The possibility of super-somnolent mentation: A new information-processing approach to sleep-onset acceleration and insomnia exemplified by serial diverse imagining

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This document resides at SFU Summit: http://summit.sfu.ca/item/12143

Abstract

This paper proposes a new conceptual framework and techniques for sleep onset acceleration: the somnolent mentation framework. It distinguishes between somnolent, asomnolent and insomnolent mentation. Somnolent mentation inherently accelerates sleep onset (SO). Insomnolent mentation (e.g., deliberating, ruminating or focusing on one's arousal) interferes with SO. Deliberate mentation approaches to insomnia attempt to influence the participant's mentation at SO. They may prescribe somnolent or counter-insomnolent mentation. Existing deliberate mentation approaches attempt mainly to counter insomnolent mentation (e.g., thought control through imagery distraction). Thus they are at best counter-insomnolent. Super-somnolent mentation is both somnolent and counter-insomnolent. Extended SO (E-SO) is defined as the period just before SO (P-SO) combined with SO. A scientific challenge is to correctly classify features of mentation as somnolent, asomnolent and insomnolent. This classification should be done both from a phenomena-based perspective—e.g., the empirical study of E-SO mentation— and from a designer-based perspective (in terms of a theory of the architecture of the human mind). This paper proposes a secondary hypothesis: the E-SO mentation emulation hypothesis. To emulate somnolent features of P-SO mentation is somnolent. This paper proposes also that some types of incoherent mentation are super-somnolent.

This paper presents no new empirical data. However, from the new conjectures, several predictions can be derived, new treatments developed, and new possibilities investigated. From the incoherent mentation principle *the serial diverse imagining* (SDI) family of techniques is derived. From this and related considerations SDI is expected to be super-somnolent.

Acknowledgements

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> There are no subject matters; no branches of learning—or, rather, of inquiry: there are only problems, and the urge to solve them. (Popper, 1983)

1. Introduction

In this paper I propose a new information-processing framework for understanding and affecting the latency of sleep onset (SO). It accounts for prior findings and makes new predictions. The new proposals presented in this paper have yet to be put to a rigorous empirical test. The main purpose of this paper is to encourage sleep labs to determine the merit of this proposal. The proposal extends and applies broad cognitive-science.[1] The paper also serves as an example of how architecture-based modeling of the mind can be applied to cognitive and cognitive-behavioral therapy (CBT). Another purpose of this paper is to draw the attention of cognitive scientists to the problems of understanding pre-sleep mentation and accelerating the onset of sleep..

Three classes of features of mentation are distinguished. 'Mentation' here includes what is classically referred to as 'affective', 'cognitive' and 'volitional' information-processing.[2] Some mentation features are insomnolent, meaning they interfere with the onset of sleep. Some are asomnolent, meaning they neither accelerate nor delay SO. Others are somnolent, meaning they accelerate SO. Mentation patterns differ as to how potently and reliably they assume the three somnolent properties. I propose the deliberate somnolent mentation (DSM) principle: To deliberately engage in counter-insomnolent, somnolent mentation promotes SO. I call this type of mentation 'super-somnolent'. This new framework can be used to analyze existing approaches and techniques and to explore new ones. This classification can be effected on both theoretical and empirical grounds. For example, mentation features that are typical of successful SO may be assumed to be somnolent; these assumptions can then be tested empirically by encouraging forms and content of mentation that affect the features (e.g., introducing, augmenting, diminishing or removing them.)

This paper also describes *serial diverse imagining* (SDI), a DSM technique. The technique is designed for broad applicability. That is, it is hypothesized to be useful for adolescents and adults (a) whether or not they suffer from insomnia (they might merely want to accelerate SO and inoculate themselves from future insomnia); (b) whether or not they have a psychiatric diagnosis; and (c) regardless of their psychiatric diagnosis if they have one (i.e., the paper has transdiagnostic scope (Harvey, Murray, Chandler, & Soehner, 2011).) I describe two implementations of these techniques. One requires information technology the other does not. SDI is meant to be used in addition to sleep hygiene and several CBT treatments. It may also replace current DSM techniques such as classical imagery distraction (Morin & Azrin, 1987).

2. Importance of SO acceleration

There are practical and scientific reasons to investigate SO acceleration. Epidemiological studies suggest that about 20% of the population in the US perceive their insomnia symptoms to be a sleep problem. On a precise reading of the DSM-IV criteria (Ohayon, 2002), 6% of the population have clinical insomnia (Ohayon, 2002). In a Danish study, 80.3% of respondents who had ever used sleep medication would prefer a nonpharmacological treatment alternative (Omvik et al., 2010). Sleep deprivation has multiple adverse effects on cognition (and hence productivity, error rates, and accident rates), physical health, moods and emotion (Colten & Altevogt, 2006). Sleep deprivation is particularly harmful to knowledge workers' cognitive productivity and may impact adversely on the overall knowledge economy. It might even contribute to the development of psychiatric disorders (Harvey et al., 2011).

People often have limited time to sleep, so it is important for cognitive scientists to develop methods to help them (a) quickly and reliably fall asleep initially and (b) promptly return to sleep after early awakenings. There are effective forms of CBT for sleep. However, many people who would like to accelerate their SO cannot or will not seek psychological treatment for this. They may see professional treatment as being too expensive, time consuming, impractical or embarrassing. Moreover, as we shall see from our review of existing techniques, cognitive therapists require new treatments in their toolkit.

Investigating SO acceleration in the manner described in this paper may have significant benefits for cognitive science and sleep research. Cognitive processes during SO are still relatively unexplored (Stenstrom, Fox, Solomonova, & Nielsen, 2012). SO may have memory consolidation functions that need to be further explored. Cognitive scientists have explored many cognitive skills. However, SO had not previously been investigated as a trainable, cognitive skill. Such framing invites us to ask new questions about mentation at SO. What makes some information-processing somnolent? Counter-insomnolent? How can new SO-acceleration techniques be derived from cognitive science? How can these techniques be supported by information technology?

2.1. Pre-sleep onset mentation and extended sleep onset (E-SO) mentation

What mentation features are characteristic of pre-SO (P-SO)?[3] The answer to this question will vary as a function of the period that counts as P-SO. The period we choose will depend in turn on our research criteria. If we are interested in somnolent features, then we may define this window to typically include the period during which the most critical and potent somnolent features are manifest. That in turn will likely vary according to many circumstances. In this paper, I select 30-40 seconds as defining the P-SO of interest. The number may be changed slightly without affecting the argument presented here.

The foregoing question is difficult to answer with current technology. It is currently not technically possible to capture human mentation without participant verbalization. If the participant is truly about to fall asleep, then there is no reason for P-SO content to be committed to secondary memory. If the participant commits working memory information to secondary memory, it is because the participant is not falling asleep, therefore it does not qualify as P-SO mental content. Moreover, P-SO mentation introduces content that may replace P-SO. Primary memory content degrades rapidly, particularly if it is not rehearsed and if new information displaces it, which are typical conditions of P-SO. Therefore, waking up the participant at SO and asking about their mental content will not reveal P-SO content. If a participant is woken up while trying to sleep but not yet at SO, with current technology their brain waves will not indicate that they are at P-SO. Therefore, the researcher cannot be sure upon waking a participant to elicit memory content that the participant is at P-SO even if in fact the participant was at P-SO.[4]

Yet as will become clear to the reader, P-SO mental content is of great interest for the purposes of this paper.

In this context, I introduce the concept of extended SO (E-SO). This includes P-SO and SO. I refer to P-SO mentation while recognizing that it will in many respects be different from SO mentation. When research techniques are improved to enable characterization of P-SO mentation, the framework produced in this theory can be updated to reflect whatever distinctions between these states are discovered. I assume nevertheless that some P-SO mentation features are instrumental to triggering SO and that they share some features with SO.

3. Insomnolent mentation in the insomnia literature

Many cognitive approaches to SO acceleration are, at least implicitly, designed to reduce or inhibit insomnolent mentation. That is, they are meant to be counter-insomnolent. In this section, I focus on features of mentation that are active while a participant is attempting to fall asleep and that interfere with SO (i.e., are insomnolent).

Harvey, Tang, & Browning (2005) reviewed cognitive approaches to understanding and remedying insomnia. They pointed to "thought processes in the form of unwanted intrusive thoughts and worry" as important in insomnia. They are putatively insomnolent mentation. Harvey *et al.* also point to mentally processing active concerns as insomnolent.

The construct of *concern*, being theoretically critical, needs a theoretical framework.[5] More generally, to align sleep research with cognitive science, one needs an information-processing framework that characterizes the processing of goals, other motivators and cognitive content. The human cognition and affect framework (H-CogAff) supplies such a framework (Beaudoin, 1994; Beaudoin & Sloman, 1993; Sloman, 1987; 2003). The folk-psychological concept of concern can be mapped to the H-CogAff concept of inner motivator. An inner motivator is an information-processing

control state that disposes one to create goals (wishes, wants, desires, intentions) and assessments of particular objects as being liked or disliked, events as being desirable or undesirable, and behaviors as being right or wrong. The H-CogAff framework posits the existence of motivator generators and generators for other forms of mental content. Mental content is processed by *management processes*. The functions of management processes include assessing motivators (e.g., setting their importance, urgency and other attributes); generating possible plans, schedules and decisions (deliberating); comparing motivators; and making decisions about them. Management processes may be controlled top-down by *meta-management processes* and bottom-up by vigilance mechanisms. I leverage these concepts in this paper.[6]

In order to characterize the cognitive content of intrusive thoughts, Harvey et al. pointed to an analysis of the content of thought present in insomniacs as they attempted to fall asleep (Wicklow & Espie, 2000). Wicklow and Espie recruited 21 insomniacs. Participants were given a tape recorder to be left on by their bed side all night. They were instructed to say aloud whatever they were thinking while they were having difficulty falling asleep. Such think-aloud protocols are important, because memory for mental content is poor in general and particularly poor around sleep. In order of frequency, the following intrusive thoughts were reported (percentage of total reported thoughts is reported in brackets).

