**The Strategic Allocation Theory of Vigilance**

Samuel Murray\*1,2,3 and Santiago Amaya1,4

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1 Laboratorio de Juicios y Emociones Morales, Universidad de Los Andes, Bogotá, Colombia

2 Department of Philosophy, Providence College, Providence, RI USA

3 Neuroscience Program, Providence College, Providence, RI USA

4 Departamento de Filosofía, Universidad de los Andes, Bogotá, Colombia

\*Please address correspondence to Samuel Murray, 105 Siena Hall, 1 Cunningham Sq., Providence, RI, 02918 (email: [smurray7@providence.edu](mailto:smurray7@providence.edu)).

**Abstract:**

Despite its importance in different occupational and everyday contexts, vigilance, typically defined as the capacity to sustain attention over time, is remarkably limited. What explains these limits? Two theories have been proposed. The Overload Theory states that being vigilant consumes limited information-processing resources; when depleted, task performance degrades. The Underload Theory states that motivation to perform vigilance tasks declines over time, thereby prompting attentional shifts and hindering performance. We highlight some conceptual and empirical problems for both theories and propose an alternative: the *Strategic Allocation Theory*. For the Strategic Allocation Theory, performance on vigilance tasks optimizes as a function of intrinsic and extrinsic motivations, including metacognitive factors such as the expected value of effort and the expected value of planning. Limited capacities must be deployed across task sets to maximize expected reward. The observed limits of vigilance reflect changes in the perceived value of, among other things, sustaining attention to a task rather than attending to something else. Drawing from recent computational theories of cognitive control and meta-reasoning, we argue that the Strategic Allocation Theory explains more phenomena related to vigilance behavior than other theories, including self-report data. Lastly, we outline some of the testable predictions the theory makes across several experimental paradigms.

**Keywords:**

Vigilance, attention, meta-reasoning, cognitive control, foundations of cognitive science

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**Introduction**

Vigilance is typically operationalized as the capacity to sustain attention on task demands over time (Oken et al., 2006). Understanding the cognitive mechanisms that underlie vigilance is crucially important for explaining and potentially optimizing performance in different industrial (Finomore et al., 2009), military (Matthews et al., 2014), and everyday contexts (Schmidt et al., 2009). Many of life’s activities require the ability to sustain attention over time and failing to do so introduces substantial risks and possible harms (Williamson et al., 2011).

In the laboratory, vigilance tasks typically require a response to an infrequently occurring target stimuli embedded within frequently occurring non-targets, as exemplified in Mackworth’s classical Clock Task (Mackworth, 1948; Lichstein et al., 2000). Current implementations of the Clock Task require participants to watch a digital “clock” where the hand occasionally moves two positions in a second rather than one—this is called a *double jump*. Participants are instructed to press a key every time they detect a double jump. Other vigilance tasks require inhibition during the target event. In the Sustained Attention to Response Task (SART; see Robertson et al., 1997 and Mensen et al., 2022), single digits are displayed on a screen for brief intervals (~ 70 – 250 ms.) and participants are told to press a key for every digit except one (e.g., 3). The Clock Task and SART both test vigilance with visual stimuli, but some vigilance tasks study alternative modalities. The Bakan Vigilance Task requires participants to listen to strings of digits and make a response anytime there are three consecutive odd digits (Bakan, 1959). While vigilance tasks are often artificial and repetitive, they are intended to mirror real-world demands for sustained attention and pattern discrimination (Wickens & Carswell, 2021).

Despite its importance, performance on vigilance tasks reliably (and remarkably) degrades rather quickly, a fact that suggests that vigilance is a highly limited capacity. The decline in vigilance performance over time is known as the *vigilance decrement* (Mackworth et al., 1964). Empirical research on vigilance is dedicated to understanding the factors that contribute to the decrement by uncovering the cognitive mechanisms behind it. The overarching goal is to understand how to limit, mitigate, or alleviate entirely the decrement in different task domains (Hancock, 2017).

