A design-based approach to sleep-onset and insomnia: Super-somnolent mentation, the cognitive shuffle and serial diverse imagining

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Abstract

This paper describes an approach to sleep onset (SO) and insomnia that involves a broad, design-based theory of cognition and affect (H-CogAff, Sloman, 2003). It proposes that the SO Control System (SOCS) has somnolent and insomnolent mentation inputs. A disruption of situational awareness and temporal sense making is posited to be somnolent. Perturbance (tertiary emotion) and primary emotions are posited as insomnolent. Many prior deliberate mentation strategies, prescribed as cognitive therapy for insomnia (CT-I), appear to be insufficiently counter-insomnolent (e.g., insufficiently able to compete with *insistent* motivators) and not inherently somnolent. According to tenets presented here, serial diverse imagining, a deliberate form of mentation involving a cognitive shuffle, is predicted to be super-somnolent (somnolent and counter-insomnolent). This paper calls for the development of SOCS theories and CT-I, both from the design stance. Particular attention should be given to perturbance and the possibility of super-somnolent mentation.

Introduction

Insomnia and sleep onset (SO) present fascinating theoretical, empirical and practical challenges for researchers who adopt the design stance to understanding the mind (Sloman, 1993, 2010; McCarthy, 2008). Imagine an embodied human brain lying in bed, next to a slumbering partner, unable to produce a sufficiently somnolent mental incantation. Why and how is even successful SO only indirectly caused by executive functions? This limitation of conscious self-control is reminiscent of memory. For we cannot *directly* will ourselves to remember a fact for easy future recall. Memory uses *indirect* cues to determine the indexing priority, and hence probability of recall, of information (Anderson, 1990; Beaudoin, 2014, Ch. 7). Take the case of Alexander Luria's patient, Zasetsky, whose executive brain areas were intact, but who lost most of his left occipital and parietal cortices: he could not recall newly learnt information at will (Donald, 2001, pp. 70-83). And yet the design of memory can be exploited

through deliberate recall practice, productive practice and other indirect subterfuges such as the ones devised by Zasetsky (Beaudoin, 2014). How can the design of the human mind be exploited to promote SO, to trick the brain into triggering sleep?

Current psychological treatments for insomnia are widely regarded as being effective without having the side effects of medication (Morin & Benca, 2012; Neylan, 2011). However, there is still room to develop better pre-sleep cognitive strategies (Harvey & Tang, 2003; Schmidt, Harvey, & Van der Linden, 2011). Can a different approach to insomnia, broad cognitive science, fill this gap?

In this paper, I present and extend the super-somnolent mentation theory of SO from which are derived new deliberate mentation strategies to facilitate SO (Beaudoin, 2013). This paper illustrates how from information processing theory, psychotherapy and self-help applications can be derived and targeted at a problem that affects a very large number of people (insomnia). The theory in question is *broad* in that it involves cognitive, affective and executive mechanisms across a proposed mental architecture (Beaudoin, 2014). The super-somnolent framework helps one to classify prior (classical) "thought management" techniques for insomnia, explain limits in their effectiveness, develop new SO techniques, and relate these techniques to concerns outside the realm of sleep (e.g., play and sense making).

A Design-based Approach to Sleep Onset

The brain contains a sleep state switching system (SSSS) that controls SO and sleep exit (Brown et al., 2012, Saper et al, 2010). Current specifications of the SSSS's Sleep Onset Control Subsystem (SOCS) focus on *biological* processes such as body temperatures, hormone levels and posture. These specifications reduce mental processes to "allostatic" status (Saper et al, 2010; McEwen, 2000). While mental processes are widely assumed to affect SO, information-processing models of the SOCS are lacking.

The design-based approach of cognitive science suggests new ways of framing and addressing theoretical SO problems. Design *requirements* for the SOCS must be specified. The SOCS needs to know when it is acceptable and appropriate to initiate SO, otherwise narcoleptic events may ensue. In humans, it must consider mental information. Executive processes influence SO; however, they cannot *directly* trigger SO nor can they always inhibit it. Moreover, sub-cortical mechanisms, such as the hypothalamus, cannot decode semantic, cortical information. These constraints present theoretical challenges in specifying the dynamic, temporally extended, two-way interactions between mental mechanisms and other components of the SOCS. How ought information about or traces from mental processing be integrated and affect subcortical components of the SOCS to determine whether progression on the path towards sleep should be pursued or inhibited?

