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The Neuroanatomy of Autobiographical Memory: A Slow Cortical Potential Study of Autobiographical Memory Retrieval

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Changes in slow cortical potentials recorded at the scalp were tracked while participants retrieved autobiographical memories and then held them in mind. During retrieval extensive areas over left frontal scalp exhibited marked negative dc shifts and a similar though smaller effect was also observed over right frontal regions. As a memory was formed and then held in mind, electrodes located over posterior temporal and occipital regions exhibited marked negative shifts. It is proposed that the left frontal negativity primarily reflects cortical activation associated with the operation of a complex retrieval process, whereas the later temporal and occipital negativity (the result of the retrieval process) reflects activation corresponding to the formation and maintenance of a detailed memory.

Key Words: EEG; retrieval; frontal lobes; autobiographical memory; neuroanatomy of memory; temporal-occipital lobes.

Our understanding of higher order forms of cognition such as autobiographical remembering is gradually but systematically increasing. The function of autobiographical knowledge in defining identity, linking personal history to public history, supporting a network of personal goals and projects across the life span, and ultimately in grounding the self in experience are all aspects of this type of remembering currently receiving sustained investigation (cf. Conway & Pleydell-Pearce, 2000, for review). In striking contrast, our comprehension of the neural substrate that supports this central form of cognition is based largely on a series of case studies of brain damaged patients and a very small number of neuroimaging studies (cf. Conway & Fthenaki, 2000, for review). This lacuna is a serious impediment to theory construction and to developing an understanding of the ways in which autobiographical memory can be disrupted and lost following, injury, trauma, and the effects of age. Here we attempt to redress this imbalance by reporting the first systematic study of autobiographical memory using the electroencephalogram (EEG). As is shown the findings are striking, lend support to a current theory of autobiographical remembering (Conway & Pleydell-Pearce, 2000), and deepen our understanding of the neural substrate of autobiographical memory (AM). In addition, and also of importance in our view, they demonstrate that the neurophysiology of this type of “higher order” cognition can be effectively studied using the well-established technology of EEG (see Rugg & Coles, 1995). Indeed, the fine temporal resolution of EEG makes it uniquely

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suited to studying complex cognitive processes that are extended in time.

Currently the study of autobiographical memory has advanced to a point at which there is consensus on some of the broad cognitive features of this type of remembering. Two features generally agreed upon and supported by a wide range of findings are that (1) autobiographical memories are mental constructions (of the self) and (2) they very often feature imagery while simultaneously containing abstract personal knowledge (see Conway, 1990, 1996a; Conway & Pleydell-Pearce, 2000, for reviews). Our own model of autobiographical memory is built around these common features and within it specific memories are conceived of as transitory dynamic mental constructions effortfully generated and effortfully maintained for comparatively brief periods of time (seconds and minutes) by centrally mediated control processes that operate upon a complex underlying knowledge base (Conway, 1992, 1996a; Conway & Fthenaki, 2000; Conway & Pleydell-Pearce, 2000; see too Moscovitch, 1992, 1995; Moscovitch & Melo, 1997, and Wheeler, Stuss, & Tulving, 1997, for related lines of theorizing). This model can be mapped onto data from studies of AM following neurological injuries and in a recent review we concluded that disruption of the generative/construction process was mainly associated with damage to networks in anterior regions of the brain, e.g., frontal lobes, temporofrontal junction, and temporal poles, whereas impairments to access of knowledge of specific AMs was associated with damage to networks in the middle and posterior regions, e.g., medial temporal lobes (MTLs), posterior temporal lobes, temporal-occipital junction, and occipital lobes (see Conway & Fthenaki, 2000, and also Markowitsch, 1998). This view somewhat obscures the fact that specific cases vary considerably. Nevertheless a strong inference that can be drawn from the patient data is that because AM is disrupted by many different lesion sites, then widely distributed networks must contribute to the construction process. It also seems highly probable that these topographically distributed networks become involved in memory construction at different points in the process as it dynamically unfolds over time. Although, it should be noted that at the moment, nothing is known of the actual temporal sequence of neural processes that must underlie autobiographical memory construction.

This latter point is of importance both in it's own right and also because it is of considerable significance to models such as those of Conway and Pleydell-Pearce (2000) which postulate a particular pattern of widespread cortical processing that changes over time as a memory is formed. The claim of widespread brain activation during memory construction is itself hardly a novel one; however, the more specific claim that activation extends over time starting in (left) frontal networks and terminating (at memory formation) with a shift of activation to right hemisphere posterior networks is indeed a new proposal and a critical claim of the Conway and Pleydell-Pearce (2000) model. The important point here being that autobiographical remembering is a dynamic process extended in time and present in particular brain regions at different points during memory construction. These brain regions mediate various cognitive structures postulated by Conway and Pleydell-Pearce to underpin the construction of autobiographical memories. In the study reported here, then, we used the fine temporal resolution of EEG recordings to track changes in slow cortical potentials (SCPs), measured from the scalp, as these occur during the process of memory construction, holding a memory in mind, and dismissing a memory from mind. Our aim is to identify which regions of neocortex are recruited at which points during autobiographical memory construction and so build a map of the flow of activity characteristic of autobiographical remembering. This will be a critical test of the neuroanatomical processing postulated by Conway and Pleydell-Pearce (2000) and, by implication, of the cognitive structures they suggest enable this type of remembering. It is this latter aspect of the model that we briefly consider next.

The Self-Memory System

Conway and Pleydell-Pearce (2000) propose that AMs are constructed in what they term the *Self-Memory System* (SMS) which is a multicomponent memory system superordinate to