The Royal Road to Time: How Understanding of the Evolution of Time in the Brain Addresses Memory, Dreaming, Flow, and Other Psychological Phenomena

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Source: *The American Journal of Psychology*, Vol. 128, No. 1 (Spring 2015), pp. 1-14

Published by: University of Illinois Press

Stable URL: https://www.jstor.org/stable/10.5406/amerjpsyc.128.1.0001

The Royal Road to Time: How Understanding of the Evolution of Time in the Brain Addresses Memory, Dreaming, Flow, and Other Psychological Phenomena

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It has been claimed that dreams are the royal road to the unconscious mind. The present work argues that dreams and associated brain states such as memory, attention, flow, and perhaps even consciousness itself arise from diverse conflicts over control of time in the brain. Dreams are the brain's offline efforts to distill projections of the future, while memory represents the vestiges of the past successes and survived failures of those and other conscious projections. Memory thus acts to inform and improve the prediction of possible future states through the use of conscious prospects (planning) and unconscious prospective memory (dreams). When successful, these prospects result in states of flow for conscious planning and déjà vu for its unconscious comparator. In consequence, and contrary to normal expectation, memory is overwhelmingly oriented to deal with the future. Consciousness is the comparable process operating in the present moment. Thus past, present, and future are homeomorphic with the parts of memory (episodic and autobiographical) that recall a personal past, consciousness, and the differing dimensions of prospective memory to plan for future circumstances, respectively. Dreaming (i.e., unconscious prospective memory), has the luxury to run multiple "what if" simulations of many possible futures, essentially offline. I explicate these propositions and their relations to allied constructs such as déjà vu and flow. More generally, I propose that what appear to us as a range of normal psychological experiences are actually manifestations of an ongoing pathological battle for control within the brain. The landscape of this conflict is time. I suggest that there are at least 3 general systems bidding for this control, and in the process of evolution, each system has individually conferred a sequentially increasing survival advantage, but only at the expense of a still incomplete functional integration. Through juxtaposition of these respective brain systems, I endeavor to resolve some fundamental paradoxes and conundrums expressed in the basic psychological and behavioral processes of sleep, consciousness, and memory. The implication of this conceptual framework for the overall conception of time is then briefly adumbrated.

It may be conceptually feasible that physics will eventually resolve many, if not all, of the fundamental problems of duration (Hawking, 1988). Indeed, a comprehensive description of duration as the relationship between object and object in the universe would seem to represent, on an intellectual level at least, a prospectively achievable goal (Russell, 1915). However, in its present incarnation at least, physics cannot resolve the problem of time because time is a relational property necessarily involving the pres-

ence of a living observer (cf., Gibson, 1975; Grondin, 2001). If we want to solve the mystery of time as a subject–object relationship, as opposed to duration, which is an object–object relationship, and especially if we want to understand the subtleties and nuances of our subjective perception of time, we have to look to the brain and its evolutionary organization (Striedter, 2005; and see Hancock, 2010).

For the most part this means looking into the human brain. Even referring to this organ as *the* brain encourages the view that this structure is an exclusively coherent and discrete entity. Certainly this is how it is conceived of in the everyday world. However, the brain is a multileveled, multistructured system that represents an evolutionary palimpsest in which newer structures have necessarily been erected on older ones and more complex response processes have been superimposed on simpler and more primitive behavior patterns. Our phenomenological experience tells us that this hybrid system, our brain, works, but this perception of normality is largely an illusion of habit. Such a habitual assumption is reinforced and supported by the manifest absence of personal, dysfunctional forms of brain activity that we see in those with either chronic or acute damage or disease of the brain (see Cohen, 1967). Buttressed by labels such as "the unity of consciousness," our belief in the normality of putative everyday experience is more a result of intellectual neglect and the dominance of hubris than it is of understanding and insight.

Time in the Brain: A Descriptive Approach

If my preceding premises are valid, then all of human time as we can know it is to be found in the brain. Our experience of time results from the interaction between at least three, somewhat discrete brain mechanisms that deal with the temporal processing of change in the pattern of environmental stimulation encoded as duration. A highly descriptive framework of this tripartite division is given in Figure 1. Because each level is necessarily erected on its forebear, intrinsic evolutionary constraints are placed on the latter two of these three respective brain mechanisms. The earliest (nominally lowest) of these mechanisms concerns the continuity of the perception of self, where *self* is used in a very wide and general sense. This capacity of self-distinction is shared by all living organisms (Schrödinger, 1944).

Indeed, distinction of self provides essential information about the persistence of an organism's existence in space and time. Because all living organisms possess both spatial and temporal extent, a vital survival requirement is that they be able to distinguish self from nonself. Spatially, this obligatory distinction is accomplished at the respective boundary layers between organism and environment (for an allegorical insight into such boundary conditions see Abbott, 1884; for a possible phenomenological exception see Ehrsson, 2007). However, in addition to the necessary spatial differentiation, a comparable temporal distinction must also be sustained. In humans, the most evident action of this mechanism is found in the brain stem, although as a character of all living things this function is certainly cellular in its most primitive form (Calvin, 1983). For human perception, the classic model by Treisman (1963) represents an important foundation from which to evaluate this particular level. Treisman's model is dependent for its original pulse train on some form of endogenous oscillation. While modified by factors such as temperature (see Hancock, 1984, 1993; Hoagland, 1933), the precise neurophysiological nature of this foundational pulse train and its various neuroanatomical and neurophysiological pathways continues to be the topic of highly active investigation (see Wittmann & Wassenhove, 2009).

