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To cite this article: Andreea Zaman & Charlotte Russell (2021): Does auto-noetic consciousness in episodic memory rely on recall from a first-person perspective?, Journal of Cognitive Psychology, DOI: [10.1080/20445911.2021.1922419](https://doi.org/10.1080/20445911.2021.1922419)

To link to this article: <https://doi.org/10.1080/20445911.2021.1922419>



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Published online: 11 May 2021.



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Does autooetic consciousness in episodic memory rely on recall from a first-person perspective?

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ABSTRACT

Here, we review the literature on autooetic consciousness in episodic memory, our memory for personally experienced events, in order to understand its relationship to visual perspective. Autooetic consciousness is the sense of self we experience when recalling a memory from our life (Tulving (1985). Memory and consciousness. *Canadian Psychology/Psychologie Canadienne*, 26(1), 1–12). It is our ability to mentally travel through time, to re-experience and be subjectively aware of this as our memory (e.g. Wheeler, Stuss, & Tulving (1997). Toward a theory of episodic memory: The frontal lobes and autooetic consciousness. *Psychological Bulletin*, 121(3), 331–354). We examine whether reliving an event we have experienced is supported by our ability to recall from a first-person perspective. Considering that experiences start from the perspective of our own eyes, it seems reasonable to suggest that recall from a first-person viewpoint is associated with a greater subjective experience of travelling back in time to re-experience the event. Here, we review current measures of autooetic consciousness. We then present an overview of work on visual imagery and memory. Evidence relating to the visual perspective of imagery and autooetic consciousness will then be discussed. Finally, the review will encompass neural evidence for the role of the parietal cortex, angular gyrus in particular, in these processes as demonstrated by experimental manipulations of perspective in episodic memory.

ARTICLE HISTORY



Received 30 June 2020
Accepted 22 April 2021

Keywords

Autooetic consciousness;
episodic memory; first-
person visual perspective;
parietal cortex

Tulving coined the term episodic memory to distinguish memory for personal events from recollecting facts and knowledge about the world—semantic memory (e.g. Tulving & Donaldson, 1972). Rather than being a simple receptacle of event memories, the episodic system appears to facilitate mental travel through time, from the present to the past and the future. Vital to episodic memory is autooetic consciousness (Tulving et al., 1983). This refers to the capacity to mentally represent our continuous existence embedded in specific remembered events and contexts (Vandekerckhove et al., 2014), enabling us to become aware of subjective experiences from the past, present and future (Wheeler et al., 1997). Autooetic consciousness means that when we recall an event from our own life, inherent in this recollection is the ability to self-reference this experience. That is, we recollect it as an event that we ourselves experienced in our past.

Events we live through, and eventually might recall, are all experienced through the perspective of our own eyes. We interact with them in various and diverse ways, but the gathering of visual information and context from events is from an ego-centric—own eyes—perspective. This being the case it is likely that these self-referenced memories are more compelling at recall if they are accessible from the same perspective as they were encoded—the perspective of our own eyes or a first-person perspective. Indeed, it seems to be the case that this is the canonical way in which we recollect memories from our own life. If we attempt to remember the last time we had dinner with a particular friend, we are likely to construct a visual mental image of the scene of our dinner as we perceived it at the time. When we are able to mentally recreate the original perspective at recollection, we are likely to feel we are vividly recalling the

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particular event from our own life. As a result, accurate recall of the first-person perspective appears integral to complete episodic recollection. The use of the first-person perspective, when compared with the third-person or an observer perspective, is associated with increased vividness, a greater feeling of reliving or reexperiencing and increased emotional intensity in this recollective experience (e.g. Libby & Eibach, 2002; Marcotti & St Jacques, 2018; Palombo et al., 2018; Robinson & Swanson, 1993; Sekiguchi & Nonaka, 2014; St Jacques et al., 2017). Aside from subjective judgement, accessibility of the perspective used at encoding is likely to be beneficial to memory accuracy as this forms part of the spatial contexts of the actual event. For example, there is long-standing evidence that the availability of contextual cues from encoding facilitates memory retrieval (e.g. Godden & Baddeley, 1975). As a caveat to the statement that memories are always encoded from a first-person perspective, there are particular instances where this is not necessarily the case. For example, those with dissociative identity disorder experience the presence of two or more personality states or 'alters' and in some cases, one alter may encode events with a full episodic and auto-noetic status which is inaccessible to the other alters, as such these are third-person memories from the same body (Morton, 2018). Intriguing instances like this are an exception and as such are outside the scope of this brief review.