The history of vigilance research stretches back to the 1940s (Mackworth, 1948), with many different theories attempting to explain the decrement.[[1]](#footnote-1) Today, there are two prominent theories of the decrement. Both theories view the decrement as resulting from breakdowns of sustained attention, although each view takes a different stance on how these breakdowns occur. The *Overload Theory* states that vigilance tasks require sustained attention, where sustaining attention consumes limited information-processing resources (Warm, Parasuraman, & Matthews, 2008). When these resources are depleted, participants are fatigued and need rest. During periods of fatigue, task performance degrades (Tran et al., 2020). The *Underload Theory* claims that interest and motivation determine where one focuses attention. Over time, people lose interest in the task and begin to think about something else. When attention is diverted from the task, performance degrades (Thomson et al., 2015).

Importantly, both the Underload and Overload theories explain the decline in vigilance performance *over time* rather than any single error in performing. Errors can arise from many different cognitive and situational factors besides deficits in sustained attention. But the decrement does not reflect individual error; rather, it reflects the tendency for performance in vigilance tasks *on average* to degrade over time. In other words, explanations of the decrement focus on performance deficits at the level of *blocks* rather than the level of *trials*.

1. **Outstanding questions and problems**

While both theories can claim some empirical support, each theory has major explanatory gaps. Proponents of the Overload Theory have failed to provide an adequate account of the underlying resources that deplete and replenish over time in performing vigilance tasks. This partly reflects a general conceptual vagueness about how to understand the role of cognitive resources in explaining cognitive phenomena (Navon, 1984). Specific hypotheses, on the other hand, lack evidential support. There is, for example, no biologically plausible resource that depletes and replenishes over time scales that might explain the vigilance decrement. Further, some observations run contrary to the predictions of the Overload Theory, for instance, experimental tests that vary task engagement while holding the need for vigilance steady do not find any decrement (Ralph et al., 2017) More significantly, specific criticisms tend to mask a deeper issue with the Overload Theory: given the importance of vigilance and the number of resources available to the brain, it is unclear why more resources wouldn’t be devoted toward maintaining vigilance behavior over somewhat longer timescales.

The Underload Theory has difficulty explaining why the decrement emerges when people are performing vigilance tasks in which they (plausibly) remain highly motivated to perform the task perfectly. For example, expert radiologists make more mistakes over time when interpreting medical tests, leading to diagnostic errors (Bruno et al., 2015). Relatedly, the Underload Theory has difficulty explaining the effectiveness of rest or intermittent breaks in alleviating the vigilance decrement (Ariga & Lleras, 2011; Ross, Russell, & Helton, 2014; Taylor-Phillips et al., 2024). For the Underload Theory, breaks must serve as an opportunity to recover interest or discover new motivation to perform the task. But this is implausible because some laboratory-based vigilance tasks are extremely boring and it seems unlikely that breaks allow participants to become more interested in the task. Also, some vigilance tasks are such that individuals seem to be highly motivated for the entire duration of the task, as the example of medical screening indicates.

The incompleteness of these two theories suggests a need for a new perspective on vigilance. In this review, we propose a novel account of vigilance by approaching it from the perspective of meta-control and planning. When situated within the broader framework of temporally-extended planning agency, the functional profile of vigilance becomes clearer, including its susceptibility to performance deficits over time.

1. **Task engagement**

Early vigilance researchers claimed that typical vigilance tasks involve two decisions: (1) How to engage with the task, and; (2) Whether to make a response to the task on the basis of an observation (see Mackworth, 1970). Early applications of signal detection theory to vigilance behavior shed light on the factors associated with the second kind of decision (Broadbent, 1971; See et al., 1997; Lynn & Feldman Barrett, 2014). However, considerably less has been said about the first kind of decision. This might stem from the assumption that vigilance tasks required sustained attention, and participants, according to a common interpretation of the task, are simply directing their attention at the task until they are either depleted or uninterested. If this is the case, then there is no interesting question about the *manner* of task engagement.