At the next level, beyond the necessity for identified self-persistence, almost all organisms to survive must synchronize their activities with the durational constraints of the environment that surrounds them. Perception–action systems permit the organism to achieve these critical synchronous responses. In nature, such responses are independent of any necessary reference to an external, arbitrary timekeeping convention, such as a clock (cf. Cleeremans & Sarrazin, 2007; Gibson, 1979; Hancock, 2005b; Hancock & de Ridder, 2003; Hancock & Manser, 1997). With the selective evolutionary advantage of social interaction, these latter external formalized referents (e.g., clocks; Cipolla, 1967) have become useful to humans. However, as social constructs, clocks and the "time" they render remain only incompletely integrated with the former intrinsic perception–action responses (cf., Montemayor, 2012). Thus, we humans can generate social "time" tags that help describe our environmental actions, but we do not need to do so.
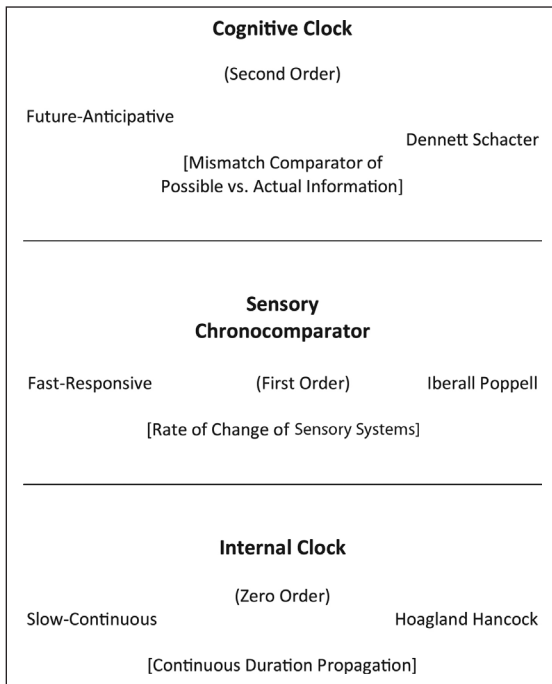
Cognitive Clock

(Second Order)

Future-Anticipative

Dennett Schacter

[Mismatch Comparator of
Possible vs. Actual Information]

**Sensory
Chronocomparator**

Fast-Responsive   (First Order)   Iberall Poppell

[Rate of Change of Sensory Systems]

Internal Clock

(Zero Order)

Slow-Continuous   Hoagland Hancock

[Continuous Duration Propagation]

FIGURE 1. 3-level representation of human temporal capacities and their respective functions. The lowest level, the "internal clock," dispenses a continuous analog signal whose primary role is to sustain the persistence of self. This function is influenced by body temperature. It is rare that this capacity is suspended, although there are circumstances in which this does happen, as in some forms of anesthesia. The second level, the sensory chronocomparator, compares capacities across **differing** forms of sensory input (and by implication different effector) systems. These cross-comparisons do not need to reference any external, arbitrary timekeeping mechanism. The primary function of this level is the synchronization of perception–action with the external spatiotemporal constraints of the world. The third level, the "cognitive clock," is designed to go "faster than real time" by anticipating the future. Thus the cognitive clock in real time spends its existence searching through immediate percepts for anticipation matches. In non–real time (i.e., in dreams), it tries various possibilities (mental simulations) concerning unlikely courses of events and thus the perplexing nature of dreaming

An example of this convenience of social timing is seen in athletic competition, where it is necessary to use an external clock referent to establish world records (i.e., an absolute time comparator). Such a record is then open for challenge by all others around the world, as long as the timekeeping mechanism does not vary from one location to the next. In contrast, in the majority of Olympic Games events, the gold medal winner has only to beat all other competitors on that day in the final race. To win the latter contest the athlete does not necessarily need to get anywhere near the world record, and so in such events, absolute timing is unnecessary. (Of course, those viewing the spectacle are interested also in whether world records are broken, and many contests are becoming so close that deciding a winner is now determined by the electronic timing mechanism rather than a human judge; see Riegel, 1981, and Liu, Paul, & Fu, 2012). As a general proposition, most of the activity in perception–action systems lives in the world of relative timing in which other external events set the context (i.e., the actions of a predator), not some absolute timing framework.

If the lowest-level function provides self-persistence and the next superimposed level of perception–action deals with imperative responses to the immediacy of present survival demands, where is nature to go in order to improve any organism's temporal, survival capacities? The answer, at least in the human brain, has been to find a way to go "faster than time" (and see also Kahneman, 2011). Largely centered on functions in the frontal cortex, humans exceed the constraints of real time by generating a series of "what if" scenarios that permit the anticipation of possible courses of future events. This is especially true when they have to face very stressful and challenging conditions (Hancock & Warm, 1989; Hancock & Weaver, 2005). This highest-level temporal mechanism, which acts to project, compare, and confirm possible courses of action, shows that memory itself is largely an artifact created by the requirements to anticipate the future (and see Hancock, 2005a). This initial and general tripartite division also helps us begin to address the nature and function of various types of sleeping phases, which represent forms of truce in this battle for control of time in the brain by the three respective control levels. We can couch these arguments in a brief excursion into one question at the heart of empirical psychology that was posed before psychology itself was even considered a scientific term or a formal branch of knowledge.