Here, we review evidence relating to the idea that the creation of a visuospatial mental image from our own perspective at retrieval might facilitate auto-noetic consciousness in episodic memory. In the first section, we discuss the experimental methods that have attempted to access essential features of auto-noetic consciousness in memory research. Research has operationalised auto-noetic consciousness in diverse ways, although all methods to date necessitate self-report. After that, we examine some of the large body of research on the relationship between visual imagery in episodic memory, as the self-reported vividness of remembered memories appears to be intricately linked to visual imagery abilities (e.g. Brewer & Pani, 1996; Conway et al., 2004). The third section reviews specific evidence that when a first-person perspective is available in the mental image used at recall, it leads to a stronger sense of re-experiencing the event. Finally, we turn to neuroscientific evidence linking the parietal cortex to the ability

to recall from a first-person perspective and, potentially, to facilitate auto-noetic consciousness in episodic memory.

1. Experimental methods for accessing auto-noetic consciousness

As defined above, auto-noetic consciousness is the sense of self we feel when we recall a memory (Gardiner, 2001; Tulving, 2002). In clarifying the features of this capacity, certain subjective experiences have been assessed. These include a sense of conscious recollection, a reliving of the event and/or a feeling of mentally travelling back in time. These three terms—recollection, reliving, mental time travel—might be seen as proxies for auto-noetic consciousness and indeed research has associated these subjective descriptions with that sense (e.g. see Irish et al., 2008). However, it is unknown if these three represent exactly the same capacity or indeed are interchangeable. In the measures discussed below, they are useful surrogates of auto-noetic consciousness as they are accessible and understandable to research participants. To this end, within this review, we refer to recollection, reliving and mental time travel as referring to a sense of auto-noetic consciousness.

The methods described below, which have measured auto-noetic consciousness, have highlighted a relationship between certain features of memory and an increased sense of auto-noetic consciousness. These features include vivid mental imagery and a large number of details. We do not take these features to indicate auto-noetic consciousness in themselves, but we are interested in how these may mediate the relationship between recall and auto-noetic consciousness.

As a step towards understanding whether the visual perspective of one's mental image at recall is important for auto-noetic consciousness, we need to understand how the capacity to experience auto-noetic consciousness has been measured. Below we consider some principal ways in which experimenters have tried to access this capacity.

1.1. Remember/Know paradigm

Perhaps, the primary measure experimenters incorporate into studies of episodic memory, when they would like to understand whether participants experience auto-noetic consciousness, is the Remember/Know paradigm (Tulving, 1985). The

Remember/Know paradigm attempts to quantify participants' experience when they recall a previously encoded item. In the original study (Tulving, 1985), participants studied a list of words, later presented in a recognition task, intermixed with unstudied words. For each word, participants made a 'Yes' or 'No' decision about whether the word had appeared in the study list. If the decision was 'Yes'—participants were asked if they 'remembered' seeing that word or 'knew' that the word had been presented. A 'remember' response was taken as evidence that participants recalled experiencing the presentation of that word in that specific experimental context. For a 'know' response, they recognised the word 'on some other basis', without self-recollection but merely an awareness of familiarity (Gardiner, 2001). The Remember/Know paradigm, aims to distinguish between two kinds of consciousness—knowledge involving the self (autonoetic), measured via 'remember' responses versus knowledge which does not involve the self (noetic) measured through 'know' responses (Tulving, 1985). The Remember/Know paradigm was developed further by Gardiner (1988). He defined 'Remembering' as the ability to become consciously aware of what was experienced at the time the test item was first presented, and 'knowing' as the recognition that a test item was previously presented, without the ability to consciously recollect anything about its actual occurrence or what was experienced at that time. Together, these definitions are perhaps the crux of why Remember/Know responses are often used as a proxy for autonoetic consciousness.

However, there are issues with using 'remember' judgements as a surrogate for autonoetic consciousness. For example, it has been shown that the way in which instructions are given in a Remember/Know paradigm changes how participants allocate their responses to each one (e.g. Geraci et al., 2009). More recently, Williams and Lindsay (2019) demonstrated that if further details were given to participants, which included that they should allocate a 'know' response if they have high confidence in having seen the stimulus but had no recollective experience, this choice was selected many more times than without this information. This suggests that the Remember/Know paradigm may often reflect participants' confidence levels in their response rather than necessarily the subjective recollective experience (see also, Dunn, 2004). In a clear demonstration of the difficulties in using this

measure, Umanath and Coane (2020) examined differences between how experts in different areas of psychology and lay participants, recruited via MTurk, define what it means when one says, 'I remember' versus 'I know'. Their results demonstrated that lay participants, unlike the experts, seldom used terms such as 'familiarity' for a 'know' response and much less frequently associated a 'remember' response with a recollection. Since the terms 'remember' and 'know' seem to reflect different cognitive processes, affected by prior knowledge, we can conclude that despite its universality, the Remember/Know paradigm may not be the best measure of autonoetic consciousness.