1. Rehearsing/planning and problem-solving (43%)

2. Sleep and its consequences (20%)

3. Reflection on quality of thoughts (12%)

4. Arousal status (9%)

5. External noise (6%)

6. Autonomic experiences (6%)

7. Procedural factors (3%)

8. Rising from bed (1%)

While these non-experimental results do not allow us to infer causation, they are consistent with the hypothesis that management processing of motivators (Beaudoin, 1994; Beaudoin & Sloman, 1993) is insomnolent. Wicklow & Espie reported that the reported mental content was not necessarily worrisome. Not all motivators are worrisome. However, one must not assume that 'worries' are the only insomnolent content. As mentioned to above, it seems likely that processing non-worrisome motivators, at least in certain ways, may also be insomnolent. The question arises, in terms of the H-CogAff framework, what management patterns would we expect to be insomnolent? This will be addressed in the next section.

Harvey (2002) postulated that concern-related imagining has different effects on SO latency than verbal thinking does. (In other words they have different somnolence

properties.) Harvey *et al.* (2005) reported that people tend to automatically produce images ("intrusive thoughts") related to their concerns. Entertaining concern-laden images is thought to temporarily increase arousal, which in turn is considered to be insomnolent. Such imagining tends to produce a short-term autonomic arousal. However, it also is thought to ultimately "be associated with more successful emotional processing (Borkovec, Ray, & Stober, 1998)". Harvey postulated that disengaging from these images by shifting into verbal mentation may perpetuate rather than interfere with the resolution of the concerns.

Nelson & Harvey (2002) examined this conjecture empirically. They conducted a study in which before going to sleep, insomniac participants[7] were exposed to a stressor. The stressor was that they would be called upon to give a 5-min video-taped speech to a small audience the next day. The topic was to be assigned the next day. Participants had been trained that day to think in images and to thinking verbally. At bed time, some participants were instructed to think about the speech topic in images for 6-min, other participants in words. They rated their anxiety after this 6-min period, but before falling asleep. They also rated their anxiety in the morning. Participants in the imagery condition felt more anxious before falling asleep but less so in the morning than those in the verbal condition. Harvey and Payne interpret these results as meaning that "thinking in images resulted in the resolution of worry whereas thinking in verbal thought resulted in the maintenance of worry". The mechanism underlying this result is unclear. However, Harvey and Payne explained it in terms of negative properties of imagery control (Harvey, 2002), what we would call putative insomnolent properties of some forms of imagery control. Imagery control refers to the participants' avoidance of images in favor of thoughts. But what is the mechanism according to which verbal thinking regarding stressors is more insomnolent than verbal thinking?

Harvey's (2002) is based on the theory of the processing of worries proposed by Borkovec et al. (1998). (Recall that worries are a type of concern and therefore a type of motivator.) Borkovec et al. (1998) is in turn based on associationist tenants (Mowrer, 1947).[8] In such associationist CBT, the object of a worry is a conditioned-aversive stimulus (CS). Activating a representation of the CS elicits a physiological conditioned response. Accordingly, to neutralize this internal response, one needs to undergo an extinction procedure. Extinction consists of the presentation of the CS without the presence of an unconditioned aversive stimulus. Thus, to lie in bed imagining the worse might then make the worse seem less aversive. To avoid imagining the worrisome thought prevents the extinction (so the theory goes). In this theory, then, verbal processing inhibits a process that might resolve the anxiety that is preventing one from falling asleep. It also maintains an insomnolent bodily state.

Regardless of the amount of variance that can adequately be accounted for by this associationist theory, there is a more parsimonious and general explanation of the data. It may be that, mental fatigue aside, managing *insistent* motivators is insomnolent whether or not the processed motivator is negatively valenced. Insistence is the propensity of a motivator to disrupt attention (Beaudoin, 1994; Sloman, 1987). For example, lying in bed

planning an important debate that one gleefully expects to win is likely to be insomnolent. For the mathematically inclined, solving a series of trivial, unimportant but fascinating geometrical problems might also be insomnolent. Some children, optimistic about the morrow, have difficulty falling asleep on Christmas eve. This more parsimonious explanation suggests a more general treatment: to inhibit the management of these insistent motivators via a meta-management strategy that engages meta-management processes. Moreover, in the new account offered here, one need not suppose that active mental processing is itself insomnolent.

Sleep research has yet to systematically explore the space of motivators and management processes that may affect sleep onset. Motivators have many attributes that vary in qualitative and quantitative ways, such as importance, urgency, intensity, insistence and complexity (Beaudoin, 1994; Kagan, 1972; Sloman, 1987). Moreover, there are many different types of management processes, as I alluded to above. Furthermore, the binary distinction between 'image-based' thinking and 'verbal-thinking', while common, is problematic. In particular, there are many mixed forms of representation (Peterson, 1996; Sloman, 1985; 2002a; 2011b). Problem-solving with analogical representations, that one might be tempted to characterize in terms of "images", is possible and common for mathematicians of all ages (Funt, 1980; Sinclair, 2006; Sloman, 1985). If, like mathematicians, and presumably unlike the participants in Harvey's experiments, participants were highly skilled at reasoning with diagrams, it may be that reasoning diagrammatically about their problems, particularly if they were open-ended and/or intractable, would also keep them awake. This would also weaken the Borkovec et al. (1998) associationist theory. I take these comments as an extension of the claim by Harvey et al. (2005) that there is a need to distinguish between rumination, worry and intrusions.

Let us now consider meta-management, including meta-cognition and thought-control.[9] Sleep research has assimilated the idea that not all strategies for controlling management processes are equally effective. For instance, simply trying not to think of something can make it difficult not to think of it. For example, participants who are simply instructed not to think of white bears are likely to find themselves, sooner rather than later, thinking about them (Wegner, 1994). Wegner found that unfocused self-distraction is particularly ineffective. Providing participants with something else to think about (a distractor) is more effective (Wegner, Schneider, Knutson, & McMahon, 1991). This principle has been successfully applied in sleep contexts. According to Harvey (2002), a major research goal here is to identify the benefits and disadvantages of various thought management strategies. "Recognizing the complexity of different forms of thought and systematically identifying management strategies that are helpful and unhelpful for effectively managing unwanted thought while trying to get to sleep will be an important direction for future research." (Harvey et al., 2005). In this vein, below I describe SDI, a super-somnolent thought management strategy. It is unclear whether there is consensus in the sleep research community as to whether meta-management is

intrinsically insomnolent or somnolent. The position taken here is that a priori it is asomnolent. Somnolence is a function of management and vigilance processes.[10]

Harvey et al. summarized research on "perceptual" processes related to sleep (Harvey & Tang, 2012). Recall that (Wicklow & Espie, 2000) found that 20% of cognitive intrusions in their sample were about falling asleep. Insomniacs spend proportionally more of their daytime and bed time thinking about and worrying about falling asleep. Poor sleepers are more likely to underestimate the quality of their sleep. They overestimate their SO latencies and they underestimate the total amount of time they spend asleep (Harvey & Tang, 2012). Harvey & Tang (2012) argued that insomniacs genuinely do misperceive themselves as being awake when they actually are asleep.

The question arises, how does faulty sleep-monitoring affect sleep? Fully answering this question would require a more involved information-processing analysis than will be performed here. Harvey & Tang (2012) found support for three explanations for the under-estimation of sleep in insomniacs, one of which is relevant to this paper because it relates to waking cognition. Their preferred hypothesis is that insomniacs tend to worry about not falling asleep. The more information one processes, the slower time appears. Worrying involves "increased cognitive activity", so it is thought to make time seem slower. Moreover, insomniacs tend to pay more attention to their states of wakefulness and to sleep threats. Falsely believing that they have been awake a long time may make insomniacs more anxious.

I would add a qualification to the foregoing reasoning. It is not necessarily universally the case that the more information one processes, the slower time appears. Two hours watching an action-packed movie can fly by compared to sitting in an empty, quiet theatre for two hours with nothing to do. Imagining multiple scenes, under some circumstances, might also disengage time monitors. Moreover, I conjecture that an activity (SDI) in which insomniacs process more information than classical imagery distraction may be more somnolent than classical imagery distraction.

It should be noted that in the insomnia literature, the term 'image' seems to be used without sufficiently accommodating for the fact that specifying image concepts in a way that is amenable to information-processing accounts is a difficult and somewhat unmet challenge. Minsky's concept of simulus (Minsky, 2006), although in need of elaboration, is more promising than the concept of image for information-processing theories. This is not just a semantic point: This paper critically assumes that imagining is fragmentary and schematic.

4. Insomnolent mentation is coherent mentation

There lies unexploited in insomnia research a very promising fact: Mental states experienced while people are having trouble falling asleep involve coherent (i.e., successful) sense-making. By 'sense-making', I mean an attempt to interpret and comprehend mental content (constructed more or less remotely from external stimulation) as it unfolds.[11] All of the intrusions reported by Wicklow and Espie, for example, are not

only mental intrusions, they are potent material for sense-making. Worrying about day-time concerns involves sense-making, even if the overall impressions generated are not particularly rational. (Sense-making ought not to be confounded with common-sense or rationality.) I conjecture that a critical feature of insomnolent mentation is that it is overall similar to daytime management processing in general, and that it involves coherent sense-making in particular. Critically, this sense-making can last for several seconds and minutes. In such mentation transpire recurrent themes and rumination. The coherence of this mentation, in my account, is more problematic (insomnolent) than the activity level or self-monitoring (meta-management) as such.