A Question of Temporal Integration
The preceding overview is an overarching introduction to the issue of time and the brain. What follows is a more directed account of the concerns at hand. In respect of time in the brain, it might first be thought

that the three disparate mechanisms I have identified cooperate fairly seamlessly and in concert with one another to produce what we experience as an apparently harmonious and coherently integrated temporal whole (and see Smith & Hancock, 1995). After all, from the introspective view as internal observers of our own experience, we do not encounter any obvious discontinuities, disruptions, or dysfunctions that might lead us to suspect otherwise. We are certainly aware that there exist neuropathologies of time in which some people do experience such problems, but these are, by definition, nonnormal states (see Cohen, 1967; Fischer, Griffin, & Liss, 1962). Thus, disorders such as schizophrenia (Spencer et al., 2004) and Korsakov's syndrome (Mimura, Kinsbourne, & O'Connor, 2000) are interesting windows on the way in which "normal" perception has somehow been altered or perverted, but nominally "normal" experiences are, by convention, not pathological in nature. However, for us to consider the proposition that the "normal" brain might be disharmonious in some fashion, it becomes necessary to challenge this apparently self-evident assumption.

What may disturb the relatively dogmatic slumbers associated with the acceptance of "normality" is the consideration of a classic issue in perceptual psychology. This is most appropriately known as the Molyneux problem (Molyneux, 1688/1978,

1693/1979). To understand the significance of this problem requires a temporary but justifiable excursion from the main theme of this work. The Molyneux problem is named after an Irishman, William Molyneux, who posed the following question to the philosopher John Locke in relation to some of Locke's statements in his pivotal text *An Essay Concerning Human Understanding* (Locke, 1690). Molyneux asked the following question: If a person who had been blind from birth but knew the difference between a cube and a sphere from touch alone had his or her sight cured, would the person then be able to tell the cube from the sphere from the sight of them alone? It is a question related to what we would now call the "binding" problem (Treisman, 1996, 1999) which asks how accumulated sensory experience is combined into a single reality (see Hancock, 2005b).

One can actually go further than the practical and even empirically testable question Molyneux posed (see Connolly, 2013). This extension can be stated as follows: Could a person, divorced since birth from all forms of external sensory experience, actually think? In essence, what could be known from the pure contemplation of self? It is a question philosophers will readily recognize as one of their own. Apparently, the poor observer doomed to this latter fate would, as I have argued initially here, possess at least a primitive sense of time. That is, as a living being, the person
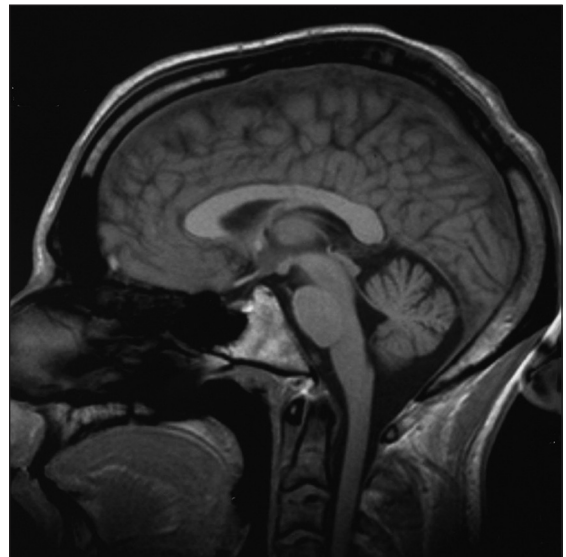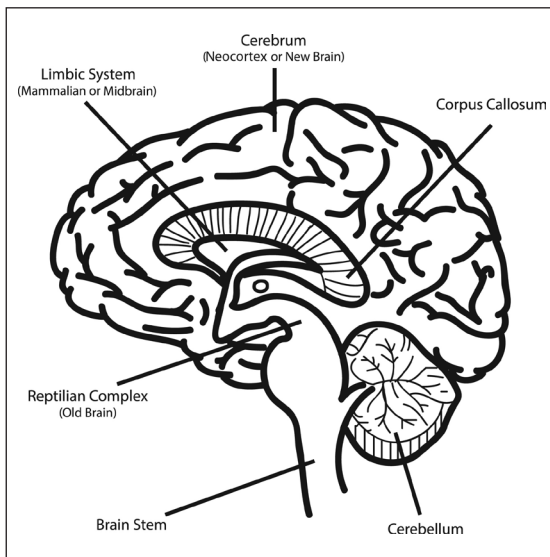

FIGURE 2. Gross anatomy of the human brain as shown in sagittal section. Notice the manifest vertical differentiation of the structures shown

would have access to a sense of his or her own temporal (and presumably spatial) persistence of self. What the person could make of, or from, this persistence is an interesting philosophical issue, but my central concern here is time. Where is this persistence of self encoded? How does it operate in complex, multicellular organisms? Critically, is the sensation of self-persistence a fundamental characteristic of life itself (see Schrödinger, 1944)? Any form of sensory integration would necessarily have to be erected on this primal capacity. It is from this contemplation that one can consider explicitly what would be the case if these two basic processes (i.e., self-persistence and perception of changing sensory experience from the environment) did not cooperate harmoniously, as is commonly assumed. What would be the case if they actually battled for control in the brain?