To answer this question, we need new information processing concepts, a characterization of wakeful cognition, and a mental architecture.

Mental taxonomy and architecture

To understand SO and devise insomnia therapies from the design stance, it is helpful (a) to classify mental states and processes in terms of their influence on SOCS; and (b) to embed the SOCS in a *broad* information processing architecture. *Asomnolent mentation* has no systematic effect on SO latency; *insomnolent* mentation tends to increase it; and *somnolent* mentation tends to decrease it. *Counter-insomnolent* mentation is deliberate mentation that interferes with insomnolent mentation. For example, if problem solving were insomnolent and meditation were incompatible with problem solving, then meditation may be counter-insomnolent. Mentation that is both counter-insomnolent and somnolent is said to be *super-somnolent* (Beaudoin, 2013).

The SOCS detects and processes insomnolent and somnolent mentation features. A fundamental scientific challenge is to characterize this integrative decision process, which may be complex and vary within and between individuals. One could create an elaborate taxonomy of mentation features (e.g., pertaining to speed of processing, amount of verbalization, degree of meta-management, assessment, scheduling, planning, deciding and/or imagery, or attributes of the motivators currently underlying mentation), and investigate whether, to what extent and how these features are treated as somnolent or insomnolent by a parsimonious SOCS. Empirical research might provide surprising answers (e.g., that processes that might intuitively be expected to be insomnolent are actually asomnolent).

Because the SOCS is embedded not only in a neural architecture, but also a mental one, a design-based research program should be explicitly informed by a broad architecture of the human mind, one that is designed to handle the evolutionary requirements of autonomous agency such as the one proposed by Beaudoin & Sloman (1993), Beaudoin (2014, 1993), and Sloman (2003), now known as the H-CogAff theory, or Donald (2001). H-CogAff posits motive generators, which create or activate content for consideration by management processes; attention filtering, to heuristically determine which motives may gain attention; management processes to assess and decide motivators; and meta-management processes. (The latter two are often lumped together as 'executive processes').

H-CogAff distinguishes between primary, secondary and tertiary emotions. Primary emotions involve low level alarm systems and action tendencies. Motivators vary in insistence (tendency to disrupt attention), intensity (propensity to drive behavior), importance (value), urgency (importance as a function of time) and other dimensions (Beaudoin, 1994). In perturbance (a form of tertiary emotions), insistent motivators

tend to disrupt management processing despite possible meta-management efforts (Sloman, 1987).

Simon (1967) was the first to draw attention to the importance of interrupts at the emotion-laden intersection of cognition and affect. Wright, Sloman & Beaudoin (1995) characterize grief as perturbance. Dorothy Tennov wrote and Helen Fisher research echoes that "Limerence is first and foremost a condition of cognitive obsession". The same is true of all tertiary emotions. They present a challenge to self-regulation. See Wells & Matthews (1994) for further substantiation and clinical implications of loss of control of attention in emotions.

Candidate insomnolent and somnolent features

The SOCS must *heuristically* integrate reliable, valid and easily detectable mentation features in its decisions to begin, further, suspend or reverse the progression towards sleep. The following two considerations lead to Hypothesis 1.

First, wakefulness (and hence consciousness) typically involves sense making and awareness of temporally extended situations, including perceptual and cognitive integration, pattern detection, and prediction—even in the case of mind wandering (Smallwood & Schooler, 2006).

Second, mentation in the SO window is unique in the circadian cycle. SO is accompanied by loss of control of mental processes, loss of awareness of the environment, and (often) micro-dreams (Yang et al., 2010; Stenstrom, Fox, Solomonova, & Nielsen, 2012). More abstractly, varied self-generated imagery, varied memory access and reduced coherence are typical of SO. According to the SO emulation hypothesis, deliberate mentation strategies designed to mimic important features of SO mentation may shed light on somnolence, insomnolence and counter-insomnolence. The question arises, which of these SO features are not merely contributions to SO mentation, but causally important, inputs to the SOCS?

