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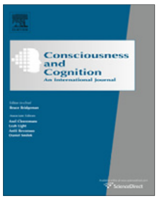

Memory, autonoetic consciousness, and the self ☆

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ABSTRACT

Memory is a general attribute of living species, whose diversification reflects both evolutionary and developmental processes. Episodic-autobiographical memory (EAM) is regarded as the highest human ontogenetic achievement and as probably being uniquely human. EAM, autonoetic consciousness and the self are intimately linked, grounding, supporting and enriching each other's development and cohesiveness. Their development is influenced by the socio-cultural–linguistic environment in which an individual grows up or lives. On the other hand, through language, textualization and social exchange, all three elements leak into the world and participate to the dynamic shaping and re-shaping of the cultural scaffolding of the self, mental time traveling and EAM formation. Deficits in self-related processing, autonetic consciousness, emotional processing and mental time traveling can all lead to or co-occur with EAM disturbances, as we illustrate by findings from EAM impairments associated with neurological or psychiatric disorders.

1. Introduction

Memory is a multi-facetted attribute of all animals and may even be found in rudimentary forms in the flora and in so-called intelligent machines. This speaks for a million year-long process of memory evolution. More recent theories in psychology and the neurosciences have acknowledged this process by proposing different memory systems, especially in phylogenetically advanced species. The endowment with a developed body that has enabled the exploration of the environment over wide distances (embodiment; Pfeifer & Bongard, 2007) has most likely led to the diversification of memories as well as the need to store information long term (cf. Campbell & Garcia, 2009). This is evident in species such as certain birds (Miyata, Gajdon, Huber, & Fujita, 2010; Weir, Chappell, & Kacelnik, 2002), whales and dolphins (Reiss & Marino, 2001), elephants (Plotnik, de Waal, & Reiss, 2006), the great apes (Bard, Todd, Bernier, Love, & Leavens, 2006; Call & Tomasello, 2008; Kitchen, Denton, & Brent, 1996), and New World capuchin monkeys (de Waal, Dindo, Freeman, & Hall, 2005). Furthermore, being a social animal and engaging in cooperative behavior (Brosnan & Bshary, 2010; de Waal & Suchak, 2010; Melis & Semmann, 2010) required and enabled a more flexible application of mental capacities (Blakemore, 2010), though it is still debated whether and to what degree animals developed at least rudimentary abilities of foresight, prospection, and theory of mind (e.g., Gilbert & Wilson, 2007; Hare & Tomasello, 2005; Miyata et al., in press; Osvath, 2010; Roberts & Feeney, 2009; Suddendorf, Addis, & Corballis, 2009a; Suddendorf, Corballis, & Collier-Baker, 2009b). Similar to memory, basic self–non-self distinctions, such as the ones linked to physiological processes of immunity or digestion, are features of all viable species. The main unanswered question is the extent to which different species are capable of higher levels of conscious self-representations and self-awareness. Tulving (2005) has a clear position when stating "I argue that only human beings possess

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'autonoetic' episodic memory and the ability to mentally travel into the past and into the future, and that in that sense they are unique." (p. 4). Though debated, his position has been supported by a number of findings also from human memory research (Botzung, Denkova, & Manning, 2008). Firstly, not all human beings possess the ability for mental time traveling: Patients with severe mental retardation or dementia may lack this capacity and patients with other disorders may show deficits in integrating autobiographic memories with autonoetic consciousness and their selfhood. Examples are individuals with Asperger syndrome or autism. Tanweer, Rathbone, and Souchav (2010) found that adult Asperger individuals recalled in comparison to matched controls fewer events from their personal past and rated them much less specifically (responding more frequently to them as being just 'known', but not 'remembered' – a finding typical for patients with amnesia; see, e.g., Bengner & Malina, 2008; Hirano, Noguchi, Hosokowa, & Takayama, 2002; Noulhiane et al., 2008; Yonelinas, Kroll, Dobbins, Lazzara, & Knight, 1998). They also made in comparison to the controls fewer social identity statements and provided more abstract, trait-linked identities. Individuals with autism were found to have an atypical neural response pattern to judgments about their self, when their brains were studied with functional neuroimaging methods (Lombardo et al., 2010). The authors also detected "that the magnitude of neural self-other distinctions in the ventro medial prefrontal cortex was strongly related to the magnitude of early childhood social impairments" (p. 611).

