant speech effect: Some comments on Neath. *Psychonomic Bulletin and Review*, 7, 544–549.
- Baddeley, A. D. (2002). Is working memory still working? *European Psychologist*, 7, 85-87.
- Baddeley, A. D., & Hitch, G. J. (1974). Working memory. In G. A. Bower (Ed.), Recent advances in learning and motivation (Vol. 8, pp. 47–89). New York: Academic Press.
- Baddeley, A. D., & Hull, A. J. (1979). Prefix and suffix effects: Do they have a common basis? *Journal of Verbal Learning & Verbal Behavior*, 18, 129–140.
- Baddeley, A. D., & Larsen, J. D. (2003). The disruption of STM: A response to our commentators. *Quarterly Journal of Experimental Psychology*, 56A, 1301–1306.
- Baddeley, A. D., & Larsen, J. D. (2007). The phonological loop unmasked? A comment on the evidence for a "perceptual-gestural" alternative. *Quarterly Journal of Experimental Psychology*, 60, 497–504.
- Baddeley, A., Lewis, V., & Vallar, G. (1984). Exploring the articulatory loop. *Quarterly Journal of Experimental Psychology*, 36A, 233–252.
- Bloom, L. C., & Watkins, M. J. (1999). Twocomponent theory of the suffix effect: Contrary findings. Journal of Experimental Psychology: Learning, Memory, and Cognition, 25, 1452–1475.
- Bregman, A. S. (1990). Auditory scene analysis: The perceptual organization of sound. Cambridge, MA: MIT Press.
- Bregman, A. S., & Campbell, J. (1971). Primary auditory stream segregation and perception of order in rapid sequence of tones. *Journal of Experimental Psychology*, 89, 244–249.

- Crowder, R. G. (1978). Mechanisms of auditory backward masking in the stimulus suffix effect. *Psychological Review*, 85, 502–524.
- Ellis, A. W. (1980). Errors in speech and short-term memory: The effects of phonemic similarity and syllable position. *Journal of Verbal Learning and Verbal Behavior*, 19, 624–634.
- Hanley, J. R., & Bakopoulou, E. (2003). Irrelevant speech, articulatory suppression and phonological similarity: A test of the phonological loop model and the feature model. *Psychonomic Bulletin and Review*, 10, 435–444.
- Jones, D., Hughes, R. W., & Macken, W. J. (2006). Perceptual organization masquerading as phonological storage: Further support for a perceptual-gestural view of short-term memory. *Journal of Memory and Language*, 54, 265–281.
- Jones, D., Macken, W. J., & Nicholls, A. P. (2004). The phonological store of working memory: Is it phonological and is it a store? *Journal of Experimental Psychology: Learning, Memory, and Cognition*, 30, 656-674.
- Larsen, J., & Baddeley, A. D. (2003). Disruption of verbal STM by irrelevant speech, articulatory suppression and manual tapping: Do they have a common source? *Quarterly Journal of Experimental Psychology*, 56A, 1249–1268.
- Macken, W. J., & Jones, D. M. (2003). Reification of phonological storage. *Quarterly Journal of Experimental Psychology*, 56A, 1279–1288.
- Macken, W. J., Tremblay, S., Houghton, R. J., Nicholls, A. P., & Jones, D. M. (2003). Does auditory streaming require attention? Evidence from attentional selectivity in short-term memory. *Journal of Experimental Psychology: Human* Perception and Performance, 29, 43–51.
- Murray, D. J. (1968). Articulation and acoustic confusability in short-term memory. *Journal of Experimental Psychology*, 78, 679–684.
- Nicholls, A. P., & Jones, D. M. (2002). Capturing the suffix: Cognitive streaming in immediate serial recall. *Journal of Experimental Psychology: Learning Memory and Cognition*, 28, 12–28.
- Page, M. P. A., & Norris, D. G. (2003). The irrelevant sound effect: What needs modelling and a tentative model. *Quarterly Journal of Experimental Psychology*, 56A, 1289–1300.
- Peterson, L. R., & Johnson, S. T. (1971). Some effects of minimizing articulation on short-term memory. Journal of Verbal Learning and Verbal Behavior, 10, 346–354.