

Review

Brain Mechanisms of Reality Monitoring

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Reality monitoring processes are necessary for discriminating between internally generated information and information that originated in the outside world. They help us to identify our thoughts, feelings, and imaginations, and to distinguish them from events we may have experienced or have been told about by someone else. Reality monitoring errors range from confusions between real and imagined experiences, that are byproducts of normal cognition, to symptoms of mental illness such as hallucinations. Recent advances support an emerging neurocognitive characterization of reality monitoring that provides insights into its underlying operating principles and neural mechanisms, the differing ways in which impairment may occur in health and disease, and the potential for rehabilitation strategies to be devised that might help those who experience clinically significant reality monitoring disruption.

How Do We Know What Is Real?

Thinking back over your life, you can often find yourself mentally transported back in time, reliving a past episode, sometimes in vivid detail. Except – how do you know that you were actually there when the event originally took place? How can you be sure that you are remembering a faithful representation of what happened, as opposed to an event you might have previously imagined, or a story told to you by someone else? In short, how do you determine whether your memories are real?

One prominent theory, the Source Monitoring Framework, proposes that there are decision processes involved in making attributions about the origin of information that comes to mind, including discriminating information that was generated by internal cognitive functions, such as thought and imagination, from information that was derived from the outside world by perceptual processes ('reality monitoring' [1,2]). According to this framework, memories do not contain propositional tags that directly specify their source. Instead, we make attributions about the origin of a mental experience by considering its features in light of assumptions about the characteristics that tend to be associated with various sources. For example, a person might infer that an apparent 'memory' rich in visuoperceptual detail is likely to be real ('I can remember what the dentist's office looked like' [3]) whereas one comprising mainly traces of internally generated thoughts might instead have been imagined ('I could remember I had a very specific reason for making the association'; 'I made the decision by knowing what my train of thought was during the exercise' [4]).

Reality monitoring errors tend to involve misidentifying internally generated events as being real, for example misattributing particularly vivid imaginations to perception, or assuming that the absence of memory for cognitive operations indicates that a memory is unlikely to have been self-generated [4], although misattributions in the other direction also occur, such as in cryptomnesia [5]. Similarity between potential sources increases the likelihood of source errors [6]. For example, misattribution errors are more common for auditory than visual stimuli,

Trends

Mounting evidence identifies anterior prefrontal cortex as playing a key role in reality monitoring, the ability to distinguish internally from externally generated information.

Individual differences in reality monitoring performance in healthy volunteers are associated with variability in functional activity and structural morphology in this region of the brain.

Differences are also seen in clinical conditions such as schizophrenia, in which people sometimes experience disturbed awareness of what is real.

Dysfunction in anterior prefrontal cortex increases vulnerability to misidentify internally generated information as external in origin, providing a possible neurocognitive basis for psychiatric symptoms such as hallucinations.

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perhaps because ‘inner speech’ and real speech tend to be more similar than visual imagery and actual visual perceptions and, hence, are more vulnerable to confusion [7]. It is important to note that the features that are activated when a ‘target’ memory is cued are determined by processes engaged during encoding of the event (e.g., the quality of feature binding), during the interval between the initial event and the act of ‘remembering’ (e.g., the number of reactivations), and during retrieval (e.g., the cue eliciting the memory). In addition, features from other events can be activated at any point, potentially influencing the characteristics of the remembered event [8]. In addition to the phenomenal qualities of mental experiences, reality monitoring may also involve explicit retrieval of supporting or conflicting information, and may be influenced by prior knowledge, beliefs, and motives [9]. Thus, there are multiple factors operating during encoding and retrieval, as well as in the intervening period, that can produce source misattributions in healthy individuals, and multiple ways that processes can be disrupted in clinical populations.

In the past few years a number of laboratories around the world have explored the brain mechanisms underlying reality monitoring processes using cognitive neuroscience methods including functional brain imaging of healthy volunteers and studies of neurological, psychiatric, and developmental disorders, as well as of normal aging [10]. The aim has been to understand how the brain supports our capacity to determine the sources of mental experiences, including distinguishing what is real from what we have imagined, an ability that is vital for maintaining confidence in our memories, and in understanding ourselves as individuals in the world with a past and a future. In characterizing how these processes might be instantiated in the brain, we can better understand the way in which they may break down in disorders such as schizophrenia, in which a person’s relation to reality can be altered in ways that disrupt their everyday functioning.

Anterior Prefrontal Cortex (PFC) and Reality Monitoring

Neuropsychological and neuroimaging studies have identified a network of brain regions involved in the recollection of source information, which include prefrontal, medial temporal, and parietal cortices [10–12]. In broad terms, regions of PFC are thought to provide cognitive control over the encoding and retrieval of feature representations that are bound together in a spatial frame by the hippocampus and further integrated by parietal cortex into a first-person perspective that supports the subjective experience of remembering [9,13]. The role of the PFC appears to be particularly crucial for source memory, and lesions to the frontal lobes typically cause severe difficulties with the recollection of such contextual details even when old/new item recognition is unimpaired [14,15]. Distinct prefrontal regions may make separable functional contributions to source memory [11], with ventrolateral PFC subregions linked to the specification of retrieval cues and the maintenance of retrieved information, and the dorsolateral PFC exhibiting activity during post-retrieval monitoring [16–18].

One region that has emerged as playing a key role in reality monitoring is the anterior PFC, an area right at the front of the brain that, in relative terms, is roughly twice as large in the human brain than in even the great apes [19]. It has lower cellular density and higher dendritic complexity than comparable cortical regions [20], and is thought to be among the last areas to achieve myelination [21], enabling nerve cells to transmit information more rapidly and facilitating more complex cognitive abilities. As such, although the functions performed by this area are not well understood, they have generally been considered likely to be among the ‘higher’ levels of human complex cognition [21–24]. The role played by the anterior PFC in memory has been difficult to characterize. Several neuroimaging experiments published in the early 2000s reported activation in this region during the recollection of source details [16,18,25,26], but this was not consistently observed [17,27,28]. An absence of anterior PFC activity could of course always be attributable to insufficient experimental power or to

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