Introduction

How much do visual and verbal working memory have in common?

Baddeley & Hitch’s (1974) working memory model:

- Viscuospatial sketchpad
- Central executive
- Phonological loop

Baddeley, 2003

> Domain-specific differences:
  - Spatial properties for visual stimuli; temporal properties for verbal stimuli
  - Categorical nature of verbal stimuli

Given these differences, is the assumption of a central executive shared by both domains correct?

1. Is the division of resources the same in visual and verbal WM?
   - Is it the same for production and perception in verbal WM?

2. Does attention influence the allocation of resources in the same way?

3. Which components of working memory does resource allocation affect?
   - Does it only affect encoding, or can it affect later processes?

Experiment 1: Effect of Set Size on Deviation

N = 48 participants, N = 672 trials
Manipulation: set size of 1, 2, or 4

Conclusion: Deviation increases with additional items, even from 1 to 2

Experiment 2: Effect of Attentional Cues on Deviation

N = 45 participants, N = 672 trials
Manipulation: cueing

Conclusion: Deviation decreases for cued items relative to baseline, at the expense of uncued items

Experiment 3: Effect of Cue Timing on Deviation

N = 100 participants, N = 504 trials
Manipulation: timing of the cue
   - Before the stimui (can influence encoding) or after the stimuli (cannot influence encoding)

Conclusion: Cues that cannot influence encoding affect uncued items, but not cued items

Experiment 4: Effect of Word Length on Deviation in Production

N = 2,201 consonants (N = 675 substitutions)
Variad word length (3–9 phonemes)

Conclusion: Deviation increases as word length increases

Discussion

> In both verbal and visual working memory:
  - Working memory is a continuously divisible resource
  - More resources are allocated to attended items, at the expense of unattended items

> In verbal working memory, cues early enough to influence encoding affect both attended and unattended items, while cues that come later can only affect unattended items

> Within the verbal domain, resource allocation in working memory for production and comprehension are similar

> This is consistent with a shared central executive component responsible for allocating resources across working memory subsystems

References


A resource model of phonological working memory in language production and perception

A pivotal concept in classic (buffer) models of working memory (WM) is the notion of fixed capacity, a parameter that determines how many items can be retained in working memory at any given time. Explicitly held in theories of WM in the visual domain (Cowan, 2001), the assumption has also been implicitly held in theories of WM in language, because of the discrete nature of measurement for linguistic units. For example, responses are categorized as correct or incorrect, and errors are defined by nominal categories. Notions of categorical perception (Liberman, Harris, Hoffman, & Griffith, 1957) seem to validate this choice, suggesting that the mechanisms underlying WM in language might indeed be non-continuous.

Recently, the “resource model” of WM has challenged the notion of discrete fixed-capacity WM in the visual domain (Ma, Husain, & Bays, 2014). The resource model views WM as a resource divided between representations to be held in memory regardless of their number. As number of representations increases, each item receives fewer resources and is thus encoded with less “precision”, i.e., with more variability around the mean. Fixed-capacity models would predict perfect precision up to the capacity limit (at least 3 items according to any capacity-limited theory), with a sharp drop past the limit. The resource model, on the other hand, predicts a monotonic decrease in precision with any increase in set size (even from 1 to 2). This project tests these predictions in the language domain by devising continuous measures of phonological WM.

To test phonological WM in perception, 48 neurotypical participants rated syllables on a continuum (1-100) between phoneme pairs that differed in a single feature, e.g., from most /kA/-like to most /gA/-like. The stimuli appeared in set sizes of 1, 2 and 4 (4 different pairs, 672 trials). To test phonological WM in production, an individual with aphasia (CK) with intact comprehension and a predominantly phonological error profile named 444 pictures on two separate occasions. CK’s responses were aligned with their targets and consonant segments (2,201 total, 675 substitution errors) were scored for dissimilarity using the ALINE distance (Kondrak, 2002), which is the sum of the phonological feature differences weighted by salience. The resource model predicts increasing rating variability with increasing set size and larger ALINE distances with increasing word length.

In keeping with the predictions of the resource model, variability increased monotonically (almost linearly) as a function of number of items to be held in WM in both perception (Fig. 1, \(t = 2.025, p < 0.05\)) and production (Fig. 2, \(t = 6.312, p < 0.001\)), even after other variables such as position were accounted for in the model. Moreover, the increase was reliable even between set sizes 1 and 2 (\(t = 4.427, p < 0.001\)) in perception, which is below the capacity limit in any fixed-capacity model of WM.

In summary, our results demonstrate the utility of continuous measures, i.e., measures of precision instead of accuracy, for probing cognitive operations underlying phonological processing, and specifically support a resource model of phonological WM that functions according to the same principles in perception and production.
Figure 1
Variability (SD) ± 95% CI of ratings in phonological perception as a function of set size.

Figure 2
Variability (measured as ALINE distances) ± 95% CI in production as a function of word length. Because the shortest picture name was a CVC, the length measure of the x-axis starts at 3.
References