1.2. Field/Observer questioning

The Remember/Know paradigm aims to access information about autonoetic consciousness at recall but does not directly probe any specific aspects about the visual mental representation experienced, such as the perspective of this image. To measure this directly, the Field/Observer question has been incorporated into some autobiographical memory assessments. This measure explicitly asks participants to rate whether their memory was recalled from a Field (first-person) or an Observer (third-person) perspective. Nigro and Neisser (1983) assessed these two ways of recalling personal experiences, Field and Observer perspectives. This seminal study suggested that whether first—or third- person recall was used depended on the specific aspects of the event being recalled—for example, public speaking was more frequently recalled from a third-person perspective. However, the context of being watched giving a presentation is likely to prompt participants to focus on how they appeared to observers, potentially boosting the use of third-person recall in this situation. Since that study, most research using Field/Observer questioning has suggested that the first-person perspective is used most frequently for more recent episodic memories in young healthy participants and that recall from this perspective is associated with greater detail (e.g. see Verhaeghen et al., 2018). It is also clear that memories retained from the perspective in which they were encoded, i.e. first-person, remain more emotionally intense (see Sekiguchi & Nonaka, 2014). As a useful advance, the previous two studies and others (e.g. Berntsen & Rubin, 2006) adopt a continuous scale for Field/Observer judgements rather than employing a limited or

even binary choice. Given that this is a subjective judgement, this flexibility is likely to enable a more nuanced measurement of the experience.

A further distinction in the use of Field/Observer questioning is the use of separate scales for each perspective. That is, participants rate the degree to which the mental imagery of their recall is from a Field perspective (first-person) and separately rate the degree to which it is from that of an Observer (third-person). Research has shown that when healthy participants rated their memory recall on separate scales of the first- and third-person perspectives, both perspectives were rated as high, suggesting that that memory recall can be accompanied by more than one perspective (e.g. Butler et al., 2016; Rice & Rubin, 2009, 2011). Pertinent here is that ratings of vividness of the memory have correlated with first-person perspective, but not with third-person perspective ratings (Rice & Rubin, 2011).

1.3. TEMPau

Incorporating both the Remember/Know measure and the Field/Observer paradigm, Piolino and colleagues (e.g. 2003, 2006, 2009) created an autobiographical memory interview—Test Episodique de Memoire du Passe (TEMPau). This instrument addresses the state of consciousness and the self-perspective accompanying memory recall across the lifespan by using measures of episodic reexperiencing. Using the TEMPau, Piolino and co-workers tested the effects of ageing on episodic elements of autobiographical memory and measured auto-noetic consciousness. Participants freely recalled memories from five life periods. After the recall of each event, participants reported their visual self-perspective via the Field/Observer question, and the state of consciousness experienced via a Remember/Know paradigm. There was an age-related decrease concerning memory specificity and spontaneity in the autobiographical recall. Compared to young adults, older participants recollected recent memories from an observer (third-person) perspective more frequently and often rated memories as less vivid and ‘known’ rather than ‘remembered’. In the light of these results, the authors (2006) suggested that auto-noetic consciousness is relatively better preserved in older adults when they remember events from their distant past, rather than their recent memories. Of interest is the fact that first-person perspective in

older adults is not uniformly low for all ages of memory and in fact first-person recall is relatively preserved in memories made between 18 and 30 years of age (see Piolino et al., 2006). This might reflect the fact that this period incorporates the ‘reminiscence bump’ in which memories made during young adulthood appear more resistant to forgetting (e.g. Jansari & Parkin, 1996). In relation to this, in an online assessment of autobiographical memory, not using the TEMPau, Janssen et al. (2011) examined the relationship between age of participants, age of the memory and the subjective experiences of reliving and vividness at recall. In this study, the sense of reliving and vividness of the memory was greater in more recent memories, compared to remote memories. Surprisingly, older adults rated their memories as higher on both these scales than younger adults.

In relation to the evidence presented above, studies using TEMPau in clinical populations, in particular those with depression, have produced intriguing results regarding memory, emotional content and visual perspective. For example, currently euthymic depressed patients showed a reduction in a compound measure of episodic specificity from the TEMPau (including number of details recalled, ratings of auto-noetic consciousness and field perspective) for positive memories only (Bergouignan et al., 2008). Separate analysis revealed that although auto-noetic consciousness itself was not reduced for positive memories, field perspective was (see also, Lemogne et al., 2006; 2009). This evidence suggests that processes underlying auto-noetic consciousness may be dissociated from the first-person perspective at recall in some clinical populations. Taken together, work examining visual perspective and auto-noetic consciousness in psychiatric groups and across the lifespan in the sizable online study of Janssen et al. (2011) suggests that there should be caution in assuming that there is always a strong universal association between recollection, analogous to auto-noetic consciousness, and the availability of the first-person perspective at recall. In certain circumstances, it appears that this might not be the case.

