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Designing Habits of Mind: Modeling Mental Patterns of Users of Pervasive Systems

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Designing Habits of Mind: Modeling Mental Patterns of Users of Pervasive Systems

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Abstract

What if we could show how pervasive, interactive products influence the mental habits that frame an individual's life experience?

This paper studies how pervasive, interactive products influence the mental habits that frame an individual's life experiences. Based on 12 user interviews and a literature review of attention and meta-cognitive regulation, it identifies interaction design patterns for how such systems influence mental patterns and concludes with a descriptive and predictive model illustrating how mental states shift around product use. This model can be used to evaluate and redesign systems to improve mental patterns through influencing cognitive and affective states.

Keywords: Cognition, attention, awareness, mental habits, habits of mind, distraction, focus, calm, stress, neuroscience.

ACM CLASSIFICATION KEYWORDS
H.5.m. Information interfaces and presentation (e.g., HCI): Miscellaneous.
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Introduction and Motivation

Interactive systems pervade and influence everyday behaviors, thoughts, feelings and actions, augmenting users' cognitive and affective patterns [13, 18, 19]. This includes how and how often users shift their attention – knowingly or not – and the quality of that attention [6].

This influence of interactive products on mental patterns has not been neutral; chronic mental fatigue, anxiety and an inability to focus are common issues of multi-taskers [12, 14, 3]. The trend has emerged, probably not coincidentally, with a growing popular interest in neural mechanisms and interventions to mitigate the effects of frequent multi-tasking or to train and cultivate optimal mental strategies including cognitive focus, affective calm and rest [17, 8].

An illustrative example of this trend is mobile web browsing. Letting people look up information quickly is obviously powerful but the persistent availability of such information can incent users to rely on digital aids rather than on their physical environment, memory recollections or social interactions [18]. When repeated over time, this tendency can manifest itself as a hesitancy to draw on other people, leading to degraded social ties. For example, a study of teens found a positive correlation between the frequency of talking with peers via online or text messaging and social anxiety (discomfort talking with others face-to-face) [1, 19].

Responses to this trend include technology Sabbaths [15] break-taking applications and calming technologies [11] – that, though mitigating the problem, address the symptoms and not the cause. An emerging trend is to (re)design interactive products blamed for the problem towards purposeful (and, one assumes, positive) influence on mental patterns.

Through interviews and a literature review, this paper proposes methods to model and influence habits of mind. The paper concludes with a discussion of how such models can be used and how incentive structures can evolve to cultivate product design that honors human values instead of solely exploiting additive or goal-driven tendencies.

Related Work

Attention is "the set of processes enabling and guiding the selection of incoming perceptual information in order to limit the external stimuli processed by our bounded cognitive system and to avoid overloading it" [11]. Attention can be either *endogenous* (voluntary, top-down, goal-driven, slower) or *exogenous* (captured by an external event, bottom-up, stimulus-driven).

Sohlberg and Mateer distinguish five categories of attention: focused, sustained, selective (maintaining attention in the face of distractions), alternating (the ability to shift between different cognitive tasks) and divided (the ability to attend to multiple sources simultaneously) [17].

Distractions degrade productivity, as the cost to re-start a task is significant [5, 10, 14]. Surveying over 3,000 North American girls aged 8-12, Pea and colleagues identified levels of media multi-taskers and found notable differences [13]. Higher levels of media multitasking and digital social interaction were associated with negative social indicators, such as a low sense of normalcy compared to peers or more frequent feelings of judgment and stress.

Levy and Wobbrock [10] conducted an experimental study highlighting the positive effects of an eight-week training course in mindfulness-based meditation. Experimental subjects focused on tasks longer, switched between tasks less frequently and reported less negative emotions post-task than non-participating subjects.

Evaluating mental patterns lies at the forefront of modern science, using techniques as varied as fMRI, mindfulness meditation and experience sampling [8, 10, 2, 17, 6]. This research has identified neural states such as *open monitoring* (OM), *mind-wandering* (MW), *default mode network* (DMN) and *focused attention* (FA), potentially useful when evaluating the quality and desirability of mental states.

Meta-cognition refers to 'what individuals know about their own cognition or about cognition in general' while *regulation* of cognition refers to 'metacognitive activities that help control one's thinking or learning' [7, 9, 16]. The latter is commonly described to include three components: planning, monitoring, and evaluation.

Many information models of cognition and metacognition exist but none describe how interactive products influence usage and affective state. As this focus was our interest, we sought to study mental patterns in an effort to model them and create a tool for interaction designers and researchers.