To derive an account of what that battle might look like, we have to first examine the gross morphology of the human brain. As can be seen from Figure 2, and as is well known to researchers in the psychological and neurosciences, the brain is no homogeneous entity. Even a cursory inspection shows obvious indications of anatomical parsing between numbers of clearly differentiable structures. As well as the well-known division into two hemispheres, the brain then can be differentiated vertically into three general regions. The one in the center is the brain stem, the area that tops it and surrounds it is the limbic system, and the structure superimposed on this latter region is the neocortex. This general differentiation has been called the triune brain (MacLean, 1990). This notion divides the brain into the reptilian complex, the limbic system, and the neocortex. For the sake of didactic simplicity, I refer to these as the lower, middle, and upper brains, respectively, although this refers predominantly to their physical location and somewhat less to their complex control functions.

The Role of Sleep in Temporal Integration

Consider the ongoing battle for time and control in light of this tripartite differentiation. The lower-level brain stem has the advantage of being first in existence. In both the law and nature, possession is nine tenths of the battle (see Draxe, 1616). My point here is that primacy of possession confers on the incumbent great strength, particularly the effect of inertia. This

seminal form of the brain thus owns the metaphorical high ground, especially in terms of the "basic" drives for food, sex, shelter, water (or in more general terms, survival capacities). The middle level must necessarily battle this preexisting structure for periodic (and express the aspiration for exclusive) control. (It should be noted that, in general, all three entities have to live in uneasy alliance in order to facilitate overall survival, but periodically [daily] all are in conflict for supremacy) (Figure 3). As in all conflicts, the middle-level brain begins to win its battle as the lower (poikilothermic-originating) level brain stem starts to weaken. This weakening especially occurs as the
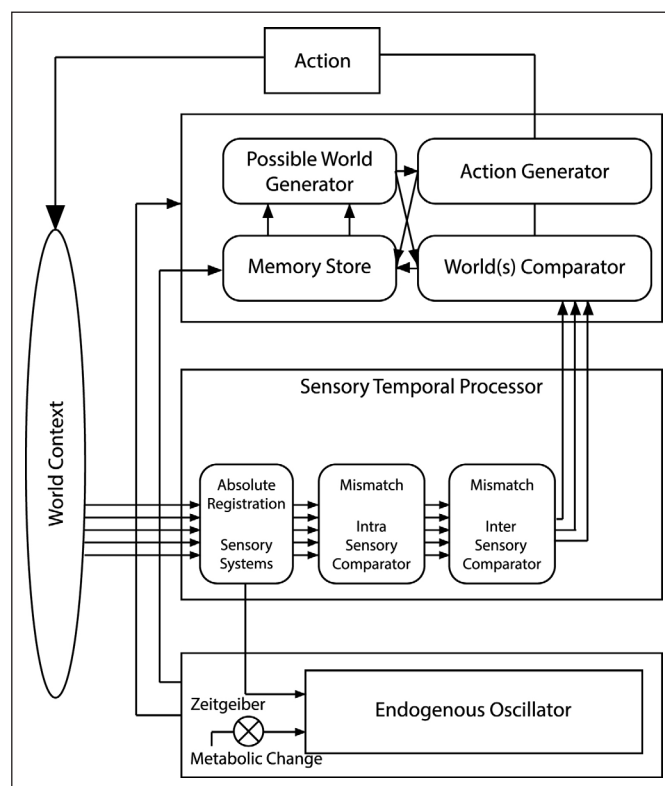

FIGURE 3. Model of human temporal capacities and their respective interconnections (after Hancock, Szalma, & Oron-Gilad, 2005). This expresses the same basic conception as in Figure 1 except that the interconnections between differing levels are now articulated. The lowest level responds to internal and external zeitgebers; the middle level is now responsive to the context of the external world and through sensory integration provides perceptual displays that are used for the world comparator at the upper level. Interacting with memory stores and possible worlds, the action is resolved either by an immediate pattern match or by a piecemeal solution based on reactive responses from the sensory temporal processor. The difference between dominant usage of the upper versus the middle level corresponds to the difference between "fast" and "slow" decision making (Kahneman, 2011)

sun goes down. Activity level in the lower level is strongly influenced by the oscillation of the circadian cycle. The middle level starts to dominate as this circadian cycle descends toward its lowest point, which occurs in the later evening and early morning. The morphology of this rhythm is certainly related to the light–dark cycle associated with the earth's rotation, but the cycle itself is synchronized but not absolutely phase-locked to the terrestrial, diurnal rhythm (Aschoff, 1984a, 1984b). This is the case because an inflexible association would inhibit opportunities for evolutionary adaptation (e.g., distant migration).