In contrast, there is evidence that the older the event being recalled, the less episodically detailed memories become and thereby less associated with auto-noetic consciousness (e.g. Palombo et al., 2018). In this account, the malleable nature of memory allows it to be sensitive to mnemonic influence, whereby information from the original

event is diminished, so existing knowledge is used to reconstruct this aspect of the memory (e.g. Butler et al., 2016), analogous to the idea that memories become semanticised over time (Cermak, 1984).

1.4. Assessment of auto-noetic consciousness

A thorough and direct measurement of auto-noetic consciousness is the Assessment of Auto-noetic Consciousness, developed by Irish et al. (2008). For each memory participants recollect in this paradigm, they answer a series of questions aimed at targeting potential aspects of auto-noetic consciousness or auto-noetic 'reliving'. 'Reliving' in this assessment is used as an index for the presence of auto-noetic consciousness in the memory. After recall, participants rate the vividness of their recall, perspective of recall, continuity of imagery, emotional re-experiencing, overall re-experiencing, emotional valence and a question explicitly asking whether they feel they are 'reliving' the memory or simply 'looking back'. In a factor analysis of these questions, Irish et al. (2011) demonstrated that recalling the imagery of the event with great continuity (like a 'video') was associated most strongly with a sense of 'reliving' the memory at recall. In this analysis, tagging the event as being recalled from an 'own eyes' perspective was less associated than continuity of imagery with the sense of reliving the event. This useful approach allows an important delineation of factors that might be involved in auto-noetic consciousness. However, we would suggest that this relatively long series of questions to a mixed group of participants (healthy middle-aged, healthy older aged and a group with mild Alzheimer's Disease) might not provide a full understanding of the relevant processes as yet. There remains an important question of what constitutes the mental experience when perceiving a memory recalled with 'continuous imagery'. For instance, it is possible that when the first-person perspective is available within this continuous image, it facilitates the sense of reliving. Also, as discussed above, there are some difficulties with lay interpretations of Remember/Know questions. We have experienced this ourselves with Field/Observer judgements as participants often note the binary choice is a suboptimal fit with their subjective experience (Kapsetaki et al., *in press*). Specifying what is being asked in these questions more closely and

using continuous scales might interrogate these mental processes more effectively.

Assessment of a mental experience such as auto-noetic consciousness is inherently challenging. Some elegant experimental designs have tried to capture the markers of auto-noesis, but there is no one measure that is universally accepted to be a surrogate for this capacity of our episodic system. We would suggest that there are three potentially helpful approaches to explore. First, it would be beneficial to create standardised instructions for the complex questioning used to access mental experience at recall. Second, the use of experimenter delineated numerical scales for ratings might be better replaced with continuous or sliding scales, which are more clearly interpreted by participants. As discussed above, this has been used in studies looking at visual perspective. We have recently compared continuous scales to delineated numerical scales and elicited additional distinctions between subjective recall experiences in older when compared with younger adults (Watkins-Muleba et al., *in prep*). Finally, any measure that does not need to rely on self-report would be a huge step forwards as this would negate the need for participant interpretation of experimental instructions and/or the required response.

2. Relationship between quality of visual imagery and episodic memory

In the previous section, we have seen that the mental imagery available at retrieval is central to measures of auto-noetic consciousness in memory. Visual imagery is an essential characteristic of the phenomenology of recollection in episodic memory and therefore, any individual differences in imagery style or in associated skills will potentially be revealing (e.g. see Brewer & Gardner, 1996; Conway et al., 2004; D'Argembeau & Van der Linden, 2006; Greenberg & Knowlton, 2014). For example, Greenberg and Knowlton (2014) did not find a relationship between autobiographical memory and a standard scale of visual imagery (Vividness of Visual Imagery Questionnaire (VVIQ; Marks, 1973) but a clear correlation between visual imagery during recollection and a greater sense of reliving one's own experience. This result is consistent with previous work showing that visual imagery is necessary, but not sufficient for a strong sense of re-experiencing (Rubin et al., 2003). Greenberg and

Knowlton (2014) delineated their participants into 'verbalisers' or 'visualisers' in relation to mental imagery in memory and demonstrated that both relied on visual imagery for a sense of reliving the memory but that the verbalisers also found their sense of reliving enhanced by auditory imagery (see also Vannucci et al., 2016). This individual difference in mental imagery relates usefully to the work of Palombo and colleagues who have examined the impact of variations in imagery processes on autobiographical memory (e.g. Palombo et al., 2015, 2018). In a particularly clear demonstration, participants with Severely Deficient Autobiographical Memory (SDAM), which is a lifelong deficit in recalling events from one's own life, were seen to be able to recall verbal information at an equivalent level to control participants but were significantly impaired in their autobiographical memory—including the level of 'visualisation' while remembering (Palombo et al., 2015).

