



Modalities of memory: Is reading lips like hearing voices?



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ABSTRACT

Functional similarities in verbal memory performance across presentation modalities (written, heard, lipread) are often taken to point to a common underlying representational form upon which the modalities converge. We show here instead that the pattern of performance depends critically on presentation modality and different mechanisms give rise to superficially similar effects across modalities. Lipread recency is underpinned by different mechanisms to auditory recency, and while the effect of an auditory suffix on an auditory list is due to the perceptual grouping of the suffix with the list, the corresponding effect with lipread speech is due to misidentification of the lexical content of the lipread suffix. Further, while a lipread suffix does not disrupt auditory recency, an auditory suffix does disrupt recency for lipread lists. However, this effect is due to attentional capture ensuing from the presentation of an unexpected auditory event, and is evident both with verbal and nonverbal auditory suffixes. These findings add to a growing body of evidence that short-term verbal memory performance is determined by modality-specific perceptual and motor processes, rather than by the storage and manipulation of phonological representations.

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1. Introduction

A founding assumption of the cognitive approach to linguistic behaviour is that there are central representations of linguistic information upon which information from one or more of a range of sensory modalities converges (e.g., Chomsky, 1957; Chomsky & Halle, 1968). Principally, hearing and vision converge in this way, with the common representation usually being rendered as an abstract, phonological form, postulated to be distinct from both the perceptual processes that provide input to it, and the motor processes that enable output from it. The *sine qua non* of such abstract representation is the need to account for interactions amongst, and functional similarities across, the processing of linguistic material from the various modalities. Distinctions between heard, read, and silently lipread speech, for example, are attributed not to fundamentally different forms of representation derived for each

modality, but rather to such mechanisms as different encoding routes to phonological representation from heard and seen inputs (e.g., Baddeley, 1992, 2010, 2012; Repovš & Baddeley, 2006) modality specific features supplementary to the phonological form (e.g., Nairne, 1990; Neath & Nairne, 1995; Penney, 1989; Winkler, Denham, & Nelken, 2009) or different attentional/encoding constraints across modalities (e.g., Burgess & Hitch, 1999; Page & Norris, 1998). At the same time, commonality in the pattern of performance across modalities is attributed to the common underlying phonological form of representation.

Our particular concern here is with the nature of representations derived from silently lipread and auditory speech, which serves to illustrate this general issue nicely. Speech, in everyday communicative settings is often encountered multimodally; in face-to-face communication, listeners have access to both auditory and visual aspects of the speaker's utterances and such multimodal information facilitates communication in a range of settings indicating some form of confluence of the different modalities of information (e.g., Bishop & Miller, 2009;

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McGettigan et al., 2012). That heard and seen speech both gain access to a common representational form is suggested by critical similarities in detailed aspects of short-term memory performance; specifically, serial recall of sequences of both auditory and lipread material shows enhanced performance towards the end of the sequence compared to that for read material – the *recency effect*. Further, such enhanced performance is disrupted in both cases by the presentation of a redundant, end-of-list verbal item in the same modality as the sequence, but which participants are told is not part of the memory sequence – the *suffix effect* (e.g., Campbell & Dodd, 1982; deGelder & Vroomen, 1992; Gathercole, 1987; Greene & Crowder, 1984; Spöehr & Corin, 1978). Further, there is evidence of cross-modal interactions in short-term memory between auditory and lipread verbal material, including a disruptive effect of a lipread suffix on an auditory memory sequence, and the corresponding effect of an auditory suffix on a lipread sequence. Such interactions also seem to call for a common form of representation shared by the two modalities (e.g., Campbell & Dodd, 1980, 1982; deGelder & Vroomen, 1992; Gathercole, 1987; Greene & Crowder, 1984; Spöehr & Corin, 1978).