User Study: Products and Habits of Mind

We conducted interviews with 12 university undergraduates (seven female, five male) to understand how they reflected on their own mental patterns in relation to interactive products. Interviews focused on two topics: (1) How does the respondent conceive of his/her mental patterns? (2) What do they perceive as their 'optimal' mental patterns? These questions were asked sequentially.

To make the answers concrete, we asked interviewees to visually depict their habits of mind. We explained that there was no 'wrong' answer, to allow room for interpretation. Despite this open framing, responses primarily reflected on moments in which the respondent was engaged in a common task or work-related activity. Figure 1 depicts two representative illustrations.

Four respondents represented their habits of mind thematically (Bottom), alluding to some form of mental compartmentalization. The remaining eight respondents represented their habits with regard to time and *relative quality*, indicating dips and peaks among work, relaxation, attention and distraction.

Based on the responses, a trend emerged comparing descriptions of actual and optimal habits of mind. Respondents who described their habits as fragmented later described optimal habits as contrasting to their own (i.e., including greater balance, concentration and ease) while respondents who described controlled, measured and focused habits of mind described little or no gap between actual and optimal habits. From this trend we deduced a positive value placed on goal-driven, controlled and focused mental patterns. This is early confirmation of the hypothesis that users are becoming cognizant of the effect pervasive systems have on mental habits.

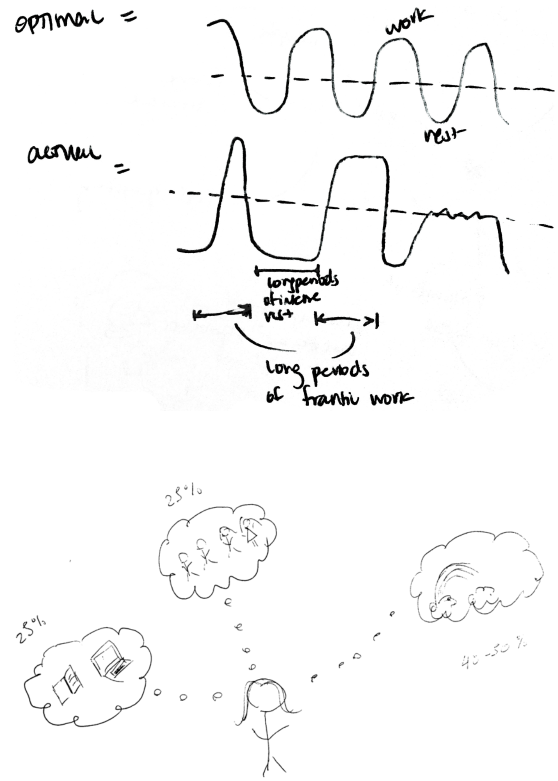

Figure 1: Two Representative Responses to What Actual and Optimal Mental Patterns Look Like

(Top) A ‘signal’ pattern with ‘Time’ on the x-axis and ‘Quality’ on the y-axis. ‘Actual’ indicates a series of highly focused peaks and lengthy valleys of relaxation. ‘Optimal’ depicts a gradual wave alternating between work and rest.

(Bottom) A thematic mapping, grouping the contents of thoughts into buckets (left to right: studying, social, and daydreaming). ‘Optimal’ is depicted by relative comparison.

Analyzing Mental Patterns for UI Designs

This section draws on the interview results to identify three design patterns governing how technology (usually unintentionally) influences habits of mind and to present a model of how this interaction can be modeled.

Design Patterns

Participants mentioned different categories of applications that influence them. Starting from this list and extrapolating to commonly observed applications, we identified three design patterns that influence habits of mind differently.

Asynchronous stream (e.g., social media)

This pattern describes systems that contain 'streams' of information that can be updated by other social agents and automated sources. It is most influential when the nature of the updates cannot be predicted, as with human agents such as email and social media (e.g. Facebook). This pattern lends itself to 'micro-tasks' (e.g. less than 1 sec) [5, 12].

Synchronous stream (e.g., task list, calendar)

This pattern describes a stream that cannot be updated by third parties but usually still asks the user to maintain awareness of it, thereby adding cognitive load and internal distractions. Such tasks will likely influence meta-cognitive regulation because they retain a presence in the mind even when not attended to explicitly. Examples include task list and calendar.

Monolith (e.g., programming, productivity)

These tasks are self-contained tasks and not 'streams' of disconnected fragments. They require full attention and cannot be effectively executed in micro-tasks. Adding asynchronous social data, such as real-time document updates from a co-worker's edits, can change how it influences the user's mental pattern, adding an asynchronous stream.