Obviously, daytime higher-order mental processing (management and met-management processing) also involve sense-making. Whether one is assessing real or imagined situations and external motivators, imagining possible states of affairs, remembering, planning, scheduling or making decisions, one is normally engaged in coherent, sense-making. As one becomes drowsy and starts to fall asleep, one's mental processes are increasingly less constrained by sense-making.

Management and meta-management processing can in important respects be incoherent. Coherence is not an absolute concept. Mental processing can be incoherent in one respect while being incoherent in some other respect. For example, a person can serially entertain random, unrelated mental content (scenes or simuli, for example) in his mind without integrating them. Each element of the series is amenable to coherent interpretation. The serial content is incoherent to the extent that the person refrains from relating serial items to each other and to some overarching schema. The deliberate process of entertaining random content may itself be abstractly coherent with respect to the objective to do so.

5. Somnolent mentation: incoherence

In the previous section, I proposed that insomnolent mentation is coherent. That is to say that engaging in coherent mentation tends to interfere with falling asleep, mental fatigue considerations aside. I take a further step by proposing that somnolent mentation critically is incoherent. This is not to say that it is completely devoid of sense-making. Rather it is to say that somnolent mentation has *self-generated* content but it significantly attenuates, sometimes perhaps to the point of temporary suspension, the global interpretation of successively generated content.

The concept of sense-making was first systematically applied to sleep research by Seligman & Yellen (1987). They proposed that sense-making happens continuously from birth onwards, even while one is asleep. They emphasized that the material available to sense-making during sleep differs from that of waking states. During REM sleep, the mind attempts to make sense of relatively frequent, intense, randomly generated visual images. During non-REM (NREM) sleep, the brain generates fewer images for sense-making processes to integrate. Less sense is therefore created during NREM. As they put

it, "During NREM sleep, the integrator is still functioning but has little to integrate." (p. 18).

An inference one can draw from their theory is that NREM sleep is characterized by less coherent mentation. Sense-making processes may be operative, but they are literally not making as much sense as is typical at other times of the day. Seligman and Yellen may have underestimated the amount of asynchronous mental content generated at SO. However, SO may nevertheless be (and I propose is) characterized by incoherence. Another fertile but unexploited possibility is of incoherent patterns of mentation naturally (and potentially deliberately) being generated with larger quantities of content. The mental content may, for example, be so diverse that the "integrator" cannot coherently integrate it. Or the "integrator" may be switched into a different mode, where it only focuses on the current object, and cannot (or will not) try to coherently integrate the current content with previous content. There could be many causes for this. For example, if working-memory capacity were severely reduced at SO, temporally-extended integration would suffer: i.e., one could only integrate very recent information. Or, working-memory content might decay more quickly at sleep onset, at least for some of its content. Or, activating content from secondary memory may be more difficult at SO. Unsworth & Engle (2007) have called for research on individual differences in activating secondary memory. I call for research on differences in secondary-memory activation properties within individuals across the circadian cycle.) Another cause would be a programmed, functional mode of operation of the brain that is used to induce sleep.

While the *integrator* concept was a useful simplification, it is in need of repair. There is not a single mechanism that performs mental integration. The seriality of integrative mental experience is the result of parallel mental processes that share limited resources, such as working memory and the connectome. This has aptly been characterized in Baars' (1988) theory of consciousness. Shanahan's concept of coalitions of temporarily coupled mental processes elaborates this further (Shanahan, 2010; 2012). Shanahan refers to this integration as the 'communication through coherence' hypothesis.[12] The connectome is a coherence substratum. In this view, a large number of mechanisms operate in parallel, contributing to sense-making. Global sense is made when a small subset of these processes communicate with each other over the shared interaction medium. Mechanisms that are currently not communicating over the shared medium are not necessarily dormant. They may continue to vie for access to the global communication channel. Thus, management and meta-management processes can be interleaved.

Meta-management mechanisms are capable of monitoring and controlling activity in the global-communication channel. They are important contributors to global, temporally integrated sense-making. They themselves can be controlled by reactive and goal-based processes. They can deliberately control their own attempts at sense-making. Like other management processes and other mental processes, meta-management processes can be trained through practice, including deliberate practice. (See Ericsson (2008) for an introduction to deliberate practice.) Moreover, meta-management processes

can monitor mental processing to detect coherence (with respect to some criteria) and enact a pattern of incoherence. People do not tend to do this spontaneously. However, it is something that can easily be trained given a technique like SDI.

Coherence is a relative concept, meaning that mentation content or patterns may be more or less coherent with respect to specific criteria. For example, Stenstrom et al. (2012) report that a participant at SO experienced "vivid dreaming containing coherent scenes—as opposed to isolated objects often associated with general SO imagery." This datum (from a single participant) may appear to contradict my incoherent mentation hypothesis. However, it does not. A scene in a dream may be internally coherent without being coherent with prior scenes. Moreover, even if several successive scenes are coherent to an external observer, the participant might not make sense of them in a coherent manner, even if during the day the same participant could easily project sense onto that same scene. The participant might be sense-making, on being interrupted by an experimenter querying for mental content, outside of an E-SO state. What matters to somnolence is the subjective restriction of sense-making.

I propose that incoherent mentation is not only correlated with falling asleep, it is somnolent. That is the the incoherent mentation somnolence hypothesis. This means that such mentation can induce drowsiness and ultimately sleep. Incoherent mentation is a signal to subcortical regions to continue the transition into sleep, i.e.,. that management processes are no longer managing concerns and making sense, they are in shutdown mode.

The argument for the incoherent mentation hypothesis is analogous to Anderson's rational analysis of memory (Anderson, 1990). Human memory faces a tremendous challenge: of all the information that it processes during the day, what should it retain and learn from[13]? A rational answer to this question is: whatever information the person has called upon during the day. Information that the person has frequently "accessed" is more likely to be needed in the future than information that has not been accessed. Anderson refers to this as the "history factor", it is one of two major factors he identifies as pertinent for memory systems to use to determine what information is likely to be needed in the future. So the mind should make it more readily accessible, presumably by establishing and improving indexes for it. Attempting to recall information signals what ought to be learnt. This explains some of the most significant properties of memory, including the so called test-effect and spacing effects (Kuo & Hirshman, 1996; McDaniel, Roediger, & McDermott, 2007). Repeatedly testing oneself on material to be remembered facilitates future recall and use of that information (Cepeda et al., 2009; Karpicke & Roediger, 2008; Roediger & Karpicke, 2006). (See Beaudoin (2011a) for applications for knowledge workers and cognitive productivity.) The rational analysis does not commit one to particular model of memory (encoding, storage and usage of information).

The rational analysis of memory makes sense of the fact that people cannot simply will themselves to remember something. One can't simply read a paragraph, tell oneself "I will remember this", and thereby be able to remember it. One normally needs to

practice over time. Formulating a more specific goal, such as a specific question to answer is also insufficient. Applying a mnemonic without practice is not as effective as with practice (Fritz, Morris, Acton, Voelkel, & Etkind, 2007). The brain cannot generally be commanded to memorize something. The brain is designed to treat attempts to explicitly recall or utilize information as a cue to establish and index representations for future use.[14]

Similarly, the human brain does not directly respond to the command to fall asleep. It must get its cues from somewhere. However, lower levels of the brain critically must be able to trigger sleep on the basis of cortical states. Otherwise, the agent might experience something akin to an episode of a narcolepsy. According to the incoherent mentation hypothesis, prolonged incoherent mentation is, *intrinsically*, such a trigger. The precise mechanism by which incoherence is computed and triggers drowsiness is left open. This is analogous to the rational explanation of memory. Many different models are compatible with it.

The incoherent mentation hypothesis has two compatible forms. I have just described the intrinsic form. Incoherence is not merely an artifact of the brain's transition to sleep. It is a state that is leveraged by the mind to signal and trigger underlying SO mechanisms including brain-level mechanisms.[15]

There are also contingent ways in which incoherent mentation is somnolent: by virtue of associative conditioning. Here we have another pregnant fact. Incoherent states are almost perfectly correlated with sleeping states and SO in particular. They are almost absent from waking states. P-SO may consistent of a gradual loss of coherence in mentation. Given the highly associative nature of the brain, memory and learning, it seems plausible to suggest that the occurrence of such a mental state can, in virtue of it being a highly discriminative cue (Norman & Bobrow, 1979), induce drowsiness and eventually sleep as a conditioned response of sorts.

The popular 'stimulus control' behavioral method of combatting insomnia is predicated on associative conditioning (Bootzin, Epstein, & Wood, 1991; Knapp, 1976). Participants are advised to only use the bed for sleep and sex. That means for example: no reading or watching TV in bed. If the participant cannot sleep after 20 minutes or so, then the participant is supposed to exit the bed so that it doesn't become associated with wakeful states. The idea is to ensure that the bed is highly correlated with sleeping. However, the associations on which stimulus control depend are external whereas those of somnolent mentation are internal. Further contrasts are described where SDI is discussed below.