However, results from some self-report studies of vigilance suggest that this assumption is inadequate and that people attempt to perform vigilance tasks strategically. Paul Bakan (1963) used a 100-item post-task survey to assess qualitative factors in vigilance performance. He found that very few people reported trying to sustain attention for the entirety of a 2-hour vigilance task; instead, some people reported trying to find patterns in the stimuli or identifying portions of the task where rest would be unlikely to result in errors. Giambra et al. (1988) also found that continuously sustaining attention was not a commonly reported strategy in vigilance tasks. More common was for participants to engage and disengage with the tasks at different intervals. For example, participants reported taking a brief mental break after detecting a target stimulus on the assumption that targets were unlikely to occur in close succession.

These results might be discounted as instances of non-compliance from participants. The fact that participants do not sustain attention throughout might encourage the engineering of task parameters to induce compliance. We believe, however, that these results ought to be taken at face value and, when taken as such, they reveal something deep about the nature of the task.[[2]](#footnote-2) They reveal that vigilance tasks include a strategic element. In short, the strategy consists in using latent information about the reward structure of the task, the effectiveness of apportioning attention to the task, and expectations about task demands to regulate the degree to which they sustain attention to the task compared to attending to something else (see also Livingston, 1992).

The fact that participants perform vigilance tasks strategically suggests that the mode of task engagement is an important part of explaining vigilance behavior and, possibly, the decrement. When asking about task engagement, the primary concern is not about whether one should make a particular response or not (a trial-level decision), but *how* to go about performing the task (a block-level decision). In this sense, the mode of task engagement reflects a *meta*-decision: a decision about the policies for approaching the series of trial-level decisions that compose the task. This kind of meta-decision falls under the purview of meta-reasoning (Boureau et al., 2015; Churchland & Ditterich, 2012; Fechner, Schooler & Pachur, 2018). Thus, to understand modes of task engagement related to vigilance, we propose to assess the function and processes of meta-reasoning. This, in turn, can be used to shed light on the source of the vigilance decrement.

1. **Modes of engagement**

The study of meta-reasoning seeks to understand how human beings navigate information-rich environments with limited psychological capacities (Boureau et al., 2015; Kool & Botvinick, 2014; Shenhav, Botvinick, & Cohen, 2013). At any given time, there are many things one could think about, but one cannot focus on everything simultaneously. Thus, human beings must differentially allocate their psychological capacities over time. These different allocations correspond to different modes of task engagement. One mode is more proactive, where this consists in sustaining goal representations in working memory continuously to bias attention, perception, and action systems toward goal-relevant processing and shield such processing from distractors. Another mode of task engagement is more reactive, where this consists in transient, bottom-up reactivation of goal representations at the moment of action, relying on spontaneous recall or bottom-up associative cues to trigger goal implementation (Braver, 2012). Notice that each mode corresponds to part of a cognitive strategy: a mode of engagement towards a task bears on the degree to which attention is sustained on that task relative to other available tasks. Proactive engagement implies greater focal attention, while reactive engagement implies more scattered attention.

Each strategy comes with costs and benefits. The benefit of a proactive strategy is that continuously maintaining a task representation in working memory minimizes interference and enables flexible adjustment in response to top-down regulation. The costs, however, are that maintaining a task set in working memory reduces sensitivity to bottom-up information processing, thereby reducing the likelihood of adjusting in response to environmental contingencies. Proactive strategies are demanding due to the strict capacity limits on working memory and attention. Reactive strategies are less demanding, and so enable the scattering of attention. However, this bears a distinct cost. Reactive strategies are more vulnerable to attentional capture, weakened associative cues, or insufficiently discriminable events that fail to trigger implementation of the task representation at the appropriate time. Because of these competing costs and benefits, people cannot rely exclusively on one strategy, and hence must make trade-offs.

Recent research has examined some of the factors that influence these trade-offs. Some of these findings are intuitive. People are more proactive as task difficulty increases and more reactive as task difficulty decreases (Kang & Chiu, 2021). People are more reactive as the reward associated with task performance diminishes and more proactive as reward increases (Bowers et al., 2021; Mäki-Marttunen et al., 2019). Highly novel tasks tend to elicit proactive engagement and repetitive or routine tasks elicit reactive engagement (Cole et al., 2017; Cole et al., 2018). These are indicative of straightforward cost-benefit analyses associated with the costs and benefits of performance. People engage more reactively with easy, routine, or non-rewarding tasks and more proactively with difficult, novel, or rewarding tasks.