A small proportion of individuals appear to lack the ability to form visual mental images entirely, a phenomenon that has been called *aphantasia* (e.g. Zeman et al., 2016). Zeman et al. (2010) reported a 'pure' case of imagery disorder in a 65-year-old man who became unable to bring images to his mind's eye after coronary angioplasty. Following this case study, the same group described a larger sample ($n=21$) with a lifelong lack of mental imagery, termed *congenital aphantasia*. Importantly, two-thirds of these individuals reported difficulties with re-experiencing autobiographical memories (Zeman et al., 2015). In a very recent study in this group, Dawes et al. (2020) investigated whether people with *aphantasia* report reduced imagery in other sensory domains and assessed self-reports of episodic memory ability. Two hundred and sixty-seven participants with *aphantasia* and two large control samples completed The Episodic Memory Imagery Questionnaire (EMIQ; Dawes et al., 2020) and the Vividness of Visual Imagery Questionnaire mentioned earlier. Those with *aphantasia* reported less vivid and phenomenologically rich autobiographical memories, suggesting a constructive role for visual imagery in forming a mental representation of episodic events.

It should be noted that these studies were not directly concerned with the visual perspective for imagery generated during memory retrieval. However, via different sources and methodologies, these studies provide evidence that imagery itself

is important in episodic autobiographical memory. Coherent visual imagery is associated with more vivid recall and a sense of reliving a life event—both of which are important for the sense of *autonoetic consciousness* in the memory. We turn now to evidence relating directly to the visual perspective inherent in this imagery.

3. Role of visual perspective in episodic recall and *autonoetic consciousness*

We have seen that visual imagery is strongly associated with a richer experience in recalling a memory and that when a first-person perspective is available at recall, the memory is potentially more subjectively compelling. Here, we discuss research directly examining the role of the first-person perspective in memory recall in order to understand if there is sufficient evidence to claim that first-person, own eyes, perspective at recall is necessary for a sense of *autonoetic consciousness*.

In our earlier section on experimental measures of *autonoetic consciousness*, we discussed measures of visual perspective in episodic recall. These measures ask participants to express whether memory retrieval was from a *Field* (first-person) or *Observer* (third-person) perspective. Within this work memories that are rated as being more from a first-person perspective are consistently scored as more detailed, more vivid and associated with a greater sense of reliving an episode from one's life (e.g. Butler et al., 2016; Marcotti & St Jacques, 2018; Robinson & Swanson, 1993; Sekiguchi & Nonaka, 2014; St Jacques et al., 2017; Verhaeghen et al., 2018). For example, Sekiguchi and Nonaka (2014) demonstrated a reduction in subjective reports of experienced emotional intensity during memory retrieval when participants shifted from a first- to a third-person perspective during recall. This effect persisted in memories retrieved one month later. This link with emotion and first-person perspective was replicated by Siedlecki (2015).

In an experimental study with a laboratory-based episodic memory task, rather than episodic autobiographical memory interviews, Butler et al. (2016) involved participants in 'mini-events' so that these experienced events could serve as encoded stimuli for later recall. Over the following three weeks, they asked participants to repeatedly retrieve memories for these, without any specific instructions. Results demonstrated that when memory for these

events was repeatedly retrieved from a first-person perspective, the memory remained clearer and richer (Butler et al., 2016). A large body of research on visual perspective in episodic memory has been carried out by St Jacques and co-workers. This work has shown that in healthy individuals, shifting from the encoding perspective at retrieval can reduce the overall memory accuracy, leading to a reduction in reported subjective vividness (e.g. St Jacques et al., 2018, 2017; Marcotti & St Jacques, 2018; for a review, see St Jacques, 2019). For example, as in Butler et al. (2016), in an encoding session, Marcotti and St Jacques (2018) engaged their participants in a series of multi-sensory mini-events. A week later, participants returned and were asked to recall these mini-events either from the original own-eyes perspective or from the perspective of an observer and to rate the vividness of each recall experience. In this way, Marcotti and St Jacques were able to objectively measure whether the accuracy for these mini-events was affected by switching perspectives at recall. Shifting to a third-person perspective did indeed reduce overall accuracy in memory recall and the authors were able to correlate this decline of accuracy with the self-reported vividness in the recall session. These experimental studies did not directly assess auto-noetic consciousness within the recalled memories, but the results speak to a differentiation in the subjective experience available at memory recall when the first-person perspective through which the memory was originally encoded is preserved. In further related work, it has been shown that being able to view a body part from one's first-person perspective (e.g. a pointing arm) during an encoding task facilitates memory for the associated event (e.g. see Bréchet et al., 2019). This potentially suggests that additional cues in relation to one's own self- perspective enhance our ability to recall events.