Mental fatigue, in the absence of excessive tension[16] can also cause drowsiness. Demanding mental activities lead to mental fatigue. This fatigue in turn impairs sense-making. Some (difficult) mental activities however may be somnolent though they may also have insomnolent properties. Presumably, most people don't, without prompting, tend to engage in difficult mental activities in bed for the deliberate purpose of accelerating SO. I also assume that they don't deliberately engage in incoherent

mentation. If these assumptions are correct, then people may be depriving themselves of a tool to control and accelerate SO.

6. Super-somnolent mentation

Let me summarize the argument to this point. Some types of mentation are insomnolent. Managing insistent motivators (i.e., motivators that are bottom-up, heuristically assessed as being important and urgent) is likely to be insomnolent. Some types of mentation are likely to be asomnolent. Managing one's management processes for instance might not intrinsically be somnolent or insomnolent. Some mentation may be somnolent. For example, incoherent mentation and difficult, taxing (tiring) mentation may be somnolent.

If there are indeed patterns of mental activity occurring at SO that are conducive to the transition from being awake to being asleep, i.e., natural somnolent mentation, then it may be the case that deliberately engaging in somnolent mentation may promote SO. I refer to this activity as deliberate somnolent mentation. Given that somnolent mentation is not necessarily counter-insomnolent, before proposing a deliberate somnolent mentation technique, one should ensure that it is also counter-insomnolent. I refer to techniques that have these two desirable properties as super-somnolent.

Such a technique could have signifiant therapeutic value for treating insomnia. It would also be of practical value to people who simply wish to accelerate falling asleep and to have better control over their SO. It would of course also be of scientific interest (for cognitive science and sleep research). A candidate I propose is *serial diverse imagining*.

The counter-insomnolent property is important because a mental pattern might, while being somnolent and non-insomnolent, be interleaved with mental patterns that are insomnolent. To be optimally effective, the therapeutic technique must also interfere and be incompatible with insomnolent mentation.

As mentioned above, it is recognized that one can't simply instruct an insomniac to avoid thinking about his or her current concerns. One needs to provide them with something else to think about.[17] The most promising distracting tasks involve imagery. One such 'imagery replacement' task that has been explored involves training participants to engage in "imagining a situation they found interesting and engaging, but also pleasant and relaxing" (Harvey & Payne, 2002). While this has produced encouraging results, the difference between this group and a general distraction group (who were told to "simply distract from thoughts, worries and concerns") were only marginally significant. Digdon & Koble (2011) also found imagery distraction to be useful, but not significantly better than two alternatives they studied. Moreover the following limitations apply:

1. While Harvey and Payne claimed that they provided a "very specific alternative cognitive task" to general distraction, despite the fact that they trained the participants, they did not provide participants with a very specific algorithm to

distract themselves. Therefore, it is likely that the minds of participants in their study who attempt to use this will wander and then be distracted by concerns.[18] Serial diverse imagery, described below, provides a much more specific and very easy to follow algorithm for distraction.

2. Their imagery task cannot be counted on to prevent participants from imagining worrisome images. It is not sufficiently engaging.

3. The task is not designed to provide variety of cognitive content. Their experiment was only performed one evening. It seems likely that attempting to utilize this technique for several weeks would cause some participants to run out of content to imagine. The consequent boredom would make them susceptible to the concerns that the researchers are trying to prevent them from thinking about.

4. As Harvey and Payne noted, participants differ in their ability to visualize. This technique relies too heavily on visualization skills.

5. The technique does not have somnolent properties. It is at best counter-insomnolent.

Woolfolk & McNulty (1983) and Morin & Azrin (1987) tried a more specific imagery replacement task. Participants were taught to focus on a specific object at a time and to imagine it as vividly as possible for *two minutes*. While this task is not equally susceptible to the first two problems, it fares worse on the the third problem. One ought not to expect participants who are brimming with worries that keep them awake to imagine the same limited set of objects, night after night, for weeks, let alone months or years. A step in the right direction then would be to provide participants with a variety of objects to choose from. However, this technique would still not have somnolent properties.

Progressive relaxation techniques and Eastern forms of meditation also have counter-insomnolent properties, provided that participants can implement them properly (Ong, Shapiro, & Manber, 2009). However, if participants have significant concerns such that their minds generate insistent motivators, their management processes are particularly susceptible, in such quiescence, to be distracted by these motivators. If they could instead be activating content for consideration by management processes, the filter-threshold for their off-task motivators may be elevated. Alternatively, the disruptive motivators might be inhibited.

A more significant problem with meditation as an SO accelerator is that it was not traditionally designed to induce sleep. A standard instruction for meditation is to be awake. Meditation is said to promote wakefulness (Kabat-Zinn, 2005). Moreover, traditional meditation techniques with which I am familiar do not have the somnolent properties listed above. This is not to say that meditation could not have such properties. If one defines meditation more generally as sustained control of management processes by meta-management processes, then techniques such as self-directed SDI qualify as meditation. But this is not traditional meditation. It is a new form of meditation.

SDI, described below, *a priori*, is expected to overcome the limitations of the previously researched somnolent mentation techniques.

7. E-SO cognition emulation hypothesis

If one is in a mental state that is indistinguishable from the state which one tends to experience at SO, odds are that one is at SO. This means, amongst other things, that SO is a distinctive mental state. Implicit in the foregoing discussion of somnolence is the hypothesis that emulating P-SO mental states and SO states may be critical to engendering sleep. I call this the E-SO mentation emulation hypothesis.

Incoherent mentation is one of the characteristics of SO mentation. I believe it is also characteristic of P-SO.

Other characteristics include bizarre imagery and disparate recollections that are not closely related to ongoing concerns and situations. (As will be alluded to below, this is also a feature of play.) While Seligman & Yellen (1987) proposed that sense-making goes on from birth to death, even through sleep, they did acknowledge that working memory constraints in sleep impact on sense-making. Regardless of their proposal, they fully acknowledge and attempt to explain that dreaming involves the production of random imagery. This production, whether coherently interpreted or not, is not purely the result of a sense-making process. Experiencing (constructing) frequent and diverse analogical representations (Sloman, 1978, Chapter 7) that are self-generated, as opposed to triggered by the senses, would also fall under the E-SO mentation emulation hypothesis.

I list the E-SO mentation emulation hypothesis separately from the incoherent mentation hypothesis because, at least logically if not empirically, the two hypotheses can stand alone. One might discover a form of mentation that is completely unique, never before experienced, that is super-somnolent and yet not incoherent. In this paper, however, I pursue forms of super-somnolence that are in significant respects related to E-SO cognition and involve incoherence. Empirical super-somnolence research should tease out the potent from the neutral features of mentation.

8. Serial diverse imagining: a super-somnolent technique

This section describes SDI, a technique which according to the foregoing analysis ought to be super-somnolent. The technique in particular implements the incoherent mentation hypothesis. The technique addresses the criticisms I have of the techniques listed above, while preserving their strengths.

SDI involves deliberately imagining successive random expressions. Expressions may be objects (e.g., a mouse), actions (e.g., flying), combinations (e.g., mouse on moon, or mouse flying, etc.). For brevity, in this paper I focus on the simple case in which the expression is a single term (noun, verb, adjective or adverb) while defining SDI more generally. Each term in principle is randomly selected from a very large pool of diverse

terms (potentially tens of thousands of terms)[19]. For each term, the participant imagines the term in a possibly empty scene. The scene may also be some vaguely imagined context. However, the scene must not contain objects from a recent scene.[20] The participant is to focus on the object of the term rather than the scene. The participant moves on to the next term every 6-10 seconds. Before illustrating SDI, I characterize it abstractly.

SDI involves deliberate incoherent mentation: the participant's mentation is incoherent across scenes. Within scenes it is coherent. It is impossible for the participant to engage in temporally integrated sense-making while following these instructions.

Whereas the Woolfolk & McNulty (1983) imagery technique expects participants to imagine items in detail, SDI does not require detailed visualization. This is for several reasons including the following.

- The 'folk psychology' (Clark, 1989) belief according to which humans naturally and vividly imagine objects or actions in scenes distorts the processes and structures of imagining. Even visual perception is not as elaborately detailed as commonly supposed. (Compare the 'immanence illusion' in Minsky (1986).) The information on the basis of which we imagine even familiar objects are very fragmentary.

- It is too computationally intensive and it is unnecessary for a machine, including the virtual machines layered on the human brain, to imagine items in detail. For the purposes of analogical reasoning (whether that be in naturally evolved intelligence or purely artificial intelligence), only schematic properties of items are required.[21] It violates the principle of theoretical parsimony to suppose that people imagine in great detail.

- Participants using SDI must quickly 'imagine' an item. They would not have time to engage in detailed reconstruction.

- It might frustrate participants to ask them to do something that minds don't do, which is to imagine items in great detail. This frustration might interfere with the technique in various ways.

SDI is based on the assumption that the mental information constructed in SDI is highly schematic and better thought of as a 'simulus' than a traditional image. (See "Arguments against the pictorial nature of imagery" in (Thomas, 2010).) This is one reason why this technique is not called "serial diverse imagery". Strictly speaking, there are no images in the mind[22]. Where in this paper I use the term "image" it should be interpreted as "simulus". This terminological maneuver does not explain the nature of imagining. It is merely meant to instill vigilance in us with respect to significant requirement and potential pitfalls in understanding mental phenomena. Other reasons I use are the same as those backing My preference for the term 'imagining' rather than 'imagery' (at least for the name of this technique) is in the tradition of Bartlett (1938) — e.g., his use of 'remembering' rather than 'memory'.

