Reduced multimodal integration of memory features following continuous theta burst stimulation of angular gyrus

Yasemin Yazara, b, Zara M. Bergström b, c, Jon S. Simonsa, b, *

a Department of Psychology, University of Cambridge, Cambridge, UK
b Behavioural and Clinical Neuroscience Institute, University of Cambridge, UK
c School of Psychology, University of Kent, Canterbury, UK

ABSTRACT

Background: Lesions of the angular gyrus (AnG) region of human parietal cortex do not cause amnesia, but appear to be associated with reduction in the ability to consciously experience the reliving of previous events.

Objectives/Hypothesis: We used continuous theta burst stimulation to test the hypothesis that the cognitive mechanism implicated in this memory deficit might be the integration of retrieved sensory event features into a coherent multimodal memory representation.

Methods: Healthy volunteers received stimulation to AnG or a vertex control site after studying stimuli that each comprised a visual object embedded in a scene, with the name of the object presented auditorily. Participants were then asked to make memory judgments about the studied stimuli that involved recollection of single event features (visual or auditory), or required integration of event features within the same modality, or across modalities.

Results: Participants' ability to retrieve context features from across multiple modalities was significantly reduced after AnG stimulation compared to stimulation of the vertex. This effect was observed only for the integration of cross-modal context features but not for integration of features within the same modality, and could not be accounted for by task difficulty as performance was matched across integration conditions following vertex stimulation.

Conclusion: These results support the hypothesis that AnG is necessary for the multimodal integration of distributed cortical episodic features into a unified conscious representation that enables the experience of remembering.

© 2017 The Authors. Published by Elsevier Inc. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

1. Introduction

Growing evidence indicates that the angular gyrus (AnG) region of lateral parietal cortex is critical for subjective aspects of contextual recollection that draw on the conscious experience of reliving previous events. Neuropsychological studies of patients with AnG lesions have demonstrated selective impairment on memory measures that emphasize experiential qualities of remembering, such as spontaneous autobiographical recall, ‘remember’ responses on remember/know tasks, and recollection confidence ratings [1–3]. Similarly, neuroimaging studies have reported enhanced AnG activity in healthy volunteers associated with assessments of recollective experience [4–6]. Recent TMS studies provide further evidence: targeting left AnG, Sestieri et al. [7] reported altered response bias in source memory attributions, indicating a role in the weighing of relevant retrieved information. Similarly, Yazar et al. [8] found that disrupting left AnG reduced participants' confidence in their contextual recollections.

Although a causal relationship between AnG and recollection has been identified, the information processing operations subserved by this region that enable the conscious experience of remembering remain unresolved. Here, we examine the proposal that during episodic memory retrieval, AnG supports processes that integrate retrieved event features of different modalities that are distributed across cortical regions into a coherent multimodal mnemonic representation [6,9,10]. Its position at the intersection between sensory association areas that are important for unimodal...
feature binding [11] makes Ang an ideal candidate for a role in the integration of cross-modal features to form a unified episodic memory representation. Moreover, its anatomical connectivity supports rich interactions with fronto-temporal and medial cortical regions associated with memory, such as hippocampus and precuneus [12]. Consistent with this proposal, Bonnici et al. recently observed neuroimaging evidence of greater Ang activity during retrieval of integrated multimodal episodic memories compared with unimodal episodic memories [9].

If Ang does indeed mediate multimodal integration during recollection then, in addition to being engaged during retrieval of multimodal memories, the region should be necessary for accurate performance on memory tasks that are dependent on such binding.

Previous neuropsychological and TMS studies used memory tasks that tested retrieval of one feature at a time, such as whether a male or female speaker had read a word aloud [3,8,13,14], which is insufficient to address this question. To test the hypothesis that Ang is necessary for integrating multisensory episodic memory features, we developed a task in which participants were asked to remember previously studied audiovisual stimuli and make recollective judgments that differed in the kind of episodic feature integration required.

The simplest form of retrieval involved recollection of only a single episodic detail, similar to previous studies, and no impairment following Ang TMS stimulation was expected. The key conditions of interest were memory judgments that required the integration of feature events either within the same modality, or across modalities. A role for Ang in integration regardless of modality would predict reduced performance following Ang stimulation in both conditions. If the role of Ang during recollection is, however, specifically to bind multimodal memory features into a conscious representation that enables the subjective ‘reliving’ of an event, as the neuroimaging results reported by Bonnici et al. [9] predict, then TMS disruption should reduce performance selectively when cross-modal integration is required.

2. Material and methods

2.1. Participants

Twenty-four healthy, right-handed, native English speakers (15 female), aged 21–34 years (M = 25.13, SD = 3.88), were recruited from volunteer panels. Participants were each tested on two separate occasions with site of stimulation (Ang or vertex) manipulated as a within-subjects variable. Participants were randomly assigned to receive Ang or vertex stimulation in their first session. All subjects had normal hearing and normal or corrected-to-normal vision and were screened for possible contraindications to TMS. Subjects gave informed consent to participate in the study in a manner approved by the University of Cambridge Human Biology Research Ethics Committee, and were reimbursed for their participation. Data from one participant had to be excluded because of failure to attend the second session, leaving 23 subjects who completed both sessions.