An alternative and complementary standpoint to consider when thinking about the role of perspective in auto-noetic consciousness is work on one's own 'self' concept. Experimental work appears to suggest that there might be differences in the perspective used when recalling memories relating to our current self when compared with, what we judge to be, our 'past self'. Libby and Eibach (2002) have shown that depending on the compatibility of our current self-concept with our past selves, episodic memories can be retrieved either from a first- or third-person perspective. For

example, people remember high-school memories related to aspects of themselves they believe have changed from a third-person rather than first-person perspective, due to their sense of discrepancy between that memory and their current self-concept. The same authors outline that when participants are asked to focus on remembering an event itself they use first-person recall but this changes to third-person when, rather than the event itself, they are asked to 'focus on the broader significance of this event in your life' while recalling (Libby & Eibach, 2011). Therefore, first-person recall is linked to experiential recall of an event and third-person recall to a broader evaluation of the event in our life. However, the picture regarding features of third-person recall is complex and perhaps dependent on task instruction. If participants are asked to judge how they have *changed* since the event they recall from a third-person perspective, they are inclined to associate themselves less with the 'self' who experienced the event. Whereas if they are asked to judge *continuity* between themselves in the memory and at the present time, they associate themselves more with the event even if it is recalled from a third-person perspective (see Libby et al., 2005). In the clinical literature, different forms of psychiatric illness are seen to modulate whether a recalled memory is easily associated with participants' current sense of self. This association is related to both emotional content of the memory and visual perspective at recall (see Janssen et al., 2015). For example, those with depression rated negative memories as psychologically closer, i.e. related to their sense of current self. Directly related to the current topic, when participants' experienced a sense of reliving during recall, this was strongly associated with the use of first-person perspective and a sense of the memory being closer to their current sense of self. This work, on clinical groups, is further evidence converging on the relationship between recall perspective and the sense of self-experienced at recollection. Seemingly, the sense of one's self across time affects and is affected by the visual perspective used when recalling autobiographical memories.

The studies presented above highlight a possible link between visual perspective and vividness of visual imagery, emotional reexperiencing and episodic richness in memory recall. We seem to re-experience episodes more intensely and vividly when we recall these from the same perspective we used at encoding. When shifting from a first- to a third-

person perspective, memories are rated as less vivid, with fewer emotional components and less sense of re-experiencing. Importantly, this is not due to shifting recall perspective itself as a shift from third to first person does not result in these decrements. The bulk of evidence appears to connect recall from a first-person perspective with characteristics that are associated with auto-noetic consciousness. Additionally, work on the self-concept within autobiographical memory demonstrates that the first-person recall is attendant in memories which are more readily associated with our current concept of our self. However, much of the work on perspective in memory does not directly assess auto-noetic consciousness for these memories. Additionally, as we have already seen, measuring auto-noetic consciousness in an experimental paradigm is challenging. It is possible that understanding the underlying neural basis of the relationship between the first-person perspective and episodic memory will help elucidate whether this is connected to auto-noetic consciousness.

5. Neural evidence regarding the relationship between visual perspective, episodic recall and auto-noetic consciousness

Computational and neuroimaging evidence suggests that to create an accurate image of the world around us— from our own first-person perspective—we rely on the parietal cortex (see Burgess et al., 2001; 2002; Burgess, 2008; Lambrey et al., 2012). The parietal cortex is fundamental within episodic recall with its role is being increasingly specified (for reviews Rugg & King, 2018; Sestieri et al., 2017). Here, we will examine the evidence for the role of the parietal cortex in visual perspective and auto-noetic consciousness in episodic memory.

5.1. Neuropsychological evidence from patients with parietal lesions

Performance of patients with damage to parietal cortices in episodic memory tasks reveals subtle deficits in the vividness and richness of recall despite overall accuracy in these tasks (e.g. Berryhill, 2012; Davidson et al., 2008; Drowos et al., 2010). Directly related to the assessment of auto-noetic consciousness, patients with damage to the parietal cortex produce fewer ‘Remember’ responses in

Remember/Know paradigms and demonstrate abnormally high confidence for incorrect responses (e.g. Simons et al., 2010; Hower et al., 2014). In assessments relying on autobiographical interviews, patients with parietal damage are able to freely recall events from their own lives, but their recollections are scored as vague, imprecise and lacking detail (Berryhill et al., 2007; Berryhill, 2012). In a seemingly clear demonstration of a possible link between parietal cortical damage and auto-noetic consciousness, Davidson et al. (2008) gave patients a battery of neuropsychological tests; the Remember/Know paradigm using word pairs, a Remember/Know paradigm during autobiographical memory recall and the Autobiographical Interview (Levine et al., 2002). Although the patients did not have amnesia, they appeared to have an impairment of auto-noetic consciousness. Specifically, they made fewer ‘Remember’ judgements both in the episodic word pair task and in the autobiographical interview. Crucially, recollections made by the patients were accompanied with a poor sense of having experienced this event themselves. This evidence suggests that the parietal cortex may be involved in the subjective experience during episodic recall, which also extends to impairments specific to egocentric spatial information in these episodic memories (see Ciaramelli et al., 2010, 2017).