As Bartlett (1938) noted, the distinctions between imagining and remembering are rather fine. And so it is that SDI involves serial diverse *remembering*. Participants in imaging items rely on manifold, fragmentary, schematic representations of previously constructed perceptions and impressions. A participant can only imagine a dog by virtue of his prior acquaintance with dogs.

The memory properties of imagination are relevant to cognitive sleep-induction. It has been argued by several sleep researchers that sleep is critical to memory functioning. Dreaming in particular may in many respects be a bi-product of memory processes. Stenstrom et al. (2012) have recently documented in detail the mentation of a highly skilled sleep participant (i.e., skilled at reporting dream content). At SO, the participant experienced scenes containing diverse items related to previous experience. The authors conjectured that this reflected memory processes. There is surprisingly little experimental data available about SO mentation. Whatever the precise memory content of the mentation or the theory that explains the memory processes, that some memory processes are at work is compelling. SDI may not precisely emulate E-SO mentation, however, it remains that of all the techniques that have been proposed to accelerate SO, SDI is the one that most closely emulates SO mentation. As I speculated above, this may contribute to its effectiveness (compare the E-SO mentation emulation hypothesis). To be more precise, the fact that SDI involves implicitly involves serial, diverse remembering—i.e., that it demands that the participant remember much varied content—should contribute positively to its somnolence.

It would be no more effective simply to ask participants to imagine random items than it would be to ask that they not think of their concerns. Techniques of 'free association' (e.g., Mills, 1956) cannot be expected to produce random content. The purpose of these techniques in psychiatry and clinical psychology is to elicit meaningful information from the participant. In free association protocols, one resulting item is normally meaningfully associated with the following item and so on. Semantic priming, a well documented phenomenon (Tulving & Schacter, 1990), would interfere with many techniques to elicit random items. Hence 'free-association' is neither free nor a valid SDI technique.

There are two families of SDI techniques that get around these problems: technology-assisted and self-directed SDI. With *technology-assisted* SDI, software generates a random sequence of words to be imagined. Using text-to-speech technology (or pre-recorded voice files), each word is spoken through an earpiece or speaker, in sequence, a configurable number of seconds apart. (Normally, 5-10 seconds). The participant imagines items referenced by the words, as described below. CogZest, an enterprise run by the author, is developing such an instrument, which it intends to make available to sleep-researchers to test SDI and related techniques.[23]

In *self-directed* SDI, the participant conjures up an arbitrary *seed* word or expression, preferably one comprised of between 5-12 letters. The participant iteratively spells the word, each letter of which is a cue letter. For each cue letter, the participant

sequentially recalls a target that starts with that letter. The participant then imagines an instance (or application) of the target (or involving the target concept), independently for 5-10 seconds as described above. The participant may switch to a different letter if she has difficulty finding a word that starts with that letter, or for whatever reason. If the participant exhausts the letters in the seed word, she then produces a new word. She continues with this procedure until she has fallen asleep.

Here is a hypothetical example of the technique. Suppose the random seed word is "blanket". The participant might then say to herself, "B: blanket" and then imagine a blanket. She might think "B: bicycle" and imagine a bicycle. She might then think "B: buy" and imagine herself buying shoes. Notice that *buy* is a verb. That is acceptable. She might think "B: banana" and then imagine a banana hanging from a tree. She might then produce the word "breakfast", but reject it because it is too similar to the previous word. She implements the incoherence principle. This illustrates that a meta-management process is involved in SDI. The process monitors for coherence. She then selects "Basket" and imagines a basket by her desk at work. She then gets bored of "B" words and moves onto "L" words. "L: Larry" and she imagines her friend Larry. Notice that Larry is a person. That is acceptable, for SDI terms may be persons. She need not imagine Larry in any particular setting, nor need she perceive Larry performing any particular action. "L: like" and she might think of her son giving a hug to their dog, an animal they like. In other words, she imagines a concrete action that illustrates an affective disposition. "A: Amsterdam" and she might very vaguely imagine the large hand of a sailor gesturing for another order of fries in an Amsterdam pub while a rancid accordion plays in the background, a coherent image elicited from the song, "Amsterdam" sung and composed by her favorite artist, Jacques Brel (Brel, 1964). Notice that this imagining involves a simple action and the elicitation and integration of several memory items. And then, "A: Apple". And so on until SO.

This method relies on phonetic cuing to prime lexical representations (words). This is a subset of phonological priming. Any given letter maps to one or more phonemes but not directly to the smallest unit of meaning, the morpheme. According to the well-corroborated Cohort model of speech processing (Marslen-Wilson, 1995; Samuel, 2011), as soon as listeners are exposed to a phonetic stream, phonetically matching lexical representations organized in cohorts are activated. The cohorts are not morphologically organized. There is no pertinent semantic relation between the representations. It ought therefore be relatively easy for participants to produce a wide diversity of targets using a letter as cue, particularly if one allows for a few minutes of daytime training with the method. Of course, there may be all kinds of other priming effects from the seed word and previously activated items, including semantic priming (Tulving & Schacter, 1990). However, they shouldn't be particularly important given the potency of phonological priming, particularly for the purposes of SDI. Moreover, SO mentation is not perfectly incoherent: SDI will already trigger a more incoherent mental state than is typical at SO (a contributor to its super-somnolence).

Several types of SDI could be developed and explored. This would provide more variety for participants. It would also allow empirical research to optimize the technique for entire populations and idiographically. For example, one could control the ratio and distribution of verbs, concrete nouns, proper nouns of persons, proper nouns of places, and so on. Words have multiple features that may have different somnolent properties. SDI can be used with phrases as well as individual words. Participants could be encouraged to briefly imagine how they would draw the word, as if they were playing Pictionary[24]®. SDI, as alluded to above, is not restricted to terms. It can use expressions. Thus it can make use of the generative power of language. With software, all kinds of semantic relations can be explored. For example, absurd combinations could easily be explored. Absurd imagining is commonly reported when SO mentation is probed. Its somnolent properties could be explored.

8.1. Summary of super-somnolent properties of serial diverse imagining

This section describes the expected somnolent and counter-insomnolent properties of SDI, i.e., the components of super-somnolence.

8.1.1.   Somnolent properties

SDI has the following somnolent properties.

1. It is an incoherent mental process.
2. It implements the E-SO mentation emulation hypothesis

These properties are described in turn.

SDI is an incoherent mental process

SDI implements the incoherent mentation principle according to which prolonged incoherent mental processing is inherently somnolent. The inherent incoherent properties of SDI are self-explanatory, given the above descriptions of SDI and incoherent mentation. In addition, because incoherent mentation is a highly discriminative cue for sleep, through conditioning SDI should be somnolent.

Let's resume the comparison between SDI and stimulus-control principles. The correlation between being in bed and sleeping is bound to be smaller than the correlation between sleep onset mentation and falling asleep. Moreover, participants will have experienced falling asleep in other contexts besides their bed in particular and beds in general (e.g., classrooms, couches, chairs, tents). Therefore, incoherent mentation is likely to be more effective than stimulus control by virtue of the associationist principles upon which stimulus control is based. Moreover, the incoherent mentation hypothesis leverages mechanisms and has theoretical and practical advantages that stimulus control does not (several of which are listed in this paper).

This is not to say that therapists and insomniacs ought to dispense with stimulus control. SDI is compatible with most of the recommendations of stimulus control. There is an exception, however: The stimulus control recommendation according to which participants should exit bed if they are incapable of falling asleep needs to adjusted to be compatible with the super-somnolent framework. If a participant is having difficulty falling asleep while using SDI, then the participant has the option to stay in bed and continue with SDI. To the extent that the super-somnolent mentation hypothesis is correct, in the long-run and on a probabilistic basis, this will be preferable to the disruption caused by stimulus control. Persisting for an hour with SDI may be more productive than spending an hour awake outside of bed. This would help participants develop skills with SDI, perceived SO self-efficacy, and other benefits listed below. This prediction needs to be verified empirically.

Future research ought also to examine variants of SDI. If one form of SDI does not work for a participant, the participants might try a different variant, rather than getting out of bed.

SDI implements the E-SO cognition emulation hypothesis

SDI has the following features that are characteristics of E-SO mentation and that I conjecture are somnolent.

1. Diverse self-produced, imagery.

SDI is essentially replete with diverse imagining, which is of course self-produced. As noted above, many studies have reported that participants experience imagery at SO (Stenstrom et al., 2012). Often the imagery is bizarre, but it need not be. The bizarreness may sometimes stem from the juxtaposition of unrelated items, which is also a feature of SDI (its incoherence). With technology-assisted SDI using expressions, as noted above, eliciting bizarre imagery would be trivial. It can conceivably be accomplished in a self-directed manner.

2. Memory processing.

SDI implicitly engages the participant to make frequent demands on memory information and to integrate one or more aspects of it. As noted above, several studies have reported that SO mentation is ripe with memory content —e.g., Cipolli *et al.* (1992) and Stenstrom *et al.* (2012). SDI actively engages participants in reconstructive recall of prior information. Researchers can verify this feature of SDI by interrupting participants as they practice the technique and asking them to report the particular content they are imagining.

The question of course arises as to what type of memory content is characteristic of SO and whether that matters to the effectiveness of SDI. For example, Stenstrom et al. (2012) report that SO dreams contain scenes. It is unclear whether this is a somnolent feature and whether it is characteristic of P-SO. This is left for future research. More

important than the content is the potentially somnolent properties of memory processing, such as activating diverse memories that are unrelated to immediate perception and external concerns.

3. Incoherent mentation.

This construct, described above, is a feature of E-SO and of SDI.