The dominance of the middle level occurs in the late hours of the night and the earliest hours of the morning when the ambient temperature of the surroundings reaches its lowest value. This correlation is not coincidental but rather is causal. The takeover by this middle level is largely a pyrrhic victory, however. The degree of supremacy is gained only during the hours of sleep and quiescence. Thus, the first characteristic of sleep is a diminishing truce between the lower and middle levels of control (see Dement, 1992; Kleitman, 1939; Meddis, 1977). This is fundamentally dictated by the issues of energy conservation and the critical need to cement memory for the learning of basic psychomotor sequences. The extensive work of Stickgold and his colleagues has shown how such skills are facilitated during the different phases of sleep (see Wamsley & Stickgold, 2010). Thus, many organisms sleep in this slow-wave fashion in addition to humans because the need to assimilate psychomotor skills is essentially ubiquitous among mammals.

During sleep, the lower and middle brain entities tacitly agree to this temporary truce. The lower level does this by diminishing its influence (which to some degree is inevitable given the state of the sun as its original source of energy). As mentioned earlier, this change reflects its poikilothermic origins. Today, humans and many other mammals are homeotherms, having been selected for the advantage of independent mobility at the expense of a high-level calorific running cost (i.e., resting basal metabolic rate). During the ongoing truce, the middle level cooperates by seeking a quiet place in which there is no noise to tax the ears (Szalma & Hancock, 2011), closing off light from the eyes and reducing the temperature differential between skin and surroundings (i.e., seeking thermoneutrality) while cushioning acute tactile cues

by enhancing resting comfort (i.e., making a bed or nest) and assuming a nonarousing and energy-efficient horizontal posture. The characteristics of sleep are thus energy conservation and offline processing of learned sequences as far as the intermediate level of control is concerned.

These pro-survival conditions optimize the reduction of immediate reality and, as noted, facilitate the offline processing of psychomotor learning in the absence of competing noise from an otherwise conscious and very active central nervous system. The body is not inert at this point, but it is very energetically conservative, and movements here are a combination of those needed for learning and those needed to maintain optimal comfort. Many animals sleep, and as noted earlier, this is partially the result of the compromise between intrinsic poikilothermic tendencies and the later addition of homeothermic independence. However, this skirmish between the lower two levels is not the only battle for time in the human brain, and the next stage of conflict becomes ever more manifest as night progresses.

Now to the fore comes the upper level, characterized in temporal terms as the cognitive clock, which permits "faster than real time" capacities. Largely located in and controlled by the frontal cortex, it bids for control in order to run its critical "what if" simulations that permit subsequent "faster than real time" responses in later threatening survival circumstances. Consciousness may well be characterized as a series of these scenarios in which the individual cannot, in survival terms, afford to play these "what if" simulations on top of reality itself. If he or she did, the person would become temporally (i.e., spatiotemporally) disoriented and eventually schizophrenic, as is shown in the behavior patterns of those who are chronically (REM) sleep deprived (see Zarcone et al., 1975). This is why sleep deprivation is a common and effective form of torture (see Hancock, 2003). Such dissociative discordance may also be reflected in the conscious phenomena of counterfactual thinking (see Kray, George, Liljenquist, Galinsky, & Tetlock, 2010; McNamara, 2008; McNamara, Durso, Brown, & Lynch, 2003).

The cognitive clock must have its chance to run the more bizarre (i.e., further away from the probability of later reality matching) simulations in order to refine its "what if" arsenal of "faster than real time"

responses. It is storage of these latter simulations that primarily allows humans to respond so rapidly and so effectively in such critical survival circumstances when they do occur. Most interestingly, such pre-preparations for emergencies might well help explain various nomothetic patterns of human error that do occur in such conditions (see Reason, 1990). Thus, the cognitive clock must be refined and tuned, and it cannot do this while actually working on the dynamic conscious demands of the world itself (Horne, 2000).

It is in the frontal cortex that the metalevels of adaptive capability are largely entrenched and the differences of humanity from the rest of the animal kingdom mostly encoded. When does the cognitive clock then attack the two lower levels for control? The answer is when both are at their weakest, just past the lowest point of the circadian cycle. In fact, the penetration of episodes of REM sleep into the rest of the ongoing sleep cycle shows this conflict as a series of "attacks" that grow sequentially stronger and more successful as the night progresses. Thus REM begins to dominate in the latter phases of sleep. However, there is a major problem with this takeover. The upper-level "cognitive clock" simulations are optimized if it can run full-scale perception–action sequences that would be represented by gross body activity—not just the rote movement-based sequences of psychomotor learning. It is not enough to just conceive of possible future scenarios; the upper level wants to run these simulations in all their full, action-based glory. The upper level wants to engage the body to do this because these are necessarily embodied reaction strategies (see Clark, 1997). However, the two lower levels both remain constrained by energy issues and by the associated concern that a survival threat (e.g., a nocturnal predator) may be in the area, and a violently thrashing but non–purpose-directed human might make an appealing target. If any animal started to move and make noise and behave in an erratic manner, then it would lose precious energy and become an obvious target. Fortunately, today there are not many nonhuman predators in modern suburban bedrooms, although for self-centered purposes many agencies would have you believe so. Thus, human sleep remains a necessary but perhaps increasingly vestigial function whose utility is unclear until we consider the deeper motivations surrounding control and future preparation.