Secondly, developmental studies have emphasized socio-cultural–linguistic mechanisms that may be unique to the development of EAM. Small children – similar to animals – live initially in the here and now (Nelson, 2005a, 2005b). Their episodic-autobiographical memory (EAM) develops together with their self, theory of mind capacities, emotional conceptual knowledge and capacity for mental time traveling (Ghetti, DeMaster, Yonelinas, & Bunge, 2010; Rochat, 2010). Social context plays a critical role in the development of all the above neuro-cognitive functions. It was, for example, shown that simply listening to the voice from a tape recorder is not sufficient for learning early aspects of language, but instead infants require the social presence of a person (Adolphs, 2010; Kuhl, Tsao, & Liu, 2003). Theory of mind functions furthermore "appear only after children have become experienced verbal communicators" (Surian, Caldi, & Sperber, 2007, p. 580). The onset of EAM and the ToM capacities in the offspring (Nelson & Fivush, 2004) depend on the degree of elaboration of the reminiscing style of their mothers. The importance of the social component for the emergence of ToM capacities is also reflected by findings that in institutionalized children ToM capacity correlated with the adult–child ratio (Bedny, Pascual-Leone, & Saxe, 2009). Developmental changes of EAM (e.g. pertaining to autonetic consciousness) extend however beyond childhood into early adolescent years (Picard, Reffuveille, Eustache, & Piolino, 2009) and may include in late childhood (ages 8–12 years) the ability to suppress memories (Paz-Alonso, Ghetti, Matlen, Anderson, & Bunge, 2009).

On the brain level these EAM developmental changes in humans (from infancy to early adulthood) are reflected in the extensive structural and functional reorganization of different components of the neural networks supporting EAM, autonoetic consciousness and self-referential processing, ToM capacities and ability for emotional regulation (Shing et al., 2010). From a comparative cognitive-neuroscience perspective, frontopolar cortex (BA10) shows the biggest relative increase between great apes and human beings. BA10 activation recently has been found to be correlated with working memory capacity and general intelligence (Colom, Jung, & Haier, 2007). The basolateral nuclear group of amygdala shows a "progressive enlargement from insectivores to prosimians and finally simians" (Sarter & Markowitsch, 1985b, p. 348), while vice versa the centromedial nuclear group "shows a clear regression" along this phylogenetic scale. This is in line with ideas that in more phylogenetically evolved species the basolateral nuclear group expands to encompass higher cognitive–emotional functions such as EAM in the case of human beings (Cahill, Babinsky, Markowitsch, & McGaugh, 1995).

One question which remains is concerned with the role of EAM in humans. Does indeed the EAM through its intrinsic feature of mental time traveling play a main function in the survival, as it has lately been emphasized repeatedly? And if the appearance of EAM is indeed adaptive, why did it not occur in other species? Is it in fact possible that certain claims of cognitive differences between humans and other species are the product of an underdeveloped experimental methodology rather than species differences per se? Or may it be the case that the main function of EAM is in fact social – a suggestion that was put forth by several authors, though it has not been an explicit focus of extensive experimental investigations yet (Markowitsch & Welzer, 2009; Welzer & Markowitsch, 2005). A hint in favor of this hypothesis comes from the work with patients with Alzheimer's dementia: Fargeau et al. (in press) found that the social self was impaired earliest in this patient group.

In the current paper, after a presentation of memory systems and their neural correlates, we will provide a review of the relationship between EAM, autonoetic consciousness and self, by preponderantly drawing on the socio-cultural–linguistic developmental model advanced by Nelson and Fivush (2004). We will then argue that EAM disturbances can result from deficits in the accurate re-collection of the encoding context, mental time traveling, emotional disturbances or self-related processing. By describing several EAM disturbances associated with both neurological and psychiatric diseases, we will demonstrate that many (especially severe) EAM impairments arise or exist in combination with dysfunctions in the realms of emotion, self, mental time traveling and social functioning.

2. Memory systems

Memory is not unitary, but can be deconstructed along a time and content axis, respectively. Along the time axis, memory was traditionally divided into short-term and long-term memory. The short-term memory has a limited capacity of a few bits (4–7) (Cowan, 2000; Miller, 1956) and encompasses a time range of seconds to minutes. Any information that is not lost and exceeds the limited capacity of short-term memory is assigned to long-term memory stores. The above time-related