There are of course several differences between SDI mentation and SO mentation. For example, SDI 'imagery' is schematic (imaginative) whereas Nielsen (2000) notes that "Perhaps the most vivid NREM mentation reports have been collected from SO stages." He also reports that "much SO mentation (from 31–76% depending upon EEG features) is clearly hallucinatory dreaming as opposed to isolated scenes, flashes or nonhallucinated images (Vogel 1978b)." This is different from SDI, which does consist of isolated scenes. A large sample will be required to pinpoint this number. Moreover, the smaller number of isolated scenes may nevertheless have a somnolent role. SDI is at best an approximation of SO. What matters from the perspective of the E-SO mentation emulation hypothesis is that it emulates the somnolent properties of E-SO.

8.1.2. Counter-insomnolent properties

SDI is counter-insomnolent in that it very actively interferes with the processing of worries, concerns, and other insomnolent distractors cataloged by (Wicklow & Espie, 2000) and others. It should have the benefits ascribed to less diverse imagery-distraction techniques. Participants who successfully engage in SDI will be focusing their attention on all kinds of neutral external items rather than insomnolent information of the types cataloged by Wicklow & Espie (2000).

As noted earlier, general self-distraction instructions are not effective ways of distracting oneself. Salkovskis & Reynolds (1994) provided smokers with a simple but engaging task to distract them from intrusive cigarette-related thoughts. This indeed reduced the frequency of smoking-related thoughts. Knäuper, Pillay, Lacaille, McCollam, & Kelso (2011) found that requesting participants to vividly imagine engaging in their favorite activities, compared with three other tasks, reduced both the intensity and the vividness of their craving for foods. None of the alternative tasks involved imagery. As mentioned previously, imagery distraction has proven useful with insomnia (Nelson & Harvey, 2002).

It is impossible to ruminate and process motivators so long as one is engaged in an alternative task that fully occupies management processes. SDI is fairly demanding of management processes. It includes a wide variety of mental content, which may keep participants engaged and perhaps even entertained. Yet it is fairly simple to execute. Participants need merely commit the seed word to a less transitory memory buffer than working memory, retrievable with a cue.[25] In order to do this, they may elaborately imagine the first word. This is readily incorporated in the technique. Whatever the seed word (e.g., "blanket"), the participant can use it as the target of the first cue letter ("b" → "blanket"). Given the primacy effect in memory, the seed word should be easier to

remember than the words subsequently generated by the participant. That is useful, because it is the one they will need to recall after exhausting each letter. (If they forget the seed word, they can always generate a new word.) As is common in teaching meditation, participants can be told that if they get distracted, they can simply return to the task, in this case SDI (Kabat-Zinn, 2009).

There are reasons to believe that most participants will find it easier to remain focused with SDI than with other cognitive techniques (including meditation). Compared to SDI, the other techniques do not provide a very compelling, engaging and active alternative to rumination. Here is how this can be explained according to H-CogAff (Beaudoin, 1994; Sloman, 2003; Sloman, Chrisley, & Scheutz, 2005). The human mind contains asynchronous motivator generators (which are also motive activators.) In order to disrupt attention, inner motivators must be sufficiently insistent, at least on a probabilistic basis. It is not yet clear how interrupt thresholds are regulated. However, engaging in cognitively demanding tasks seems to increase filter thresholds. It may even inhibit competing motive generators. From a design-based perspective, this is to be expected (Beaudoin, 1994).

It will be useful to seek to determine the types of instructions that raise the interrupt threshold to prevent the participant's daytime concerns from interfering with SDI. Is it helpful to instruct users to treat SDI as a very important task? An engaging one? A fun task? Should there even be a competitive element? Is it useful to introduce rewards? A point system for number of words imagined? SDI introduces several possibilities beyond what the other techniques allow (e.g., stimulus control, meditation and imagery distraction). This has implications for motive processing in general, and may benefit from research on waking motive processing.

While self-directed SDI relies on the participant to produce target words to imagine, the SDI procedure is very simple and guaranteed to produce several words, given a bit of training, the potency of phonological cuing, and the generative power of the linguistic mechanisms tapped by SDI. If participants have difficulty activating a target given the phonetic analogs(s) of a letter, the SDI procedure specifies that they can add another letter. For example, if the participant cannot produce a word with 'A', the participant can append a letter to 'A', such as 'b', which yields 'Ab' and may cue 'Able', 'Ability', 'absent', 'absolute', etc. With a bit of practice, given normal learning, SDI may become as automatic as taking dictation.

As a result, SDI users will normally be able steadily to produce a sequence of targets to imagine. If this is successful, then viewed at a certain level of abstraction, it will be as if the words were coming from an external audio source. This may help participants to focus on SDI as opposed to other motivators. This would contribute to the counter-insomnolence of SDI. This ought not to vitiate the benefit mentioned above, namely that the imagining process is internally generated, rather than analogically representing sensor input.[26]

Participants who feel overly challenged by self-directed SDI or who are too tired to engage in self-directed SDI may resort to technology-assisted SDI. The external audio stream ought not only to provide them with content to imagine, it may help them focus on the SDI task and thus away from disruptive, more or less affective mental content.

SDI may also have several less direct counter-insomnolent properties. Perhaps the most significant such property is an increase in perceived self-efficacy (Bandura, 1993). Albert Bandura has systematically argued that "Among the mechanisms of agency, none is more central or pervasive than people's beliefs about their capabilities to exercise control over their own level of functioning and over events that affect their lives" (Bandura, 1993). SO can be framed as a cognitive task with important meta-management (including meta-cognitive) components. For many people, falling asleep feels like a very simple cognitive task—at least most of the time. However, arguably, many people are not very skilled at falling asleep. Their insomnolent mentation often keep them awake. This lack of efficacy contributes to a counterproductive positive feedback loop. It supports their fears of not being able to fall asleep. Readers conversant with the perceived self-efficacy literature will find this characterization to match a pattern of perceived self-inefficacy in education and other domains (Bandura, 1997). Path-analyses suggest self-efficacy beliefs account for a large degree of variance of academic achievement, through its influence on persistence and skill. Indeed, Carney & Edinger (2006) reported that amongst the several themes in the Dysfunctional Beliefs and Attitudes about Sleep questionnaire (Morin, Stone, Trinkle, Mercer, & Remsberg, 1993), hopelessness and helplessness with respect to sleep were most predictive of difficulty falling asleep.[27] Belanger, Morin, Gendron, & Blais (2005) reported that people with insomnia,whether or not they had general anxiety disorder, felt they had less effective thought control strategies than others.

To develop perceived self-efficacy in any domain, one must ultimately become skilled in that domain. Otherwise, one is deluding oneself. If the foregoing analysis of SDI is correct, then it will provide participants with control over SO. Therapist, educators and SO technology providers can then help participants recognize their actual self-efficacy. That is, they can try to help participants boost their own perceived self-efficacy. This is a frequent objective in CBT. Most of the techniques described by Leahy (2003), for example, are aimed at readjusting clients' cognitions (beliefs, perceptions, etc). Even without such external influence, it seems likely that many participants will adjust their self-efficacy beliefs. This in turn is likely to have the types of beneficial effects of improved perceived self-efficacy that have been empirically documented in so many domains (Bandura, 1997).

It is beyond the scope of this paper to examine the roles of perceived self-efficacy in great detail. However, I will note the following. The importance of perceived self-efficacy, and the need for insomnia research to avail itself of a theory of mental architecture are other reasons that the H-CogAff framework is pertinent to insomnia research.[28] Perceived self-efficacy theory rests on self-regulation meta-theory. However, the meta-theory, like current sleep research, lacks a computational architecture.[29] In the

conclusion to my Ph.D. thesis, I drew attention to the relevance of the H-CogAff[30] framework to obsessive-compulsive disorder. This was a natural proposal given that Aaron Sloman's architectural description of perturbances (tertiary emotions)[31] (Sloman, 1987). OCD, tertiary-emotions and primary insomnia are all characterized by perturbance, that is (a) the generation of mental content that disrupts management processes; and (b) a certain loss of control over management processes by the meta-management layer. It seems worthwhile to seek to understand and develop applications for these phenomena in a unified way, from the designer-stance.

There is a risk, however, that in some participants SDI fails to be counter-insomnolent. Some participants might find it difficult to follow the technique. They may lack the meta-management abilities.[32] Participants whose executive functions are sufficiently impaired or who lack fluid rationality (Stanovich, 2011) might simply give up on it. Some participants might find their failure with SDI to be stressful and frustrating. The remedy for some of them may be to use technology-assisted SDI, which is less cognitively demanding.

In sum, SDI provides a much more specific, rich and generative mentation algorithm than the forms of imagery distraction that have been used previously for insomnia, and managing cravings. It is more demanding and entertaining. These features may potentiate SDI's counter-insomnolent properties.

8.1.3. Other expected advantages of serial diverse imagining

There are other expected advantages of SDI besides its proposed super-somnolent properties.

- It is expected to be easy to train people to use SDI, as mentioned above.

- SDI is inexpensive.

- SDI has has several features of play (Brown & Vaughan, 2009).[33] Producing images is a key aspect of many forms of play and creativity. Brown & Vaughan note the following features of play: the activity engenders a sense of timelessness and diminished consciousness of the self, it is pleasurable, it is apparently purposeless, and it has improvisational potential. Playing also often involves exploring possibilities beyond one's immediate surroundings or concerns (Pellegrini, 1986). SDI shares most of these non-binary features. Interestingly, many of these features are opposite to features of insomnia (e.g., loss of sense of time, diminished consciousness of the self, pleasure). SDI is not purposeless, but for participants with the right thinking dispositions, it may be characterized as enjoyable. Many people as children played in Brown's sense. Yet, for a variety of reasons, many as adults do not play or play very little. SDI will provide adults with a justification to engage in imagining and exploring a large space of items, albeit briefly. Some SDI users may even look forward to going to bed so that they can finally free themselves of daytime concerns *and* daytime mentation and let themselves imagine. This may bring back associations

with childhood. Therapist may draw attention to this fact to help their clients enjoy and use SDI.