Based on the evidence of the types of subjective memory impairment seen in parietal patients and considering its widely accepted role in egocentric spatial representation, Russell and colleagues developed a paradigm to directly examine whether patients with lesions in the parietal cortex have difficulty discriminating, at recognition, their own encoded perspective of a scene from an alternative perspective (Russell et al., 2019). In this study, participants were presented with 3D tableaux, created in front of them from everyday items, while wearing a head-camera. They were told that images would be taken from this camera to be used in a recognition task. In the retrieval phase, the visual perspective was manipulated, whereby images were either presented from the original, first-person, perspective or a shifted perspective. Patients with damage to the lateral parietal cortex were impaired in discriminating scenes that had shifted from their encoded perspective from those that were identical to how they had been encoded. This deficit was specific to the spatial perspective aspect of the task as patients were equivalent to control participants in discriminating their

own encoded scenes from those in which the items in the scene had moved but the perspective was held constant.

5.2. Neuroimaging and neurostimulation evidence for the role of angular gyrus

Neuroimaging studies have enabled detailed analysis of parietal cortex subregions involved in aspects of episodic recall associated with autonoetic consciousness; much of this evidence appears to converge around the angular gyrus in the posterior parietal cortex (see Bréchet et al., 2018; Ramanan et al., 2017). Tibon et al. (2019) recently directly linked angular gyrus activity with the vividness of recall in an episodic task. In this task, during encoding, participants were explicitly asked to generate an association between two pictures (or a pair consisting of one picture and one sound) and were later tested on recall of the non-presented associate in a memory test. During the retrieval stage, activation in the angular gyrus was strongest for vividly remembered associates. Trelle et al. (2019) confirmed the involvement of the angular gyrus at retrieval in an episodic task—in both younger and older adults—when stimuli were correctly recollected. Further, Bonnici et al. (2016) demonstrated that classification accuracy in multi-voxel pattern analysis increased within the angular gyrus as participants reported greater vividness of recall. We also used multi-voxel pattern analysis in a study with healthy individuals using the head-camera paradigm described in the patient study above (Russell et al., 2019). This revealed that when participants judge whether a presented scene is from their own head-camera, i.e. from their own first-person perspective, the region involved in accurately judging this is the angular gyrus in both hemispheres.

Some important and revealing studies on the role of the angular gyrus in episodic recall have used neurostimulation to disrupt activity in the left angular gyrus. Disruption with repetitive TMS (Sestieri et al., 2013) and continuous theta burst stimulation (cTBS, Yazar et al., 2017) suggested that the subjective experience of remembering was impaired in participants without a loss in the accuracy of recall. A direct demonstration of the potential role of the angular gyrus in the first-person perspective during memory recall is the reduction of memories recalled from this perspective in the autobiographical interview after disruptive cTBS to

the angular gyrus (Bonnici et al., 2018). Our lab has recently attempted to enhance rather than disrupt the maintenance of perspective in episodic recall using transcranial direct current stimulation (tDCS) of the left angular gyrus, and this appears to enhance subjective sense of recall of the types of scenes of everyday objects we used previously in the head-camera task (Watkins-Muleba et al., in prep).

5.3. Neuroimaging evidence of precuneus involvement in studies of visual perspective

The angular gyrus is not the only subregion of the parietal cortex to have been associated with the visual perspective of mental imagery in episodic memory recall. There is also converging evidence for a role for the precuneus. St Jacques and colleagues (2017) asked participants to shift the original perspective from which they retrieved autobiographical memories, while providing subjective ratings on the degree to which memories were spontaneously retrieved from a first- or third-person perspective. During fMRI scanning, participants were asked to retrieve the memories from an alternative perspective to that used previously (e.g. shift from the first-person perspective to the third-person perspective or vice versa). Shifting from the original to an alternative perspective during retrieval of autobiographical memories was supported primarily by parietal cortices, in particular the precuneus. The precuneus has also been implicated in other functional imaging studies of episodic recall and its activation associated with both first-person and third-person recall (e.g. D'Argembeau et al., 2007; Eich et al., 2009; Freton et al., 2014; Grol et al., 2017). Data from a recent analysis of brain networks involved in recalling from differing visual perspectives suggest that connectivity between the parietal cortex, in particular precuneus, with the hippocampus and other central parts of the episodic network is stronger when participants recall from a third- rather than first-person perspective (Iriye & St Jacques, 2020). Furthermore, directly related to egocentric first-person recall in episodic autobiographical memory, Hebscher et al. (2018) demonstrated that individuals with a preference for the first-person perspective had higher precuneus volume.

