small subset showed excitation. These excitatory responses have been shown to be specific for particular items (Quiroga et al. 2005). Inhibition of firing to previously seen stimuli may serve to increase signal-to-noise ratio, thereby supporting sparse coding and effective mnemonic processing. Furthermore, preliminary data suggest that some cells in the hippocampus show excitatory responses to a particular item only when that item is encountered alone or in the context in which it was originally encountered (Viskontas 2006).

More recently, evidence has emerged supporting a role for the MTL in imagining future experiences. In a positron emission tomography (PET) study, Okuda et al. (2003) found greater or equivalent levels of activation while subjects spoke about future prospects versus past experiences in the right hippocampus and bilateral parahippocampal cortices. Similar results were reported in a fMRI study comparing past and future event elaboration, in which the left hippocampus and bilateral parahippocampal cortices were commonly engaged by both tasks (Addis et al. 2007). Interestingly, the authors also report that construction of future versus past events uniquely activated the right hippocampus. Neuroimaging results are supported by reports of marked impairments in imagining future events in patients with hippocampal amnesia (Hassabis et al. 2007).

As the aforementioned neurocomputational, single-unit recording, functional MRI, PET, and patient studies suggest, there is a wealth of evidence supporting a role for the hippocampus in both episodic memory and in envisioning future experiences. Although we do not deny that the prefrontal cortex plays an important and complementary role in these processes, we find that S&C rely too heavily on the recent evolution of this region in humans in arguing against mental time travel in other species. In fact, a recent study of scrub jay behavior suggests that these birds are, in fact, capable of future planning without reference to their current motivational state, or fixed action patterns, challenging the notion that future planning requires a prefrontal cortex (Raby et al. 2007). The hippocampus is phylogenetically among the oldest parts of the brain, and may therefore allow nonhuman animals to project both backwards in time and forwards into the future. Thus, as increasingly innovative nonverbal tests of episodic memory develop, we may be surprised to discover the time-traveling capabilities of a variety of species.

Emotional aspects of mental time travel

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Abstract: We consider three possible reasons why humans might accord a privileged status to emotional information when mentally traveling backward or forward in time. First, mental simulation of emotional situations helps one to make adaptive decisions. Second, it can serve an emotion regulation function. Third, it helps people to construct and maintain a positive view of the self.

Suddendorf & Corballis (S&C) convincingly argue that memories of past events and images of future ones are not literal representations of the past and future, but are instead the products of generative, constructive processes that (re)create mental representations by (re)arranging pieces of information retrieved from memory (see also Schacter & Addis 2007a). The resulting representations can therefore be highly selective, and the pieces of information that are encoded, maintained, and retrieved from memory in priority are those that are most relevant to an individual's goals, beliefs, and concerns (Conway 2005). Emotion plays an important role in this selection process, as it signals the occurrence of information that has potentially important implications with regard to goals (Ellsworth & Scherer 2003). Consequently, emotional stimuli are typically remembered with more details than neutral stimuli (D'Argembeau & Van der Linden 2005; Kensinger et al. 2006), and autobiographical memories for emotional events are associated with a higher subjective feeling of mentally reliving the past (D'Argembeau et al. 2003; Talarico et al. 2004). In addition, for both past and future, representations of positive events are associated with a greater feeling of re-experiencing (or pre-experiencing) than representations of negative events (D'Argembeau & Van der Linden 2004). In this commentary, we would therefore like to suggest that humans accord a privileged status to emotional information when they mentally travel backward or forward in time, and we consider some reasons why this might be the case.

S&C argue that the primary function of mental time travel is to enhance biological fitness in the future: Mentally simulating various versions of the future, and their respective consequences, enables one to act flexibly in the present to increase one's future survival chances. We completely agree, and would add that the affective charge of the generated mental images is a key element in this respect, the driving force that guides our current decisions. Affective states associated with mental simulations of positive and negative outcomes motivate us to engage in certain types of behaviors (e.g., start a diet) and to avoid others (e.g., quit smoking), in order to maximize the probability of attaining our goals. Future rewards and punishments need not be consciously represented to guide decision making (Bechara & Damasio 2005), but the conscious mental simulation of emotional situations, through mental time travel, undoubtedly provides unique information that promotes successful adaptation to life circumstances. Negative memories remind people of their past errors and provide cues on how to avoid undesired outcomes or minimize their consequences, whereas positive memories remind people of their past accomplishments and provide cues on how to attain success. These pieces of information regarding the personal past can be used to generate representations of the future that specify (a) which situations should be approached or avoided, and (b) how to maximize the probability of attaining/avoiding them. Mental imagery, especially visual imagery, may play a particularly important role in representing such goal-related information, as it is a sort of "language" of goals (Conway et al. 2004). Interestingly, it has been found that people who have higher visual imagery capacities generate more detailed representations of their personal past and future, and rate their representations of future events as being more emotional and meaningful (D'Argembeau & Van der Linden 2006). It would be interesting to investigate whether these individual differences are correlated with the ability to make adaptive decisions. Alternatively, the ability to envision detailed emotional past and future events should be explored in individuals who show impairments in judgment and decision-making in real-life settings, such as patients with lesions of the ventromedial prefrontal cortex (see Bechara & Damasio 2005).

Although the primary function of emotional aspects of mental time travel may be to help one make adaptive decisions, mental representations of emotional episodes probably serve other functions as well. Representations of emotional events induce significant modifications of emotional responses and feelings (Damasio et al. 2000), and may therefore be used to regulate affective states. Sometimes we remember or imagine positive experiences, not so much to help us make decisions or plan future actions, but simply to feel better in the present. There is evidence that people occasionally retrieve positive events in order to repair a negative mood (McFarland & Buehler 1998). Note that the use of mental simulations to regulate mood states is not always straightforward, however; people probably use rather complex strategies that may vary across situations. For example, one may strive to generate or prolong a positive affective state by envisioning negative events (e.g., how things might be worse), which allows one to feel good in comparison (Sanna 2000).