Modeling How Pervasive UIs Influence Mental Habits

This section explores a novel way to model mental patterns to understand how they are influenced by interactive systems. The model is novel because it reconciles theories of attention and meta-cognitive regulation as well as studies of peak performance and productivity. It draws on the Yerkes-Dodson curve [20] which places peak performance along a curve of 'arousal' depending on the task (Figure 2).

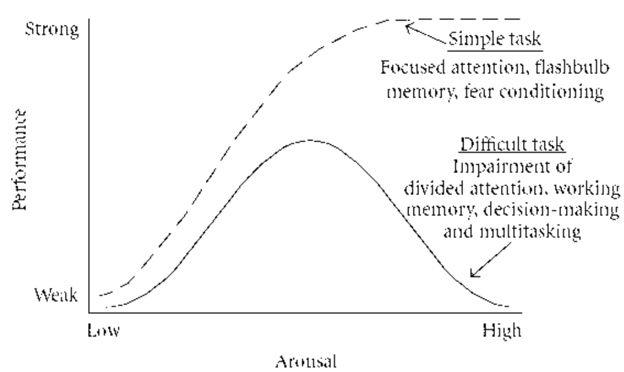

Figure 2: The Yerkes-Dodson curve [20].

While it has great descriptive power, the Yerkes-Dodson curve is of limited use to designers of modern systems because it does not predict level of arousal, i.e., for HCI researchers, a useful complement would be a model that describes how arousal level fluctuates, which could inform how the interface itself can sustain optimal performance.

The best-studied description of optimal performance is the theory of *flow state* [4]. The most relevant characteristics include complete absorption in the task and a lack of self-consciousness. Given how interviewees could identify but not implement optimal mental patterns, a meta-cognitive regulation was clearly at play distinct from attention itself.

We hypothesize that a form of self-consciousness, or meta-cognitive regulation, frequently distracts users from 'flow state.' Formed based on this hypothesis, the model below helps predict how a user engaged in a task shifts across particular mental states (Figure 3).

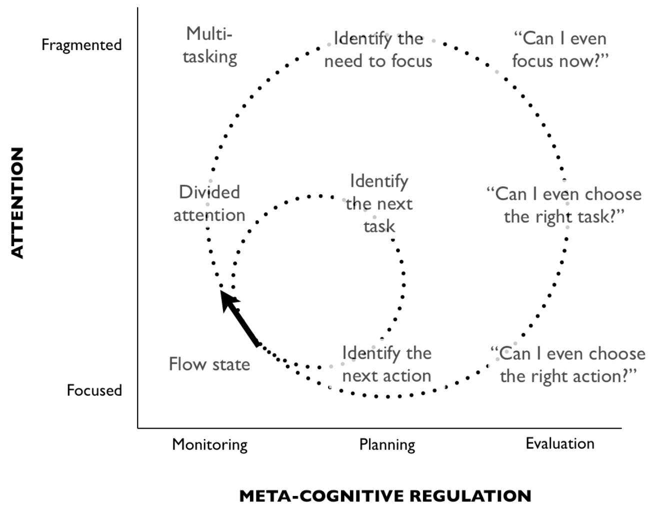

Figure 3: A state-based model of mental patterns in the context of pervasive systems.

Application of the model usually starts in the bottom left, where some duration of 'flow state' is present, regardless of duration. As the model shows, flow is characterized by a focused state where meta-cognitive regulation is simply monitoring and not planned. Based on an internal or external form of distraction, the user moves into an adjacent state. We will use a representative example: the user sees another window on-screen and is reminded of another task, moving them up to 'Divided attention'. This is magnified when a notification on their phone alerts them to an SMS message, moving them further towards fragmented attention into 'multi-tasking'.

From 'multi-tasking' the user may move right into meta-cognitive planning, aware of the multi-tasking (before this, they would not be meta-cognitively aware) or may 'automatically' regain focus and move down. In this example, he or she moves right. If the user begins judging himself or herself, adding an evaluative dimension to the internal dialogue, this can exasperate the problem (right). If not, the user may move down in the grid, where he or she begins the process of focusing and planning what step to take next.

The evaluative judgments on the right-hand column are unproductive because they concern the user, not the task. For this reason, the users is most distant from 'flow state.'

The top-right state, as far from 'flow' as possible, depicts a trajectory towards being overwhelmed, stressed and fragmented. The 'Evaluation' column refers to self-evaluation. We acknowledge that this is only a subset of what 'Evaluation' is, as referred to in the literature, but it was most applicable in this way given the purpose of the present study.