•   SDI is enjoyable. The pleasurableness of SDI for some of its users was listed as a component of play, but it is worth singling out two general considerations here. First, I conjecture that participants who score high on the following measures of thinking disposition described by (Stanovich, 2011; Stanovich, West, & Toplak, 2011; Toplak, West, & Stanovich, 2012) are more likely than others to enjoy SDI and appreciate its potential as play: Resistance to miserly information processing, belief flexibility: actively openminded thinking, tendency to seek information, enjoy thought, and fully process information. This is because those measures tap into what Stanovich et al. refer to as "the reflective mind", which corresponds to the meta-management layer in H-CogAff, as Stanovich implicitly acknowledged through relating his architecture with H-CogAff (Stanovich, 2011). Second, the content of SDI will contribute to its being enjoyable. This is because people enjoy thinking about items that they are familiar with. SDI will elicit memories from the participants. This is an idea behind the social psychology principle that "familiarity breeds liking". People tend to talk and think about what they are familiar with it. SDI broadens the scope by recruiting a larger pool from the person's prior experience. Of course, participants will need to learn to select target words and images that are not disturbing.

•   SDI is a form of meditation (as explained above). Therefore, it seems reasonable to suppose that its users ought to experience at least some of the benefits of traditional meditation. I will not here speculate on the general benefits of meditation. However, I note that SDI involves monitoring and control of mental processes. Just as many people do not play as much as they would like to, some people feel they should meditate but don't feel they can afford the time to do so or do not know how.[34] Just as SDI implicitly provides a justification for play, it also implicitly provides a justification for meditation.

•   SDI offers the possibility of also being productive. One could design specific forms of productive practice (Beaudoin, 2011a), for example, that are also SDI. (There could also be other forms of incoherent deliberate mentation that are less imaginative and that extend productive practice.)

•   SDI has properties of psychedelic mentation, though it does not require a drug.

•   The perceived self-efficacy benefits of SDI mentioned in the previous section with respect to counter-insomnolence may be transferred, with appropriate guidance. Participants who experience that they can take control of their somnolence through the applications of cognitive science, with appropriate education, therapy, and/or personal reflection, may also come to realize that they can enhance their learning and other aspects of their mental lives through cognitive science. The applications of cognitive science to adult mental development are described in Beaudoin (Manuscript in preparation).

8.2.SO acceleration in context

None of this is to suggest that SO acceleration—whatever technique is used to achieve it—should be the only tool in its users toolkit. A limitation of thought control is that it is an avoidance technique. However, the bed is not a good place to be processing one's concerns. CBT therapists have several tools at their disposal to help insomniacs deal with the root stressors that keep them awake.

SO acceleration, however is not merely of value for insomniacs. Many people are only in bed for as many hours as they need to sleep. Many of them often require several minutes to fall asleep initially and after each major awakening. Many of these people would, correctly, attribute their lack of sleep to the fact that they don't have enough time in bed; *i.e.,* they would not attribute it to insomnia. Accelerating each of their SO's may make a difference to them the next day between feeling that they are adequately rested or not. Many of them appreciate having access to an easy, reliable SO acceleration technique. However, one would not want to encourage people who are not concerned about their sleep to focus excessively on SO latency because being overly concerned with sleep time is a contributor to insomnia as suggested earlier and in Bélanger, Savard, & Morin (2010).

9. Discussion

Given the importance of insomnia and the disadvantages of pharmacological methods, sleep researchers have frequently called for research on cognitive techniques for insomnia. This paper proposed new ways of classifying mentation produced as people attempt to fall asleep: somnolent, insomnolent, counter-insomnolent and super-somnolent. It also proposed the E-SO cognition emulation principle. It proposed that some forms of incoherent mentation implement the E-SO principle and are super-somnolent. It described SDI as a candidate incoherent, E-SO implementing form of mentation. It described two SDI techniques while noting that several other forms of SDI could be explored.

CBT and cognitive therapy have roots in cognitive psychology. Cognitive psychology is inscribed in cognitive science. The fundamental tenet of cognitive science is that mental phenomena should be studied with an information-processing metaphor. Cognitive therapists use this metaphor at a high-level (e.g., Leahy, 2003). However, there is a current of theorizing in cognitive science that does not yet seem to have caught the attention of therapy developers. That is the notion of an information-processing architecture. This paper illustrates the potential posed by architectural thinking to inform therapists' (a) thinking about their clients mentation (with the concepts of management, meta-management and so on), and (b) designing of psychological interventions.[35] Cognitive psychologists themselves are often not overly concerned about architecture, because they are solving problems in narrower silos. They may posit architectures for the

specific function they are addressing —e.g., visual motion detection or working memory — without integrating this with other processes. That is understandable.

Because psychotherapists are not merely concerned with one aspect of classical cognition, but an entire person, which includes many 'cognitive', 'executive' and 'affective' processes, they would be well served by having a model of the entire mind. Otherwise, there is a risk that they interpret cognitive science concepts from the intentional stance (Dennett, 1987) rather than the designer stance (Beaudoin, 2011b; Sloman, 2005). From the intentional stance, one tends to focus on the content and rationality of thoughts, beliefs, etc.

Thus, in this paper I have emphasized the importance of considering the processing of concerns and other types of information in the light of an overall architecture of the human mind, particularly the H-CogAff architecture. I could only very briefly summarize H-CogAff here. It posits a tripartite architecture that integrates classically cognitive processes with affective ones. Harvey et al. (2005) called for research "to distinguish between rumination, worry and intrusions if a full understanding of unwanted thought in insomnia is to be achieved" (Harvey et al., 2005). The H-CogAff architecture provides many useful information-processing concepts that are germane to this call, such as the concepts of insistence and interrupt filtering (Beaudoin, 1994).

The concepts and conjectures in this paper ought to subjected to the rigors of theoretical critique and empirical testing by peers. While many of the proposals are logically related, this paper's 'inferences' are no different from the majority of derivations in psychology in that their rigor can be improved. There are usually hidden assumptions and interpretations in "predictions" in psychology. While striving for rigor, we also accept some of the benefits of failing to achieve the standards to which we aspire. One such benefit is that some elements of the theory may survive independently from a criticism of the others. For example, SDI might survive as a useful family of techniques even if several of the theoretical principles from which it was derived are weakened by potent criticism, and vice versa. Ensuing research will hopefully further the development of theory and techniques for understanding and accelerating SO, a significant modern concern.

10. References

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Addendum

Added 2014-05-12.
SDI is a subclass of a broader category of deliberate mentation strategies that I've named "the cognitive shuffle" in a recent abstract (Beaudoin, L.P. & Guloy, S. (2014). Decreasing sleep-onset latency for better cognitive performance in faculty and students: Super-somnolent mentation and the new "cognitive shuffle" technique compared with monotonous imagery training. Learning Together Conference. Simon Fraser University Faculty of Education). The cognitive shuffle involves shuffling mental content, with or without rich imagery. For example, one could in principle rapidly conjure up algebraic equations, fragments of software code, numbers, or symbols that do not necessarily elicit strong imagery. SDI is a type of "cognitive shuffle" that involves rich imagining.

Revision History

NB: No substantial changes in any of these revisions.

2013-09-12. Corrected erratum. Replaced "apnea" on p. 14 with "narcolepsy". New title for [Luc P. Beaudoin's book](#).
2014-05-12. **v.1.3** Corrected erratum "The technique does not have insomnolent properties" has been changed to "The technique does not have somnolent properties". Set project name to Cognitive Productivity Research Project (the author's main project). Added Addendum.
2015-12-12 **v.1.4**
• Amber Xie fixed section numbering problems.
• deleted "assume" in "This paper critically assumes assume that imagining is fragmentary and schematic."
• Replaced "readjusting client's" with "readjusting clients'".
• Replaced "Path-analyses suggest self-efficacy beliefs to account" with "Path-analyses suggest self-efficacy beliefs account".
• Replaced "velocity" with "latency".
• Replaced "(Seligman & Yellen, 1987) proposed" with "Seligman & Yellen (1987) proposed"
• Replaced "sleep-onset" with "sleep onset"
• Replaced "management-processes" with "management processes"
• In discussing DIY-SDI, replaced "with content to remember" with "with content to imagine".

- "(Stenstrom et al., 2012) have recently" →"Stenstrom et al. (2012) have recently". Fixed a few other citations and some of the formatting problems in the bibliography
- Updated author's affiliations.
- Renamed endnotes and moved Addendum to before endnotes, due to limitations of Pages app.

Disclosure
2014-05-12. A commercial implementation of this idea has been released on Apple's App Store by CogSci Apps Corp. of which the author is a shareholder and president. The app is **mySleepButton**. The author is also president of CogZest, which provides training services and publications in broad cognitive science.

11.   Endnotes

[1]   Broad cognitive science is a research programme that views (or ought to view) the mind as being comprised of information-processing mechanisms, layered upon the brain, and virtually responsible for all psychological experience and functioning (Sloman, 2009; 2010a; 2010b; 2011b; Sloman & Chrisley, 2003; Smith, Sloman, & Gibson, 1992). That is to say that what was treated separately by many scholars from the ancient to this day, as 'affect', 'cognition' and 'will' are all if anything states, processes and mechanisms in virtual machines, as noted below. Sloman's application of the concept of virtual machines also resolves the so called "mind-body problem".