In the experiments reported here, we provide further detailed empirical analysis of these functional patterns, which leads to very different conclusions about the nature of the representations underlying verbal short-term memory performance. Specifically, we find that the functional similarities between heard and lipread speech described above are, in fact, outcomes of different representations and processes operating across modalities. Rather than pointing to abstract phonological representations, the pattern of performance points to modality-specific and object-oriented perceptual and attentional processes as the basis for verbal short-term memory. Given the fundamental role that limited capacity, short-term processing systems play in accounts of much higher level cognitive functioning, both normal and impaired (e.g., Anderson, Reder, & Lebiere, 1996; Chen & Naveh-Benjamin, 2012; Just & Carpenter, 1992; Oberauer, 2005), the nature of those underlying representations and the origins of the constraints within such systems may have broad implications for understanding such higher level functioning. Further, given contemporary arguments about the relationship between verbal short-term memory performance and linguistic performance more generally (see e.g., Acheson & McDonald, 2009; MacDonald & Christiansen, 2002; Martin & Saffran, 1997) insights into the mechanisms underpinning verbal short-term memory performance may raise questions about the nature of linguistic representations and processing more generally. From this perspective, we will argue that our findings contribute to a growing body of evidence that raises fundamental questions about the classical conceptualisation within cognitive science – one focussed on the manipulation of ‘central’ representations – of short-term memory in particular, and, indeed, of verbal processing more generally.

The prime motive for revisiting the particular phenomena here is that recent evidence has begun to show that a range of canonical aspects of short-term verbal memory that were hitherto attributed to processes operating on

an amodal phonological level of representation have, under closer scrutiny, turned out to be attributable to modality-specific motor and perceptual processes. For example, the phonological similarity effect, whereby sequences of similar sounding verbal items (e.g., the letter sounds, *b, c, d, g, . . .*) are more poorly recalled than dissimilar sounding sequences (e.g., *f, k, l, q, . . .*), occurs whether the sequences are read or heard (e.g., Conrad & Hull, 1964; Crowder & Morton, 1969). That the effect itself seems to transcend presentation modality has been taken to suggest that it occurs at a representational level that must transcend modality (e.g., Baddeley, 2012). However, recent evidence has shown that there are in fact critical differences between the effect of such similarity as it manifests in visual- and in auditory-verbal forms (e.g., Jones, Hughes, & Macken, 2006; Jones, Macken, & Nicholls, 2004; Maidment & Macken, 2012). This evidence indicates that the (so-called) phonological similarity effect, rather than residing in interactions amongst central phonological representations, in fact has two distinct components – one underpinned by errors in the speech production mechanisms utilised to perform subvocal rehearsal and the other (specific to auditory presentation) arising within domain-general auditory perceptual sequence processing. The former, motor-based effect arises due to competition in the actual control of anatomically similar vocal gestures (e.g., Goldstein, Pouplier, Chen, Saltzman, & Byrd, 2007), while the latter, auditory effect arises from the poor perceptual resolution in acoustically relatively homogenous sequences (see e.g., Warren, 1999). Neither of these mechanisms necessitates a representational form that is amodal or phonological in essence, but rather they point to the role of domain-general perceptual and motor processes in determining short-term verbal memory.

A further key aspect of short-term memory performance that raises questions about accounts of that performance in terms of phonological representations relates to the disruptive effect of task-irrelevant background speech on verbal serial recall. This effect was originally attributed to both the memory material and the irrelevant sound occupying the same phonological level of representation (e.g., Baddeley, 1990; Salamé & Baddeley, 1982). However, we now know that it too is attributable to the interaction between auditory perceptual and speech motor processes, as opposed to central phonological representations. Specifically, the interference arises from sequential affordances in both the task-relevant memory sequence and the task-irrelevant auditory sequence that compete for control of the speech motor process (e.g., Jones & Macken, 1993; Jones et al., 2004; Macken, Phelps, & Jones, 2009) in a manner analogous to that found in visuo-motor manual control (e.g., Pavese & Buxbaum, 2002). As we will see in the experiments that follow, the precise pattern of memory performance associated with lipread and auditory speech is similarly more amenable to an account couched in terms of the contribution of domain-general (i.e., not specifically verbal) and modality-specific perceptual and motor processes than to one based on the storage and manipulation of amodal phonological representations.

On the face of it, the parallels between lipread and auditory serial recall present themselves as an impediment to

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