Hypothesis 1. Temporally incoherent mentation is somnolent. An extended period of time during which management processes are active but not integrating situational information, i.e., are not involved in temporally *extended* sense making, may be both an effect of the SOCS initiating sleep and also interpreted by the SOCS as a signal that it can continue the gradual progression into sleep.

Hypothesis 2. *Active* perturbance (tertiary emotion) is insomnolent. When management processes are captivated by insistent motivators, the SOCS tends to inhibit the progression towards sleep.

Hypothesis 3. Primary emotions are also insomnolent. The generation or activation of alarm signals and other primary emotion states inhibit the progression towards sleep.

These hypotheses demand detailed designed-based specification and empirical investigation.

Super-somnolent strategies: The cognitive shuffle and serial diverse imagining

Several cognitive treatments for insomnia prescribe thinking strategies to utilize while trying to fall asleep. Most prior *deliberate mentation strategies* have three limitations: First, they are merely thought to be *counter-insomnolent,* meaning that they are designed to interfere with insomnolent mentation; they are not inherently somnolent. Secondly, they are not particularly counter-insomnolent because the tasks are not sufficiently engaging. For example, with classical imagery distraction (Morin & Azrin, 1988), participants are given a collection of targets to vividly imagine, each for a substantial period of time, as they are trying to fall asleep. While this does promote SO, such a boring task cannot be expected to compete with intense primary emotions or insistent motivators (perturbance), meaning it is not highly counter-insomnolent. Moreover, there is no reason to suspect that such processing would be interpreted by the SOCS as a SO signal. Meditation may be counter-insomnolent; but it requires training and considerable executive effort for this task to compete with *insistent* motives; moreover successful meditation is said to be a state of alertness. Thirdly, they have not been developed from the design stance.

Topic-based cognitive refocusing, TB-CRT-I (Gellis, Arigo & Elliott, 2013), is perhaps more engaging, and hence presumably more *counter-insomnolent*, than imagery distraction and traditional meditation. In TB-CRT-I users are trained to think about a topic of interest to them at SO. However, this type of refocusing cannot be expected to be inherently *somnolent* because it hardly differs from wakeful cognition (e.g., planning and imaging pleasant activities.)

It seems therapeutically promising and theoretically germane to design and test deliberate mentation strategies that are both highly counter-insomnolent, and somnolent, i.e., *super-somnolent*. The tasks must be engaging without being insomnolent. The *cognitive shuffle* is a deliberate mentation strategy in which one briefly thinks about a neutral or pleasant target and frequently switches to unrelated targets (normally every 5-15 seconds). This could involve one or more of several types of mental processes. Serial diverse imagining (SDI) is a form of cognitive shuffle in which one briefly *imagines* various unrelated targets, such as persons, places, things, actions and/or scenes. For example, one might imagine Pluto, eyeliner, a birthday party, a shed, playing golf, and so on. One is instructed not to attempt to relate one target with another. One wouldn't, for instance, imagine placing eyeliner around Pluto at a birthday party. (This is different from typical, ineffective, thought suppression instructions.)

SDI implements Hypothesis 1 (above) in that it involves the suspension of situation awareness and temporal sense making. Sense may be made about each individual target, but the overall stream of mentation across targets is disintegrated. It elicits varied memories and images, two features associated with SO micro-dreams. This type of mentation is distinct, and uncharacteristic of waking cognition outside SO.

According to Hypothesis 2, SDI is counter-insomnolent. It is an engaging task which may increase attention filter thresholds, making it more difficult for insistent motivators (concerns, worries, etc.) to distract attention. The subject is less likely to experience an active (hence insomnolent) perturbance. SDI may also provide protection against lingering effects of primary emotions.

Note that because the cognitive shuffle is not experienced outside of SO, and the cognitive shuffle induces mentation in some respects akin to SO mentation, it should also be distinctly potent from a conditioning perspective.