From this evidence, at least part of the role of the parietal cortex in episodic memory is associated with the visual perspective from which the

memory is recalled. The precuneus appears to have a varied role and to potentially be involved with both first- and third-person recall. Convergent evidence, using different methodologies, implicates the angular gyrus with both recall from a first-person perspective and in the subjective qualities of recollection that are associated with auto-noetic consciousness. More work is needed to understand how performance across different tasks correlates to auto-noetic consciousness and to make a complete link between behavioural performance of memory for one's own perspective in objective tasks such as in Russell et al. (2019) and the subjective characteristics of memory recall which are associated with angular gyrus (e.g. Bonnici et al., 2016, 2018). Important here and potentially a way to tease apart the roles of angular gyrus and precuneus in the relationship between visual perspective and other aspects of episodic memory is the examination of effective connectivity between these regions and the hippocampus. The hippocampus has long been considered crucial for vivid recall of rich and detailed past episodes (e.g. Scoville & Milner, 1957). Research has shown that functional and effective connectivity between the hippocampus and parietal cortex is associated with mentally reliving a memory (see McCormick et al., 2015) and, more specifically, that a functional connection between both precuneus and angular gyrus and hippocampus is associated with the precision of a recalled memory (Cooper & Ritchey, 2019 mar 22). Increased clarity in the operationalisation of auto-noetic consciousness will enable neuroscience to probe these regions and their relationships for the neural correlates of this sense (see Dafni-Merom and Arzy (2020) for recent meta-analysis of the work examining functional neural activity in the sense of auto-noetic consciousness).

Conclusion

Auto-noetic consciousness allows us at any moment, to travel through time to remember past episodes. When we project our self into the past to re-experience an episode, we form a mental representation, which we 'see' in our mind's eye.

This auto-noesis may increase flexibility in preparing for future contingencies and has been proposed to be fundamental to adult human episodic memory (Klein, 2016; Suddendorf & Corballis, 2007). Throughout this review, we have used the term auto-noetic consciousness, but this has been

distinguished from a perception of auto-noetic awareness by Tulving (e.g. Tulving, 1985). Auto-noetic consciousness allows us to mentally represent ourselves in our past but does not determine what we are recalling in a particular moment. In contrast, auto-noetic awareness is the explicit awareness of ourselves in our memory recollection—a current mental representation. This subtle but essential distinction between auto-noetic consciousness and awareness implies that when the episodic system is engaged in active recollection of a relived experience that process must be accompanied by auto-noetic awareness, and this awareness is made possible by our capacity for auto-noetic consciousness. We suggest that this distinction might relate to proposals that episodic memory infused with auto-noetic 'reliving' represents a specific type of retrieval, distinct from the other modes of episodic retrieval (see Irish et al., 2011). Irish and her colleagues propose that most episodic memories may be recalled with some degree of auto-noetic consciousness but that explicit re-experiencing may signify an end of the remembering continuum. This suggests that to help us understand the determinants of auto-noesis in memory we should distinguish between episodic recall without reliving and episodic recall with reliving. It might be the case that a first-person perspective within recollection is specifically associated with auto-noetic awareness and explicit reliving of our memories.

An important step to enable us to determine whether first-person perspective is strictly necessary for auto-noetic awareness in memory is a clear and accepted measure of the presence of this sense within recollection. We have seen within this review that most current measures are problematic to some extent. Intriguing to us is the strong relationship between continuous 'video-like' imagery and the experience of reliving (Irish et al., 2011). It will be informative to understand how the layperson conceptualises 'video-like' mental imagery as this will enable us to pick apart the important constituent elements of this type of visual imagery. As stated earlier, we might expect the first-person perspective to play a role within this conceptualisation, even if not explicitly noted by participants.

This leads us to the challenge of whether a measure that does not rely on self-report could ever represent auto-noesis in memory. We created our head-camera task specifically to probe the role of the parietal cortex in episodic memory. If it is

possible to associate performance on this task with a reliable measure of auto-noetic awareness at the time of recollection, it might mean similar tasks can be developed which indirectly tap into this important human capacity. Understanding auto-noetic consciousness and its potential change across the lifespan is important. We know that many of the features that change in episodic memory with increasing age are associated with a decreasing lack of specificity in episodic recall and a heavier reliance on third-person recall. If we could measure directly whether auto-noetic consciousness changes as we get older, perhaps specifically with changes to auto-noetic awareness, it might shed light on the increasingly larger number of older adults reporting memory problems that are not associated with deficits in current objective memory tests and who thereby receive a diagnosis of subjective cognitive decline (see Howard, 2020; Jessen et al., 2020).

Our capacity for auto-noetic consciousness is intriguing, enabling us to maintain a steady representation of ourselves throughout our changing life. It is too early to confirm that first-person visual mental imagery is necessary for and fully supportive of auto-noetic consciousness, but we believe that the evidence presented here suggests that further investigation of this relationship is likely to be both fascinating and fruitful.

Disclosure statement

No potential conflict of interest was reported by the author(s).

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