2.2. Stimuli

A total of 248 audiovisual stimuli were used, each comprising a natural scene picture, an object picture, and the spoken word that referred to the object. Scenes were selected from the database at http://image-net.org. All scene pictures depicted daylight settings, and were selected such that an object could be embedded into the left or right side of the scene and could have a spatial relation to another object in the scene, such as being on top of or underneath something else. The objects were selected from the Hemera Photo-Objects 5000 CD and from ‘Google Images’. The 248 words that referred to these objects were between three and twelve letters long, with a Kucera-Francis frequency of 20–100, familiarity ratings of 300–700, and concreteness and imageability ratings of 400–800 (chosen from the Medical Research Council Psycholinguistics database at http://tinyurl.com/mrc-database). All word stimuli were recorded in both English and Scottish accents by one female and one male speaker (resulting in four versions of each word) with the audio editor Audacity® (http://audacity.sourceforge.net/).

To create the source features for the different study conditions, each scene picture was edited using Microsoft Paint. The embedded object was inserted either on the left or on the right side of the scene picture and was located either on top of or under another salient object in the scene. Four versions of each visual stimulus were created, with the object either on the left side and on top of something else in the scene, on the left side and under something else in the screen, on the right side and on top of something else in the scene or on the right side and under something else in the scene. The word was spoken either by a female voice or by a male voice, speaking in either an English or a Scottish accent. The source test conditions were created in the following manner: visual and auditory stimuli could be tested for single source features (position: top; position: under: left/right; gender: male/female; accent: English/Scottish); or combined to test for within-modality source features (position: side and position: top/left, left/under, right/top, right/under; accent and gender: Scottish/male, Scottish/female, English/male, English/female); or combined to test for cross-modal source features (gender: position: male/female, top/female, top/male, under/male, under/female; accent and position: Scottish:top, English:top, Scottish:under, English/under; gender and side: male/female, male/female, female/male, female/right; accent and side: Scottish/Left, English/Left, Scottish/right, English/right); see Fig. 1 for an example. These combinations resulted in 24 different counterbalancing formats that were rotated across participants. Order of the conditions was pseudo-randomised with no more than three consecutive trials having the same source feature conditions.

2.3. Procedure

All participants completed the same memory tasks with different stimuli on two different occasions, one experimental (Ang stimulation), and one control session (vertex stimulation), with session order counterbalanced across participants. The two sessions were three days apart, scheduled at the same time of day. On both occasions participants underwent the same procedure: practice run, study phase, continuous theta-burst stimulation (cTBS) procedure, and test phase. At the beginning of the first session, each individual’s resting motor threshold was assessed (see cTBS procedure). Participants were then familiarised with examples of the visual and auditory stimuli and instructed about the different source conditions. Once subjects were familiar with the task, a practice session was completed.

In 72 study phase trials, a fixation cross was presented for 250 ms, followed by a 3500 ms presentation of the visual stimulus. Concurrently, the auditory stimulus was presented via loudspeakers. Subjects were prompted to make a pleasantness judgment about the object by pressing one key for ‘pleasant’ and another key for ‘unpleasant’. Following cTBS, in 208 test phase trials, after a 500 ms fixation cross, a written word was presented in the middle of the screen and participants were instructed to decide whether the word had been studied or was a new word. If participants responded ‘new’, the next stimulus was then presented, otherwise they were asked to make a source judgment. The type of source condition (single source, within-modal source, cross-modal source) was displayed at the top of the screen, the target word was presented at the middle of the screen, and the embedded object took up the lower part of the screen. Participants were instructed to select the target word and the embedded object on a shared feature that was either within the same modality or across modalities. For example, if the target word was ‘cute’ and the embedded object was ‘a cat’, participants were instructed to press the same button if the source was single modality (visual or auditory). If the object was ‘the cat is sitting on the sofa’, participants were instructed to press the same button if the source was cross-modal (visual and auditory).
دریافت فوری متن کامل مقاله

امکان دانلود نسخه تمام متن مقالات انگلیسی
امکان دانلود نسخه ترجمه شده مقالات
پذیرش سفارش ترجمه تخصصی
امکان جستجو در آرشیو جامعی از صدها موضوع و هزاران مقاله
امکان دانلود رایگان ۲ صفحه اول هر مقاله
امکان پرداخت اینترنتی با کلیه کارت های عضو شتاب
دانلود فوری مقاله پس از پرداخت آنلاین
پشتیبانی کامل خرید با بهره مندی از سیستم هوشمند رهگیری سفارشات