

Much ado about eye movements to nothing: a response to Ferreira *et al.*: Taking a new look at looking at nothing

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Ferreira *et al.* [1] outline an ‘integrated representation theory’ of the ‘looking at nothing’ phenomenon that we have previously documented [2–9]. We largely agree with the explanation by Ferreira *et al.* because we have argued for the same mechanisms ourselves in prior publications. Their claim to novelty rests upon a misrepresentation of our views (see Box 1). Here, we discuss the one novel claim that Ferreira *et al.* do make, concerning the consequence of looking at nothing, rather than the mechanism by which the looking is initiated. There is no evidence, as yet, that this consequence occurs.

In some of our studies, participants heard spoken facts and looked at areas of a grid that contained faces or animated objects [2,4,6]. Although answering a question about one of the facts, participants were more likely to look back to the location associated with that fact, even though the original object was now absent. In other studies [7,8], participants looked at a set of objects which were then removed. When they heard a sentence that discussed those objects, their gaze would return to the locations where the objects had been. The question we and Ferreira *et al.* address is, what sort of mental representations lie behind these looks to empty spaces?

We proposed that a ‘spatial index’ is part of the memory representation of an object or event (its ‘episodic trace’ [7,9]). This representation integrates auditory, visual and spatial information [2,4,9,10], and seems to use object-based attention [6]. Accessing some part of that memory representation (in response to a question or a description) causes activation of the spatial index, and triggers an eye movement towards the indexed location [2,4,6,7,9]. The proposal by Ferreira *et al.* is identical in this regard:

‘looking at nothing reflects...the existence of an integrated memory representation...when part of an integrated representation is reactivated, the other parts are retrieved as well. This, in turn, causes the eyes to move to the location in which the item originally appeared’ [1].

Ferreira *et al.*’s theory explains the same behaviour (eye movements to empty locations) for the same reasons (integrated auditory, visual and spatial memory representations) using the same theories [11,12].

Ferreira *et al.* reject our account because, they claim, we reject the idea of internal representations that are tied to spatial indexes. First, this claim is simply false (see Box 1). We have never maintained that internal representations do not exist [5,7–9]. Second, their rejection rests upon the fallacy of the denial of the antecedent. The antecedent in question concerns ‘external memory’ [13], the idea that people sometimes do not store particular information about the visual world, but instead access it with an eye movement when it is required. We speculated that if there is such a thing as external memory, then a spatial indexing mechanism could have a pivotal role. Ferreira *et al.* cast doubt on the ‘external memory’ account, and conclude that our account of spatial indexing must also be rejected. This would be true only if internal memory and external memory were mutually exclusive. However, there is no reason why an opportunistic and efficient cognitive system could not use both. This is what we proposed [5,6] and Ferreira *et al.* themselves endorsed when they describe participants offloading short-term memory burdens – or not – depending on the constraints of the task.

The novel empirical claim by Ferreira *et al.* that distinguishes their account from ours is that, ‘Looking at nothing facilitates memory retrieval for other information associated with that location, including visual details and linguistic content’. Ferreira *et al.* discuss how looks to empty locations have been found to improve memory for visual properties, but they present no evidence of memory for linguistic content being improved. We reported no relationship in our data [2,4,6] between looking behaviour and memory performance. Why might this be? Until evidence is reported where eye movements are manipulated as an independent variable, and memory for linguistic information is affected, we choose to remain agnostic. In the real world, sources of information such as people and objects tend not to disappear suddenly, and so looking back to their locations would refixate ‘bundles of associated cues that will help...recall the relevant information’ [6]. In our experiments, however, the visual displays were devoid of such useful visual cues (so that we could investigate the activation of purely spatial information). We suggested that the empty display accounted for the lack of memory improvement, but the eye movements themselves established the existence of memory representations that integrated spatial information, and reflected an ingrained

Box 1. Internal representations and spatial pointers

Ferreira *et al.* mischaracterize our claims. Altmann [7] is reported as arguing that looks to nothing arise 'because the visual system uses the world as an external memory rather than relying on internal representations' and that 'because there is no internal representation of what had been present before, the visual system does not detect that the display has changed from containing objects to being empty' [1]. Altmann actually wrote: 'One might suppose, however, that when the screen is entirely blank, the processing system would be aware that there was nothing relevant in the visual field', adding that, 'spatial pointers are a component of the episodic trace associated with each item – activating that trace necessarily activates the (experiential) component encoding the location of that item, and it is this component that automatically drives the eyes towards that location' [7]. In volumes edited by Henderson, Ferreira and others [8,9], Altmann and Kamide write that these eye movements 'do not appear to be contingent on a concurrent image; the locations to which eye movements are directed appear to be determined, at least in part, by the mental representation of the scene rather than by the scene itself'. Evidently, internal representations are key to our accounts.

habit of boosting internal representations by accessing external information.

By contrast, Ferreira *et al.* say that it is 'quite likely' that our null effects on memory were actually because of spatial codes improving memory. Their assertion (a concern which we raised ourselves in 2001 [3]) is that trials on which retrieval of a particular fact was difficult, might trigger more eye movements towards the empty locations (to facilitate retrieval) than easier trials. The improvement in accuracy engendered by these looks might be offset by the lower accuracy due to the trial being difficult – hence no observed effect on memory performance as a function of looking or not looking to the empty location. This entails that trials that are more difficult (as indexed by longer response times), should show an increasing proportion of looks towards the relevant screen location. However, a reanalysis of our data (from Ref. [6]) shows no such relationship ($r^2=0.004$).

In their 'new look' at looking at nothing, Ferreira *et al.* fail to acknowledge the similarity between their account and our own, misattributing to us the claim that there are no internal representations of the elements in a visual scene. Ferreira *et al.*'s account does go one step further, claiming a memory improvement for auditory semantic information when spatial information alone is active. We

agree that it would be a fruitful endeavor to establish evidence for this extension of the theory, but there have been numerous reported failures to find such evidence and Ferreira *et al.* provide none of their own. In short, with an absence of new data or new theory, and a failure to accurately characterize our prior work, the article does not advance beyond the empirical and theoretical contributions we have already offered.

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