Finally, a third function of the emotional aspects of mental time travel may be to provide material to support representations of the self. Most people hold positive views of themselves and are more willing to consider information that bolsters their self-image than information that contradicts it (Baumeister 1998). Thus, memory tends to be biased toward confirming positive self-views. For example, as mentioned earlier, positive episodes are subjectively experienced with more details and with stronger feelings of (re)living than negative episodes, for both the past and the future (D'Argembeau & Van der Linden 2004). In addition, when asked to think about their future, people spontaneously imagine more positive than negative events (Newby-Clark & Ross 2003) and judge positive events as being more likely to happen (Weinstein 1980). The importance of the balance between positive and negative future thinking is further revealed by its disturbance in certain psychopathological conditions. For example, depressed individuals tend to generate fewer positive future events, while anxious individuals tend to generate more negative future experiences (MacLeod & Byrne 1996). Positive biases in representing the past and future probably help maintain a positive view of the self and foster optimism concerning one's personal future, which may promote physical and mental health (Taylor & Brown 1988).

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Storing events to retell them

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Abstract: Episodic memory is certainly a unique endowment, but its primary purpose is something other than to provide raw material for creative synthesis of future scenarios. Remembered episodes are exactly those that are worth telling. The function of episodic memory, in my view, is to accumulate stories that are relevant to recount in conversation.

As the authors of the target article suggest, episodic memory (EM) can be seen as a "plug-in" device added to a standard vertebrate brain, and quite an expensive one, as much of our cortical mass seems devoted to it. Suddendorf & Corballis (S&C) are certainly right to say that it demands an evolutionary explanation. Their suggestion is that EM serves only the practical purpose of providing raw material for future planning. In a similar attempt to provide an evolutionary account for EM, Brown and Kulik (1977) highlighted the benefit of storing unexpected and highly emotional events, as "a marked departure from the ordinary in a consequential domain would leave [the individual] unprepared to respond adequately and endanger his survival" (p. 97). The problem with such accounts is that EM is badly designed for its alleged function.

Does an optimal use of storage capacity leave room for the memory of instantiated episodes? In machine learning, rote learning is an inefficient strategy. The purpose of any learning task is to make generalization possible. A good way to perform induction is to aggregate experience into structures such as prototypes or clusters. Storing particular instances (e.g., cluster centers) generally makes sense if they are statistically representative. This function is implemented in living beings through semantic and procedural memory.

To delineate categories, it may be useful to remember borderline instances, as with support vectors (Cornuejols & Miclet 2002). Also, in certain applications in which data are scarce and non-homogeneous, storing actual encountered examples, regardless of their representativeness, may be a viable strategy. The Case-Based Reasoning technique (Kolodner 1993) aims at solving new problems by matching them with memorized known examples. Superficially, episodic memory could be understood as a biological implementation of these principles, but its actual form does not match up to the assignment.

Episodic memory is highly selective. It retains a tiny fraction of all our daily experiences. One may come across dozens of people each day and remember only a few encounters per month. Selected episodes are, however, retained with a significant amount of detail, including what S&C call the www criterion. From an efficiency perspective, details such as the precise location in space and time, the weather conditions, the persons present, the words exchanged, and so forth, are most often irrelevant and yet are almost systematically remembered, even in the long term in cases when emotion is high (Brown & Kulik 1977). From a computational perspective, not only do such details represent a waste of storage, they also hinder and mislead retrieval matching.

An alternative view is that EM is an outgrowth of the language faculty (Dessalles 2006). It is not fortuitous that *memorized episodes are exactly those which are narratable.* People spend one fifth of their waking time in spontaneous conversation (Dunbar 1998), and a significant share of this time is devoted to reporting past events (Tannen 1984, p. 99; Eggins & Slade 1997, p. 265). Interlocutors draw from their memory relevant episodes that they can relate to the current conversational topic and they systematically try to recount them. However, only a tiny fraction of past experiences may be recounted in this way. One crucial requirement is that reported stories must appear *unexpected* (Dessalles, in press).

The requirement of unexpectedness provides also a good prediction of the kind of episodes that are preferentially stored in memory. To appear unexpected, a situation must be *less complex* (i.e., more easily describable) than expected (Dessalles, in press). Witnessing a six-legged cow makes both a memorable event and a good story to tell, just because this cow, thanks to its unique peculiarity, requires a minimal description to be distinguished from all others. If, as we claim, the primary purpose of storing episodes is to offer material for future recounting, then systematically remembering details such as time and space location makes perfect sense. If the six-legged animal lives in the vicinity, interest is raised. Not specifying the location would leave the listener with the idea that that location requires a lengthy description, and interest drops down. By computing complexity differences, one can derive the way interest varies according to location and time, and according to various factors such as the persons involved (Dessalles, in press). For instance, the interest of coincidentally encountering someone increases with the remoteness (and thus complexity) of the place and with the simplicity of that person, if she happens to be a celebrity or a close acquaintance. It is thus crucial, when memorizing an episode, to remember every detail that may affect the cognitive complexity of the situation.

It may seem surprising that the expensive resources devoted to EM serve such a futile purpose as everyday chatter. This is only because one fails to see that casual conversation is an arena where much of our social existence is decided (Dessalles 2007). Eliciting interest through conversational stories is a high-stakes game. Boring participants are rapidly ignored and may lose their friends. When it comes to establishing solidarity bonds,