Despite the presence of such benign ecological niches as suburban bedrooms, the upper level has to run its simulations, but not attached to the musculature. It can send the signals out of the brain, as it normally would, but such signals are prevented from getting to the body. An appropriate comparison here is with the concept of efference copy in motor control (Jeannerod, 2003). Thus, during REM sleep, the brain is extremely active but the body is very largely inert. This is because the necessary learning is cognitive and composed of context-contingent strategies, not the simple psychomotor sequence learning of the lower levels. This battle for control at the upper level is also the origin of sleep paralysis (see Terrillon & Marques-Bonham, 2001). This effective decerebration solves one of the many mysteries of sleep. As night goes on, the upper level briefly dominates, occupying more and more time in REM (simulation testing) sleep itself. It thus explains why we are inert during REM sleep. If disturbed at this juncture, we can wake up during one of these episodes and be able to consciously survey the results of one of these running simulations, albeit briefly because they are of very rare immediate relevance to the now waking experience. The results of this sudden waking are our conscious experience of and access to our dreams and nightmares. Because these simulations must necessarily consist of attempts to integrate our recent experiences with our resident capacities, they inevitably focus on potential survival issues. They play "what if" scenarios with some of our greatest fears and greatest aspirations so that we can survive and even prosper if we ever have to meet them in the waking state (see Valli & Revonsuo, 2009).

To provide a simple overall dichotomy of the underlying spectrum of possible motivations for dreams, I postulate that nightmares foreshadow radical survival situations, whereas happier dreams anticipate future goal fulfillment (see McNamara, 2008). This is not to say that dreams do not take on qualitatively diverse forms of content; assuredly they do. Indeed, dream understanding would be more transparent and less opaque if such underlying themes were phenomenologically more nomothetically evident (Freud, 1899). Regardless, against an environmental background of predator–prey conflicts, embracing goals and avoiding threats provides the central differentiation for such nonconscious activity. Whereas

slow-wave sleep is primarily an energy and low-level learning compromise, REM is high-level cognitive energy compromise (i.e., expending energy in a dream state in order to survive in extremis in the waking state). Thus, the battle for time in the brain explains two forms of sleep that are superimposed on one another. It also explains why lack of sleep is not directly fatal. One does not die of failure to run "what if" scenarios; one just gets more and more confused about reality and the need to anticipate possible future threats. One does not die of lack of energy or an accumulation of toxins; one just gets progressively more enervated. In a nasty world, it is not these specific lacks per se that cause your downfall; rather, it is the roaming predator who takes advantage of your failure to respond effectively because you are tired and confused. This is the source from which death is dealt. (In our modern world, the predator might prove to be a fast-moving vehicle, or a misplaced step, resulting in a fatal slip or fall. However, these are only limited examples of modern sources of threat; see Hancock, 2005a; Hancock & Warm, 1989).

Strictly speaking, sleep is not obligatory, but if you want to function effectively, you are well advised to get a good night's rest (Meddis, 1977). As with all human capacities, there are individuals for whom each respective level of control proves either very strong or very weak, and thus there are insomniacs and those who need prolonged sleep. There are also developmental differences, and thus there are exceptional sleep patterns for neonates and teenagers, who sleep for long intervals. This depends on which of the three parts of the brain is most advanced and strongest at each stage of maturation, which are imposed on the almost obligatory time-of-day effects (see Folkard, Monk, & Lobban, 1978; Horne, 1988). For example, the REM sleep of babies indicates lots of "run time" but not much input data. The sleep of neonates must be even more of a "blooming, buzzing confusion" than their waking world (James, 1890). Teenagers show the effects of an increasingly powerful cognitive clock and thus upper-level adaptive learning, although for many of their parents, this may be hard to believe.

Memory: Days of Future Past

One of the greatest of all conundrums with respect to time is the apparent paradox in memory that life is lived forward but remembered backward. An understanding of the function of the respective brain mechanisms of time can explain and potentially dissolve this paradox. First, it is clear that human memory is not a complete and veridical record of all past events in the lifetime of the individual (Baddeley, 1992; Schacter, 2001; Tulving, 2002). Human memory is selective, sporadic, fallible, and evidently incomplete (Baddeley, 2000; Bjork & Bjork, 1996; Schacter & Addis, 2007). Why? Some might suggest that even the human brain could not contain all the information assimilated during an average lifetime. However, it is clear that memory is incomplete in rather special ways (Baddeley, 2000, 2003). For example, we do not appear to engage in the act of forgetting on a consciously selective basis (Bartlett, 1932). Rather, what remains with us are special moments of particular pertinence and relevance. It is true that we personally have a sense of autobiographical continuity, but when we are asked to recall our past, it is particular moments that stand out, not a detailed litany of any specific continuous interval of duration. Thus, we might well remember snapshots of events such as our own wedding day but not whether we had a cup of coffee yesterday. What is the purpose of this form of selectivity? The answer lies in the general purpose of memory (see Dudai & Carruthers, 2005), which is overwhelmingly if not exclusively designed to prepare for the future (see Bar, 2009; Nairne, Thompson, & Pandeirada, 2007).