[2]   I do not mean to endorse the distinction between cognition and affect. See Chapter 3 of (Ryle, 1949), Chapter 6 of (Hurley, Dennett, & Adams, 2011) and especially Beaudoin (2013), and Austin (1962). They all point to the fact that the classical distinction breaks down. Explanations of mental phenomena should not exclude valenced information-processing. (Cipolli et al., 1992) speak in terms of "mental sleep experiences".

[3]   Here it is assumed that P-SO is accompanied by alpha waves and SO is operationally defined in terms of a transition away from alpha waves.

4   Sleep researchers already acknowledge that the boundaries around the first stage
        of sleep are not precise. (Carskadon & Dement, 2011). "Is "falling asleep" a
        unitary event? Our observations suggest that it is not. Different functions, such as
        sensory awareness, memory, self-consciousness, continuity of logical thought,
        latency of response to a stimulus, and alterations in the pattern of brain potentials
        all go in parallel in a general way, but there are exceptions to every rule.
        Nevertheless, a reasonable consensus exists that the EEG change to stage 1,
        usually heralded or accompanied by slow eye movements, identifies the transition
        to sleep, provided that another EEG sleep pattern does not intervene. One might
        not always be able to pinpoint this transition to the millisecond, but it is usually
        possible to determine the change reliably within several seconds." This admission
        does not vitiate the P-SO concept.

5   Insomnia research does not seem to have yet incorporated the concept of
        architectures of mind (e.g., (Newell, 1990; Sloman, 2008). In the most general
        sense, such architectures are frameworks not only for classical cognition but also
        affective processes (Beaudoin, 1994; Boden, 2008; Sloman, 2005). The
        theoretical rationale behind the image distraction literature, for example, can be
        traced through (Borkovec et al., 1998) to a most tentative of weaning from
        associationist tenants (Mowrer, 1947). Yet (Borkovec et al., 1998) atavistically set
        their theory in associationism and behaviourism, emphasizing the B in ensuing
        CBT. For example, they claim "The negative reinforcement of worrisome
        activity described above in its various versions would provide one mechanism for
        the strengthening of the activity and thus contribute to the maintenance of both
        the worrying itself and the anxious meanings associated with its topics. Another
        potential mechanism that contributes to further elaborations of anxious meaning
        was revealed in a laboratory investigation of higher-order conditioning" (p. 567)
        And "Worry distinctively involves a predominance of verbal thought whose
        function appears to be the cognitive avoidance of threat"   I propose that CBT
        approaches to insomnia, rather than projecting behavioral concepts into the mind,
        or at least in addition to doing so, should consider mental processes in terms of an
        information-processing architecture.

6   This framework is also described in (Hawes, 2011). (Frijda, 1986) provides a
        related detailed account of the processing of concerns.

7   All of their participants were diagnosed with primary insomnia according to
        (Association, 1994).

8   Mowrer distinguished two types of learning, associationist and problem-solving.
        However, (Borkovec et al., 1998)'s account is based on the former type.

9   (Harvey et al., 2005) distinguish meta-cognition from thought management. They seem to take the view that 'meta-cognition' is restricted to beliefs about mentation, as opposed to the active monitoring of high-level processes described by (Beaudoin, 1994; Cooper & Shallice, 2000; Norman & Shallice, 1986) and Chapter 6 of (Sloman, 1978). In this paper, meta-cognition is a form of meta-management.

10 Vigilance was referred to as "vigilational processes" in (Beaudoin, 1994). They include motive generators, motive activators, and interrupt filters {Beaudoin:ve}.

11 See (Klein, Moon, & Hoffman, 2006) for a collection of concepts related to sense-making. See (Seligman & Yellen, 1987) for a general sense of sense-making used here. Sense-making is a very broad, polymorphous concept, not one to be technically defined.

12 Given that Shanahan identifies brain processes underlying communication through coherence (including the connective core), in light of the current paper it would be interesting to assess activity in the connective core at P-SO. In this case, P-SO could be determined empirically and precisely since participants need not be interrupted.

13 By "retain", I do not mean as a copy, but in some form, however schematic (Bartlett, 1938). Anderson's analysis is not particularly constructivist; however his rationalist argument applies to constructivist accounts. Constructivist theories of remembering are not exempt from the responsibility of accounting for data on distributed recall practice (Wheeler & Roediger, 1992).

14 This is not to suppose that distributed recall practice is a silver bullet. Memory is affected by multiple factors (Roediger, 2008).

15 This is not to suggest unidirectional causation between higher-level processes and lower-level arousal mechanisms. Control flows in all directions in minds and brains. See Section 3.3 of (Sloman, 2002b). This analysis assumes the mind is a multi-layer virtual machine (Sloman, 2009) layered upon a multi-layered physical machine (Grant, 2003).

16 Thayer (2001) provides a lucid account of psychological energy and activation states. He refers to the combination of fatigue and tension, which I allude to here, as 'tense tiredness'.

17 As mentioned above, there are other SO accelerating techniques, including to have subjects think about the stressful content in images to provoke some kind of catharsis (though the word "catharsis" is not used explicitly in these papers).

18   Harvey and Payne attempted to measure distractions, but they utilized self-reports which are not as valid as think aloud protocols. Also, their sample size was small. Participants were assessed one night only.

19   A variant of SDI involves imagining combinations of objects, such as a tree on a spoon.

20   This negative requirement is not subject to the types of problems that besiege unfocused self-distraction because (a) the subject is provided with, or provides himself with, a sequence of replacement objects; and (b) the subject is engaged in a cognitively demanding task.

21   The concept of analogical reasoning used here is described in (Sloman, 1985) and Chapter 7 of (Sloman, 1978).

22   Not all cognitive psychologists agree on this. For example, (Pinker, 1999) acknowledges that "Images are fragmentary. We recall glimpses of parts, arrange them in a mental tableau, and then do a juggling act to refresh each part as it fades. Worse, each glimpse records only the surfaces visible from one vantage point, distorted by perspective. (A simple demonstration is the railroad track paradox — most people see the tracks converge in their mental image, not just in real life.) To remember an object, we turn it over or walk around it, and that means our memory for it is an album of separate views. An image of the whole object is a slide show or pastiche." Yet his text assumes, unrealistically in my opinion, that images are relatively simple data structures that can be inspected. The notion of "albums" is misleading. The notion of a motivator must also not be assumed to be a data structure, as I pointed out in (Beaudoin,1994).

23   These tools are analogous to tools co-designed and co-implemented by the author to support and study self-regulated learning (SRL) (Beaudoin & Winne, 2009; P. Winne, 2006). The SRL tools are configurable, which allows researchers to manipulate pertinent independent variables. They contain sophisticated data logging, user management and data analysis functionality. That SRL research and development, whose Principal Investigator is Phil Winne, is still ongoing. SDI tools can provide similar scientific capabilities for SO acceleration research. Researchers interested in the SDI testing tools may contact the author.

24   In this game, only one member of a team at a time picks and reads a word depicting a person, a place or another type of thing, which she must draw. Her teammates must try to guess the word based solely on her drawing. This forces the drawer to imagine features of the item that have high discriminability. http://en.wikipedia.org/wiki/Pictionary (captured 2013-03-25).

25   Ericsson & Kintsch (1995) provide an alternative to traditional secondary and primary memory: long-term working memory. They explain how it applies to memory for text. Thus long-term working memory does not merely apply to esoteric domains of expertise. I expect it to be applicable to SDI.

26   This is another reason why in many cultures, parents read stories to their children. Children's imagining is somnolent.

27   As Bandura emphasized, perceived self-efficacy ought not to be construed as a global or personality variable. Someone might, for example, feel very efficacious at one task (e.g., taking dictation) but inept at another (e.g., writing poetry). Instead, it should be construed as relative to a skill. A person might feel very efficacious at one task (e.g., taking dictation) but inept at another (authoring scholarly documents). Morin's instrument taps specifically into sleep efficacy. Some sleep researchers have found a smaller relation with perceived self-efficacy (Schlarb, Kulessa, & Gulewitsch, 2012) but they used an instrument that attempts to tap *general* perceived self-efficacy (Schwarzer & Jerusalem, 1995), which *a priori* is a much less predictive construct.

28   Keith Stanovich has shown how a similar, three-level architecture can be used to make sense of an immense variety of findings in cognitive science (Stanovich, 2011; 2009). He himself cites the H-CogAff framework. See also (Beaudoin:ve}. An architectural proposal was also provided by Winne & Hadwin (1998).

29   Sloman (1993; 2002c; 2002b)

30   The framework did not have a name then, however.

31   To avoid terminological disputes, Sloman and I now distinguish between three types of emotions: primary, secondary and tertiary. Previously, we reserved the label 'emotion' for tertiary emotions. I introduced the term 'perturbance' to denote tertiary emotions (they are synonyms).

32   Meta-management implements self-monitoring and mental control. Meta-management is referred to as reflective processes in (Stanovich, 2009).

33   The concept of play is not one to be technically defined. Still, Brown & Vaughan arguably capture many important features of play. Also: (Campbell, 2009)..

34   Compare a list of common reasons why people don't exercise and recommendations to help them adhere to an exercise regimen (Anonymous, 2006).

35   In Beaudoin (2013) I explain how this architecture can be applied to adult mental development.