Because the waking human mind naturally tends to sense-making, to elicit diverse 'random' content to imagine is not easy. The task requires a specially designed strategy, for memory is highly associative. Beaudoin (2013) presented a self-directed (technology-free) lexical strategy that exploits phonetic cuing. It involves selecting a word, spelling it, and for each letter, serially imagining several other items that start with that letter. It is easy to explain this technique to insomnia clients. Alternatively, technology may be used. mySleepButton™ is a simple app developed by CogSci Apps Corp. to apply the SDI technique. It provides an audio stream of sundry common, mundane, mostly concrete items to imagine. Whereas empirical evidence for SDI has not been published in academia, experiments using mySleepButton are being planned in collaboration with sleep researchers at SFU and other universities.

Conclusion

Insomnia research and design-based cognitive science have developed in parallel with virtually no interaction. Insomnia research does not seem to have drawn from AI in general, or *design-based* models of cognition and affect in particular, though it has been informed by traditional, empirical psychology of emotion (Baglionia, Spiegelhaldera, Lombardob & Riemann, 2010; Schmidt, Harvey & VanderLinden, 2011). Yet, the most important insomnolent feature of insomnia is also the most salient feature of emotion, namely perturbance, which lies at the intersection of cognition, emotion and motive processing (Sloman, 1987; Wright, Sloman & Beaudoin, 1996).

Meanwhile, information processing models of cognition, emotion, and motivation have not explicitly characterized SO information processing. Perhaps this is because SO seems so simple — the SOCS is viewed as part of a "switch", the SSSS. We should recall, however, that few anticipated the difficulty of explaining how vision

might work until researchers tried to replicate vision in software (Lamontagne, 1976). What looks simple is sometimes quite complex.

This paper has provided new concepts that researchers, therapists and insomnia sufferers can use to think and communicate about SO and insomnia. The theory developed here is still at an early stage. This paper draws attention to the need (a) to develop broad, design-based explanations of how cortical, mental phenomena influence SO; and (b) to explore insomnia treatments based on these explanations.

Keywords: super-somnolent mentation, the cognitive shuffle, serial diverse imagining, insomnia, sleep onset, CBT-I.

References

Anderson, J. R. (1990). *The adaptive character of thought*. Mahwah, NJ: Laurence Earlbaum Associates.

Baglioni, C., Spiegelhalder, K., Lombardo, C., & Riemann, D. (2010). Sleep and emotions: A focus on insomnia. *Sleep Medicine Reviews, 14*(4), 227–238.

Beaudoin, L. P. (1994). Goal processing in autonomous agents. Ph.D. thesis. University of Birmingham, England.

Beaudoin, L. P. (2013). The possibility of super-somnolent mentation: A new information-processing approach to sleep-onset acceleration and insomnia exemplified by serial diverse imagining. Cognitive Productivity Research Project, Faculty of Education, Simon Fraser University. Retrieved from http://summit.sfu.ca/item/12143

Beaudoin, L. P. (2014). *Cognitive Productivity: Using Knowledge to Become Profoundly Effective*. Port Moody, BC: CogZest. Retrieved from https://leanpub.com/cognitiveproductivity/

Beaudoin, L. P., & Sloman, A. (1993). A study of motive processing and attention. In A. Sloman, D. Hogg, G. Humphreys, D. Partridge, & A. Ramsay (Eds.), (pp. 229–238). *Prospects for Artificial Intelligence,* Amsterdam: IOS Press.

Brown, R. E., Basheer, R., McKenna, J. T., Strecker, R. E., & McCarley, R. W. (2012). Control of Sleep and Wakefulness. *Physiological Reviews, 92*(3), 1087–1187.

CogSci Apps Corp. (2014), mySleepButton (Version 1.1.4). Available from https://itunes.apple.com/WebObjects/MZStore.woa/wa/viewSoftware?id=740251957

Donald, M. (2001). *A mind so rare: The evolution of human consciousness*. N.Y: W. W. Norton & Company.

Fisher, H. (2004). *Why we love: The nature and chemistry of romantic love*. New York, N.Y. Henry Holt & Company. Retrieved from https://itunes.apple.com/br/book/why-we-love/id569886738

Gellis, L. A., Arigo, D., & Elliott, J. C. (2013). Cognitive Refocusing Treatment for Insomnia: A Randomized Controlled Trial in University Students. *Behavior Therapy, 44*(1), 100–110.