As indicated earlier, the identification of the continuity of self in space–time is a primary function of all living systems. It is this level of functioning that underlies the autobiographical continuity of self. It allows us to continue to consistently identify ourselves as ourselves on a day-by-day basis. This capacity supports the architecture of higher-level functioning, which in turn decorates our consciousness with personal episodic memories (Hancock & Shahnami, 2010). Memory for specific events is often tied to emotion (Easterbrook, 1959). It is these memories that are laid down at crucial points in our existence in which we experience significant levels of stress. That this stress may be either distress (as in something adverse happening, i.e., nightmares coming true) or eustress (in which something extremely pleasant is occurring, i.e., dreams coming true) is immaterial to the physiological foundation of the stress response

(Hancock & Warm, 1989). These occasions are often the subject of review in which the appraisal process is critical to the perception of stress itself and its subsequent memorial foundation (Eagleman, 2008). Thus, our memory for specific episodes represents the way in which the survival process is gearing us toward dealing with stressful events in the future (Atance & O'Neill, 2001). The fact that the information so contained is exceptionally relevant to us as individuals in an autobiographical sense is immaterial to the overall process of evolution. Evolution cares about the past only to the extent that it helps us anticipate and deal with the future; organisms do not survive into the past. Evolution and nature care little for us as individuals and care nothing for our own personal memories—if nature can be actually conceived of as caring in any fashion at all (Hancock, 1996, 2012).

That memory itself is distributed across much of the brain is a form of insurance against the potentiality of localized brain damage. That is, needing this information to be available on demand as future occasions require necessitates that it not be confined to any one location (see Lashley, 1950; Pribram, 1991). For if it were, and if this location were somehow damaged or immobilized, then one's ability to use the highest level of temporal capacities (earlier referred to as the cognitive clock) could be obviated. A human being, constrained only to reactive response, would have less chance of survival, especially in a nontechnical, nonsupportive world. We see a reflection of this vulnerability in our current world in people who suffer from Alzheimer's disease. Now the apparent paradox of memory is laid bare and should be readily resolved. The fact that life is remembered backward is simply an artifact of our own particular form of consciousness, which recalls these events in an autobiographical trail. This trail itself is then formally elaborated into our general social conception of time as composed of past, present, and future and then related to the associated concepts of seconds, hours, and other invented forms by which social time is parsed (Cipolla, 1967). The model advanced here thus helps explain certain facets of the puzzles associated with basic human processes such as memory and sleep. However, these are not the only ramifications of the model; there are many others. The present work elaborates on only one more issue: that of flow and its link to the especially intriguing area of déjà vu.

The Concept of Flow

It may well be that, as the philosopher Hume originally noted, "impressions that are too vivid are perceptions." It is at this boundary of waking conscious experience, with its related temporal process in the brain, that we find the intriguing phenomenon of flow and a potential linkage to the allied concept of déjà vu. Let us begin such an examination with déjà vu (see Brown, 2004). One of the many current theories of déjà vu describes it as a sensory latency issue in which either probabilistic or pathological influences on sensory processes delay the input of the present from a companion input that should, nominally, have been derived at the same time. Thus, differing forms of visual input derived, for example, from differing visual streams (Mishkin, Ungerleider, & Macko, 1983; Ungerleider, & Mishkin, 1982) may become temporally dissociated and are thus processed sequentially instead of simultaneously (see Cleary, 2008). This is one of the short-term dysfunctional processing accounts of déjà vu. Certainly this form of disruption to the ongoing sensory stream may well constitute some proportion of the overall experiences reported as déjà vu, and in reality there remains a need to further develop a comprehensive taxonomic differentiation of all behavioral phenomena that are subsumed under the umbrella term *déjà vu* (see Brown, 2004; Cleary et al., 2012).

In respect of any such a taxonomy, there are longer-term notions of déjà vu that can be derived from the present account in which it may be suggested that a brief episodic recall of what was once a "future simulation," experienced during the cognitive phase of dreaming, is now played out exactly as it was envisaged there. That is, the full scenario and context are confirmed, if only for a brief interval. The phenomenological impression would therefore be one of repeated time, but in reality it would represent a rare statistical match with one of the future simulation scenarios contemplated by the sleeping brain. Since the distribution is a statistical one, within any individual, and across multiple individuals, the phenomenon will assumedly be scarce. The comparison here is between a nominal prediction of the future derived from one of a plethora of "what if" experiences generated during a nonconscious state. However, if one considers the same process when the comparator derives from a conscious future projection, we come to the area that has been termed a state of flow.

One of the many issues remaining in respect of déjà vu is whether the event has to have been previously recognized in consciousness in the way we recall dreams. If this were so, then people who did not experience dreams (i.e., those who did not wake in the REM phase of sleep) would not experience déjà vu, and this is an empirically testable proposition. In contrast, prior conscious experience may not actually be needed. Since dreams are designed to meet future needs and because the immediate future is the most important, déjà vu, if it is an evolutionarily adaptive phenomenon, should predominantly contain "proximal" priorities (i.e., we should most often experience déjà vu concerning something that is happening in and around the present time). If this is the case, it would be much less likely for any event of déjà vu to be about a specific snippet of an event that occurred many years previously. Presumably this also is a testable proposition (see Funkhouser & Schredl, 2010), although again it should be emphasized that these hypotheses concern only one specific facet of déjà vu, where déjà vu might well be thought of as a whole collection of associated states. However, reports of déjà vu from highly distant intervals of time seem to be rarely reported.