Other research reveals that people also respond to the expected costs and benefits of *effort*. For example, if people expect minimal interference during task performance, they engage more reactively (Gonthier, Braver, & Bugg, 2016). For example, in a non-focal prospective memory task, participants were assigned to perform either a 1-back or 2-back lexical decision task while monitoring for a target face stimulus from a stream of visual stimuli presented during the ongoing lexical decision task. The results showed that participants engaged more reactively with the prospective memory task in the 1-back compared to the 2-back condition (as evidenced by greater reliance on episodic memory to maintain the PM task representation). The results also indicated that participants were more reactive when prospective memory target stimuli were interspersed with trial-unique heterogeneous pictures (e.g., houses) compared to more proactive engagement when such cues were interspersed with similar face or face-like pictures (Lewis-Peacock, Cohen, & Norman, 2016). If the expected benefits of planning are higher, people engage with a task more proactively, as measured by reliance on model-based rather than model-free decision making (Kool, Gershman, & Cushman, 2019). And, if the target stimulus is highly predictable, people engage a task more reactively (Appelbaum et al., 2014; Czernochowski, 2015). Seli and colleagues found that when a prospective memory cue is presented on a predictable schedule, rates of self-reported mind wandering are highest directly after cue presentation and gradually diminish up until the presentation of the next cue (Seli et al., 2018)

This work implies a novel motivational component that influences task engagement: the expected value of expending control (or effort; see Shenhav et al., 2017). That is, task engagement is partly a function of the degree of control expected to perform a task adequately. Degrees of control derive from the comparative computational demands of the process (e.g., top-down vs. bottom-up attention, working vs. episodic memory, model-based vs. model-free decision-making, etc.). Despite being intrinsically motivated to perform a task well, someone might not expend much effort during task performance because it is seemingly easy enough to perform a task at a satisfactory level without such effort.

The upshot of this is that task engagement is not simply a function of how much one cares about accomplishing the task. There is a strategic component to engagement based on how much effort is expected to do the task well. These strategic trade-offs have been tested in some reinforcement learning paradigms (Kool, Gershman, & Cushman, 2017), though to date these have not been tested in vigilance tasks.

1. **Applications to vigilance**

Participants seem to adopt different modes of task engagement throughout a vigilance task. Some evidence comes from the self-report studies mentioned earlier. Many participants report trying to find patterns in stimulus presentation to make the task less boring. Indeed, when participants identify a pattern in stimulus presentation, attention is guided away from the task in predictable ways (Skelly et al., 2003; Seli et al., 2018). Others report directing attention only sporadically to the task and using interim periods to solve other problems (Baer et al., 2021; Dane, 2018; Gorgolewski et al., 2014). Instead of sustaining attention, their mode of enegagement seems more akin to multi-tasking. Relatedly, participants report greater mind wandering in the latter stages of unpredictable vigilance tasks presumably because mind wandering is associated with reactive task engagement and the unpredictability of the task makes proactive engagement relatively inefficient (Martínez-Peréz et al., 2023; Stawarczyk et al., 2014). In general, people seem to adjust task engagement as they perform the task in a way that optimizes over reward and effort. As people come to understand the latent reward structure of the task and the degree of effort needed to attain rewards, balanced against the expected value of effort that could be directed elsewhere to derive rewards from other tasks, they shift toward being more proactive or more reactive.

There is converging evidence for this interpretation coming from the study of closely related constructs. For example, when participants expect that it will be difficult to detect a cue related to a distal intention, they engage in more effortful monitoring—mediated by working memory—compared to participants who expect it will be easier to detect a cue. In the latter case, participants perform more reactively (Koslov et al., 2022; Lewis-Peacock et al., 2016). Generally, when people anticipate that tasks will be easy or that planning will not greatly increase rewards, they tend to be more reactive; when tasks are perceived to be difficult or sensitive to planning, people tend to be more proactive. C*onfidence* can make a difference to selecting a strategy.