We found a counter-clockwise motion to be a common but not necessary scenario when traversing the states. The small circle indicates a cursory task, such as checking and dismissing an external alert. The user's attention might become momentarily fragmented, but he/she can easily identify the next task and proceed to focus on the next action with minimal meta-cognition regulation.

The larger circle depicts increasingly demanding and fragmented attention. These require more meta-cognitive regulation to focus and to begin evaluating one's capacity or inclination for judgment – duly distracted from the task itself. The circumference of the circle would likely be correlated with temporal duration.

The model is useful to researchers and designers because it adds a dimension to heuristic evaluation and usability testing that describes how the interface contributes to or mitigates negative mental patterns. It can be used for stand-alone applications and, more fundamentally, for operating systems, interaction paradigms, window- management systems and task flows. Such study is necessary to complement the emergence of new interactive paradigms.

Conclusion

Interactive systems pervade cognitive and affective processes to the point where the associated phenomena must be studied more formally. Presented here is a study of how mental patterns are affected in the context of using interactive products, with the aim of supporting researchers and designers to more explicitly acknowledge the role their systems may play in influencing mental patterns as they become entrenched in neural patterns.

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References

Brown, C. (2013). Are We Becoming More Socially Awkward? An Analysis of the Relationship Between Technological Communication Use and Social Skills in College Students. *Connecticut College Honors Papers*.

Broyd, S., et al. (2009). Default-mode brain dysfunction in mental disorders: A systematic review. *Neuroscience & Biobehavioral Reviews, 33*(3), 279-296.

Cain, M. S., & Mitroff, S. R. (2011). Distractor filtering in media multitaskers. *Perception-London*, *40*(10).

Csikszentmihalyi, M. *Optimal experience: psychological studies of flow in consciousness*, Cambridge, UK: Cambridge University Press, 15–35.

Czerwinksi, M., Horvitz, E., Wilhite, S. (2004). A Diary Study of Task Switching and Interruptions. *Proc. of ACM CHI*.

Farb, N., et al. (2007). Attending to the present: mindfulness meditation reveals distinct neural modes of self-reference. *Social Cognitive and Affective Neuroscience*, *2*(4), 313-322.

Jacobs, J. E., & Paris, S. G. (1987). Children's metacognition about reading: Issues in definition, measurement, and instruction. *Ed Psych*, *22*(3-4), 255-278.

Killingsworth, M., Gilbert, D. (2010). A Wandering Mind Is an Unhappy Mind. *Science*, *330*(6006), 932-932.

Kluwe, R. H. (1987). Executive decisions and regulation of problem solving behavior. *Metacognition, motivation, and understanding*, 31-64.

Levy, D., et al. (2012). The Effects of Mindfulness Meditation Training on Multitasking in a High Stress Information Environment. In *Proc 2012 Graphics Interace Conf*, 45-52.

Moraveji, N, Soesanto, C. (2012). Towards stress-less user interfaces: 10 design heuristics based on the psychophysiology of stress. *ACM CHI Ext Abstracts*.

Ophir, E., Nass, C., & Wagner, A. D. (2009). Cognitive control in media multitaskers. *Proceedings of the National Academy of Sciences*, *106*(37), 15583-15587.

Pea, R., et al. (2012). Media use, face-to-face communication, media multitasking, and social well-being among 8- to 12-year-old girls. *Developmental psychology 48*(2), 327.

Sanbonmatsu, D. M., et al. (2013). Who Multi-Tasks and Why? Multi-Tasking Ability, Perceived Multi-Tasking Ability, Impulsivity, and Sensation Seeking. *PloS One 8*(1).

Schevitz, T. (2012). Why we need a technology Sabbath. PBS.org.

Schraw, G., & Moshman, D. (1995). Metacognitive theories. *Educational psychology review*, *7*(4), 351-371.

Sohlberg, M. M., & Mateer, C. A. (1987). Effectiveness of an attention-training program. *Journal of Clinical and Experimental Neuropsychology*, *9*(2), 117-130.

Sparrow, B., Liu, J., Wegner, D. (2011). Google effects on memory: Cognitive consequences of having information at our fingertips. *Science, 333*(6043) 776-778.

Tamyra P. (2009). Social anxiety and technology: Face-to-face communication versus technological communication among teens. *Computers in Human Behavior*, *25*(6), 1367-1372.

Yerkes, R.M., Dodson, J.D., (1908). The relation of strength of stimulus to rapidity of habit-formation. *Jour. of Comparative Neurology and Psychology*, *18*(5).

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Statement of the Knowledge Worker Productivity Research Theme
http://mediax.stanford.edu/KWP/concept

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