If the match were made with prior purposive conscious experience, or perhaps even if it were not perfect in all perceived details but rather a sufficient match was obtained to facilitate the nominally "correct" solution to each sequential environmental problem presented, then the state would approximate flow (see Csikszentmihalyi, 1990; Csikszentmihalyi & Csikszentmihalyi, 1992). Flow is defined as "a state of concentration or complete absorption with the activity at hand and the situation; a state in which people are so involved in an activity that nothing else seems to matter" (Csikszentmihalyi, 1990, p. 4). Here individuals would appear to themselves to be "solving" each sequentially presented task demand with no apparent conscious effort or associated cognitive workload (Hancock & Meshkati, 1988). These flow states should therefore occur in highly practiced situations (e.g., professional sports, concert musicians) where the constraints of the situation are necessarily limited (e.g., the environment of the playing arena and its rules, or the limits of the instrument and familiarity with the piece being played). Assumedly, the associated psychomotor skill component is highly overlearned.

Flow then refers to the apparently effortless resolution of the questions of more strategic decisions rather than concerns with execution of specific motor patterns per se. Single-seat fighter pilots report such states in which they describe themselves as being out in front of the aircraft. Thus certain aspects of both déjà vu and flow look to be statistical rarities of the case of the preexperienced mental simulation of dreaming being later played out almost veridically in conscious experience. Understanding the influence of the brain and its evolutionary development with respect to control is a necessary but insufficient component of full understanding of time and duration. As clearly articulated by Montemayor (2012; also see Hancock, 2014), what is needed is an integration of this understanding with the philosophical bases of such knowledge. Clearly, such an endeavor provides extensive cross-disciplinary challenges. A brief overview of the nature of this challenge concludes the present work.

Converging Psychological and Philosophical Perspectives

Any view of time and duration must be strongly influenced by perusal of the key philosophical works of McTaggart (1908) and Russell (1915), and by the challenges recently posed by more popular commentators such as Pirsig (1991). If we initially accept Russell's perspective, then duration is a property of the relationship between object and object. It is thus quite reasonable to talk in physical terms about the properties of such durations and sustain the proposition that distinguishes the A and B (and even C) versions of temporality (McTaggart, 1908). If Russell is correct, then time itself is a relational property of living systems, one that necessarily requires the presence of a living being. In this case it is a categorical error to talk about time in relation to nonliving things. The confusion arises because we use the common term *time* for differing aspects of the nature of physical progression. If it were not, to modern ears, an apparent tautology, it might be appropriate to specify time as one (if not the) characteristic of life itself. Thus time depends on an observer (Hancock, 2005b), whereas duration persists independent of any need for a conscious or living entity. In this view, time is a truly multifaceted, multidimensional construct because different forms of time and duration may well be experienced by different forms of living entity (see Fraser, 1987). As evolution

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apparently creates ever more complex forms of life, there is the potential for a comparable increase in the ever more sophisticated forms of time. The differentiation of time and duration, and the purported supremacy of human temporal experience, carries with it a drive to define ourselves as the natural reporters and auditors of knowledge. However, there may be important objections to such a collective egocentric framework. Among others, Pirsig (1974) sought to challenge this division, arguing that it parses existence inappropriately. The dissolution of this division is informative but leaves behind no obvious structure by which understanding can progress. Pirsig (1991) aspires to this goal of paradigmatic redefinition but, understandably, largely fails to reach it.

In general, it seems that humans are almost instinctively driven to parse experience in order to understand it. Looking to understand life in a more systematic, holistic manner is represented as much more of a spiritual journey than a pragmatic roadmap to practical scientific progress. If anything can elicit such fundamental change, it has to be the study of some essential facet of experience that ranges across the whole of human understanding. At present, the only effective dimension that fulfills this criterion is time. We are thus only now beginning to see the advantages of juxtaposing what have appeared to be abstruse philosophical puzzles against the more recent discoveries of experimental psychology and neuroscience (see Hancock, 2013; Montemayor, 2012). It is to be hoped that this will provide fruitful syntheses from which insight may be garnered.

Summary and Conclusion

The puzzle of time has persisted in human thought for at least as long as such thought has been recorded (see Augustine, 397). The helpful dichotomy by Russell (1915) implies that duration and time are not coincident terms but are references that are divided between living and nonliving systems (see also Locke, 1690; Schrödinger, 1944). This being so, the term *time* itself may represent more than the singular unitary dimensional term commonly applied to it. Here, I have argued that time itself varies as a function of the sophistication of the brain, which supports the perception of it and indicates that certain well-known psychological phenomena (e.g., memory) derive from the ways in which the evolving brain has engaged in

sequential "battles" for control as the survival pressure to respond ever more quickly and more adaptably in "time" has been imposed on the emerging elements of the active brain. I do not believe this preliminary sketch is by any means complete, and there may well be other more subtle facets of time, founded in the nuanced complexities of operations that the human brain sustains. Distinguishing these various "colors" of time will provide an important and intriguing challenge to philosophers, psychologists, and neuroscientists in their interdisciplinary endeavors for much of the duration to come.

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