Applied to vigilance, we propose a two-level meta-reasoning model to explain the strategic allocations discussed above (see **Figure 1**). In the first stage, the *deliberative* stage, the individual aims to decide *how* to engage in the task. To make this decision, information about the task, such as expected reward and the expected benefits of planning, is key. But situational and cognitive factors can also play a role. Expected interference, based on some understanding of the task environment, can prompt different modes of engagement. Individual motivation to perform the task, influenced by expected reward, can also make a difference. These can also interact with features of the different modes of engagement. For example, proactive engagement is more effortful than reactive engagement. For certain tasks, then, people might default to reactive engagement.[[3]](#footnote-3) The second stage, the *regulative* stage, is about *whether* to produce a response. Regulative decisions are, thus, based on perceptual information combined with a confidence criterion and preferences over type I vs type II errors.

Although the two stages process different kinds of information, deliberative and regulative decisions are mutually dependent. Decisions about how to engage in a task constrain whether a particular (trial-level) observation elicits a response or not. For instance, more reactive participants with a preference for minimizing false alarms will exhibit a different response profile compared to a proactive participant with a preference for minimizing misses. At the same time, based on metacognitive monitoring during the regulative stage, individuals can reopen deliberation to optimize task performance, for instance, when performance is not meeting a certain standard or experiences a high degree of error, or when actual performance reflects an inefficient allocation of effort, a switch between modes of engagement can be called for.

Still, because each of the stages is governed by different kind of information and this information can come from multiple sources, deliberative and regulative stages do not form a closed loop. Non-regulative factors might re-open deliberation, which could issue in shifting to another mode of engagement. Developing an interest in a concurrent extraneous task, for example, might re-open deliberation despite no changes in anticipated feedback at the regulatory level. At the same time, people might have something like an internal timer that prompts meta-decisions in the regulative stage in the absence of any misalignment between actual and expected performance. They might also come to acquire contextual information that might lead to changes in their confidence criterion and preferences over certain types of errors. This implies that the considerations that prompt shifts between modes of engagement need not be consciously accessible to the agent. While people are unlikely to be explicitly aware of different computational processes underlying the decision process, there are likely phenomenological correlates of these computations that are accessible to the agent. For example, people do not seem to deliberate about switching modes of engagement in terms of explicitly represented opportunity costs, but feelings of effort seem to serve as a phenomenological correlate of opportunity costs (Bermúdez, Forthcoming). People, then, might develop a variety of conscious proxies that track what happens at the computational level (Cohen, 2017).

A diagram of a diagram

Description automatically generated

*Figure 1.* A two-level model of vigilance meta-reasoning. In the deliberative stage (top), a meta-decision is made about whether to engage a task reactively or proactively based on information about expected task demands and opportunity costs, among other things. In the regulative stage (bottom), evidence about a stimulus is collected to determine whether to make a response. Evidence accumulation is constrained by meta-decisions at the deliberative stage (solid orange line). Monitoring at the regulative stage can occasionally prompt shifts back into the deliberative stage (dotted orange line).

1. **Theoretical advances**

The Strategic Allocation Theory offers a novel explanation of the vigilance decrement. Vigilance tasks share a similar latent structure. The benefits of planning are low because stimuli are often unpredictable and target stimuli are difficult to discriminate from non-target stimuli. Vigilance tasks require a high degree of effort, but increases in effort over some moderate level yield only marginal increases in expected reward. For these reasons, the Strategic Allocation Theory predicts that most participants tend to engage a vigilance task proactively in the first few minutes and then shift toward more reactive modes in the latter stages of the task. However, to the extent that reactive engagement relies on bottom-up reactivation of the task set, it is more susceptible to goal neglect, especially when target stimuli have low perceptual discriminability. Therefore, the shift toward reactive engagement leads to more errors.

In principle, these errors could lead to a revision of the chosen mode of engagement in the task. However, participants rarely switch back to proactive modes for extended periods of time because the increased effort is unlikely to yield significantly better performance. When, for instance, participants are remided of the task and encouraged to do better, performance returns to pre-decrement levels. But, shortly afterward, participants revert to reactive modes of engagement and the decrement reappears (Ariga & Lleras, 2011; Mackworth, 1948).