Harvey, A. G., & Tang, N. K. Y. (2003). *Cognitive behaviour therapy for primary insomnia: Can we rest yet? Sleep Medicine Reviews, 7*(3), 237–262.

Lamontagne, C. (1976). Steps towards a computational theory of visual motion detection: Designing a working system. Doctoral thesis. School of Artificial Intelligence, University of Edinburgh.

McCarthy, J. (2008). The well-designed child. *Artificial Intelligence, 172* (18), 2003–2014.

McEwen, B. S. (2000). Allostasis and allostatic load: implications for neuropsychopharmacology. *Neuropsychopharmacology, 22*(2), 108–124.

Morin, C. M., & Azrin, N. H. (1988). Behavioral and cognitive treatments of geriatric insomnia. *Journal of Consulting and Clinical Psychology, 56*(5), 748.

Morin, C. M., & Benca, R. (2012). Chronic insomnia. *The Lancet, 379*(9821), 1129–1141.

Neylan, T. C. (2011). Time to disseminate cognitive behavioral treatment of insomnia: comment on "Efficacy of brief behavioral treatment for chronic insomnia in older adults." *Archives of Internal Medicine, 171*(10), 895–896.

Saper, C. B., Fuller, P. M., Pedersen, N. P., Lu, J., & Scammell, T. E. (2010). Sleep State Switching. *Neuron, 68*(6), 1023–1042.

Schmidt, R. E., Harvey, A. G., & Van der Linden, M. (2011). Cognitive and affective control in insomnia. *Frontiers in Psychology*, *2*(December), 349. doi:10.3389/fpsyg.2011.00349

Seligman, M. E., & Yellen, A. (1987). What is a dream? *Behaviour research and therapy, 25*(1), 1–24.

Simon, H. A. (1967). Motivational and emotional controls of cognition. *Psychological Review, 74*(1), 29–39.

Sloman, A. (1987). Motives, mechanisms, and emotions. *Cognition & Emotion, 1*(3), 217–233.

Sloman, A. (1993). Prospects for AI as the general science of intelligence. In A. Sloman, D. Hogg, G. Humphreys, D. Partridge, & A. Ramsay (Eds.). *Prospects for Artificial Intelligence,* (pp. 1–10). Amsterdam: IOS Press. Retrieved from http://www.cs.bham.ac.uk/research/projects/cogaff/Aaron.Sloman_prospects.pdf

Sloman, A. (2003). How many separately evolved emotional beasties live within us? In R. Trappl, P. Petta, & S. Payr (Eds.), *Emotions in humans and artifacts* (pp. 35–114). MIT Press.

Sloman, A. (2010). The design-based approach to the study of mind (in humans, other animals, and machines) including the study of behaviour involving mental processes. Presented at *AISB–2010*. Retrieved from http://www.cs.bham.ac.uk/

Smallwood, J. & Schooler, J. W. (2006). The restless mind. *Psychological Bulletin, 132*(6), 946–958.

Stenstrom, P., Fox, K., Solomonova, E., & Nielsen, T. (2012). Mentation during sleep onset theta bursts in a trained participant: A role for NREM stage 1 sleep in memory processing? *International Journal of Dream Research, 5*(1), 37–46.

Tennov, D. (1998). *Love and limerence: The experience of being in love*. Scarborough House. Retrieved from: https://itunes.apple.com/ca/book/love-and-limerence/id503150060

Wells, A., & Mathews, G. (1994). *Attention and Emotion: A clinical perspective*. Hillsdale, NJ: : Lawrence Erlbaum Associates Publishers.

Wright, I., Sloman, A., & Beaudoin, L. P. (1996). *Towards a design-based analysis of emotional episodes*. *Philosophy, Psychiatry & Psychology, 3*(2), 101–126.

Yang, C.-M., Han, H.-Y., Yang, M.-H., Su, W.-C., & Lane, T. (2010). What subjective experiences determine the perception of falling asleep during sleep onset period? *Consciousness and Cognition, 19*(4), 1084–1092.

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