The explanation provided by the Strategic Allocation Theory explains other empirical results about factors that alleviate the decrement. As target stimuli become more predictable, participants shift in predictable ways between reactive and proactive modes of engagement (Deese, 1955; Seli et al., 2018). Inserting warning cues just prior to target stimuli nearly eliminates the decrement (MacLean et al., 2009). And making target stimuli engaging mitigates the decrement (Barron et al., 2011). All of these results indicate ways to modulate the expected value of effort, either by raising expected reward associated with effort, lowering the expected cost of effort, or structuring the task such that signals related to reward reliably reinforce reactive engagement. This last point is important for thinking about how to design task environments that accommodate reactive engagement and the need to make cue scheduling as predictable as possible.[[4]](#footnote-4) In a nutshell, vigilance behavior is a function of optimizing over reward and effort.

Besides this novel explanation of the decrement, the Strategic Allocation Theory fills some of the theoretical gaps from other accounts. As noted earlier, one major problem with the Overload Theory was that it lacked a plausible account of the resource that gets depleted during vigilance tasks. The Strategic Allocation Theory instead explains the limitations underlying vigilance, in terms of instric limitations of engagement modes. In short, structural limitations in working memory prevent the same task representation from being engaged proactively and reactively (Braver, 2012; Cohen, 2017). This might reflect the neuronal and synaptic properties of the networks underlying working memory (Edin et al., 2009) or the inherent instability of the attractor networks that implement working memory maintenance (Lundqvist et al., 2016; Mi et al., 2017). Whatever the explanation, the Strategic Allocation Theory explains performance decrements as the behavioral consequence of shifting modes of engagement rather than being the upshot of resource consumption.

Like the Underload theory, the Strategic Allocation theory explains the decrement in terms of motivation. But, the Strategic Allocation theory, unlike its Underload counterpart, recognizes that motivation is multi-dimensional, which means that motivation to perform the task might result in different modes of engagement. Thus, high motivation might favor a proactive mode of engagement, ultimately resulting in very few misses in the task. But it might be compatible as well with a re-active mode of engagement, which might lead to the typically observed performance decrement. Importantly, to the extent that non-regulative factors, such as interest in an extraneous task, can affect decisions at the deliberative stage, the Strategic Allocation Theory does not explain the decrement merely in terms of task properties. Opportunity costs or similar considerations also become part of the explanation. In general, on the Strategic Allocation Theory, the allocation of attention and other cognitive resources is a function of over-arching meta-decisions about *how* one will engage with a task or set of tasks, which integrate over many different kinds of information, not just the disutility of error.

Additionally, the Strategic Allocation Theory can also explain the effectiveness of short breaks on alleviating the decrement. As discussed earlier, this is a crucial piece of evidence for the Overload Theory because it seems to indicate the need to replenish resources in maintaining adequate vigilance performance over time. If vigilance tasks tend to induce more reactive engagement, as the Strategic Allocation Theory predicts, then people are likely relying on bottom-up associative cues to trigger goal activation. The function of a break, then, is to strengthen the association between the stimulus and the task representation. This, in turn, would explain why performance after breaks tends to return to pre-decrement levels (Ariga & Lleras, 2011). Relatedly, people should be able to learn associations between context and task parameters to guide task engagement. If, for example, contextual features are reliably associated with differential variability of stimulus presentation (e.g., some context is associated with a less predictable stimulus schedule), then context shifts should trigger transitions between modes of engagement.

1. **Conceptual advances**

At the outset, we noted that vigilance is typically operationalized as sustained attention. But, on the Strategic Allocation Theory, this seems to be misleading, if not a straightforward mistake. Vigilance is not simply a matter of sustaining attention on performing some task. It is, instead, a matter of apportioning effort across a variety of task sets and selecting modes of engagement for those tasks. To be sure, how vigilant a subject is has consequences for where and how they will sustain attention. But exercising vigilance goes beyond the constant sustaining of attention to a single task. Failures of vigilance help bring this point out more clearly. A failure of vigilance, such as failing to detect a double jump in the Clock task, does not manifest failing to attend in the sense of an absence or low activation of the mechanisms of attention; rather, it manifests directing attention to something that is inconsistent with an earlier goal (such as the goal of detecting a double jump) but pehaps in line with some extraneous goal (e.g., thinking about the groceries one needs to get at the store later). On the view proposed here, vigilance is about the *management* of attention across various task sets rather than simply sustaining attention to a task.

The Strategic Allocation Theory also clarifies the difference between vigilance and prospective memory. Admittedly, the two constructs are similar, to the point where they are studied using the same paradigms. The difference between the two has sometimes thought to be a matter of emphasis rather than a difference in psychological kinds (Dobbs & Reeves, 1996; Graf & Uttl, 2001). In paradigms that include tasks that could be either vigilance or prospective memory tasks, the evidence suggests that participants can be induced to rely on either capacity based on merely changing instructions (Brandimonte et al., 2011). If the researcher frames the task as a vigilance task, participants are better at detecting the target, but their accuracy and reaction times in the ongoing task get worse; if the framing emphasizes the memory component, the pattern reverses. This, however, is what we should expect if the present argument is right. Vigilance is not just a capacity for allocating attention, but also a capacity for the management of memory. How people encode, maintain, and retrieve task-based cues from memory will itself reflect the underlying strategies related to modes of engagement.

Finally, given the role of vigilance in managing attention and memory across multiple task sets, we suggest that practical norms of efficiency govern vigilance in performing multiple tasks over time. This can be understood in two ways: (1) vigilance aims to optimize reward and effort across multiple task sets, and; (2) vigilance aims to optimize the balance between more exploratory and more exploitative modes of cognition (Sripada, 2018). Thus, not only are people attempting to shift across multiple discrete tasks, but also shifting between directed and freely-moving modes of thinking (Irving, 2021).

1. **Conclusions**

By situating the phenomenon of vigilance behavior into a model of meta-reasoning, the Strategic Allocation Theory provides an explanation of the vigilance decrement different from the one offered by the Overload and Underload Theories. On the Strategic Allocation Theory of vigilance, human performance on vigilance tasks reflects the attempt to optimize on reward and effort. This optimization emerges from meta-decisions about what it takes to perform a task adequately and how much effort is needed to achieve that performance. These meta-decisions consists in selecting either reactive or proactive modes of task engagement, both of which have distinct costs and benefits. On the Strategic Allocation Theory, the decrement reflects increasingly reactive engagement with the vigilance task. This is because people expend less effort over time to the vigilance task because performance levels would not (from the perspective of the participant) respond to increased levels of effort.

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1. Davies & Parasuraman (1982) provide an overview of vigilance research from the 1940s to the 1980s, while Hancock (2017) contains an excellent summary of more recent vigilance research. [↑](#footnote-ref-1)
2. There are several reasons to take the results at face value. The proposal that many participants did not comply with task instructions is implausible. In Bakan’s study, only 8% of participants reported trying to sustain attention for the entire duration of the task. Thus, 92% of participants would count as non-compliant—an absurd figure, especially given that Bakan’s sample consisted of Air Force cadets who were eager to appease the researcher. Taking the results at face value also acknowledges that there are many ways to watch a clock or monitor an audible string of digits, only one of which consists in focusing attention on the task to the exclusion of everything else. Participants who try to find a strategy are, we contend, doing something analogous to pacing oneself through a physically demanding task. Strategies are attempts to figure out how best to “mentally pace” oneself. [↑](#footnote-ref-2)
3. Whether people default to reactive engagement is sensitive to the kinds of tasks under consideration. For some kinds of intrinsically meaningful activities, people might experience effort (or expected effort) differently. Thus, it is not the case that effort or expected effort are always computed as costs in deliberation (see Murray, 2024: §5). [↑](#footnote-ref-3)
4. One simple way to think about optimal task design is to use cues that are processed in a different modality than the one used for alternative tasks. Hence, if a person is likely to disengage from a focal task and engage in visual processing related to an alternative task, then using audio cues to reengage attention is likely to be more successful than using visual cues because the visual processing will not interfere to the same degree with the audio processing compared to the interference that might occur with processing a visual cue. [↑](#footnote-ref-4)