Identifying Learning Conditions that Minimize Mind Wandering by Modeling Individual Attributes

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Abstract. The propensity to involuntarily disengage by zoning out or mind wandering (MW) is a common phenomenon that has negative effects on learning. The ability to stay focused while learning from instructional texts involves factors related to the text, to the task, and to the individual. This study explored the possibility that learners could be placed in optimal conditions (task and text) to reduce MW based on an analysis of individual attributes. Students studied four texts which varied along dimensions of value and difficulty while reporting instances of MW. Supervised machine learning techniques based on a small set of individual difference attributes determined the optimal condition for each participant with some success when considering value and difficulty separately (kappas of .16 and .24; accuracy of 59% and 64% respectively). Results are discussed in terms of creating a learning system that prospectively places learners in the optimal condition to increase learning by minimizing MW.

Keywords: engagement, mind wandering, affect, machine learning.

1 Introduction

Advances in research on intelligent tutoring systems (ITSs) have recently intertwined aspects of the cognitive sciences with the affect sciences [1,2,3,4]. ITSs have evolved from systems that emphasize modeling student cognition [5,6] to systems that detect and respond to student affect as well [7,8,9]. One related area of interest is learner engagement. Engagement has been defined as a state of involvement in some activity or task with focused attention and intense concentration [7]. Engagement is a necessary condition to learning since learners have to attend to information in order to learn. It is not uncommon, however, for students to experience involuntary lapses in attention and suddenly realize that they were thinking about things totally unrelated to the learning content. Such mind wandering (MW) activities can be detrimental to learning [10,11], so it is important to develop systems that can sustain engagement by reducing the propensity of MW behaviors. The goal of this paper is to take steps towards developing a preventative system with the ability to place students in an optimal learning condition that would result in the least amount of MW based on measures of individual difference attributes.
1.1 Related Works

Recently, researchers have been interested in the relationship between affect and learning. D’Mello [2] conducted a meta-analysis of 24 studies that investigated the influence of student affective states on learning. Basic affective states, such as anger, fear, happiness, etc. [12], are considered to have specific and culturally unanimous qualities to them that make them rather distinguishable and easy to detect. However, it is the non-basic affective states (e.g., confusion, boredom and engagement) that were more frequent during learning with ITSs. For example, Craig and colleagues [13] identified significant and positive relationship between confusion and learning when interacting with an ITS.

Similarly, Baker and colleagues [7] observed the presence of non-basic affective states of students while they interacted with various ITSs. One of their main findings was that when boredom occurred, it was difficult to get the students to re-engage in the learning task. Instead, students experiencing boredom exhibited a propensity to engage in behaviors such as “gaming the system.” They also found that confusion and engagement were the most prevalent states and better precursors to learning than boredom since those who chose to game the system do not learn.

The studies mentioned above are just a few examples of research identifying affective states during interactions with ITSs and the different types of repercussions they can have. Research along these lines has led to the development of Reactive affect-sensitive ITSs that attempt to sense affective states that could have an effect on learning and respond accordingly [1], [14,15]. One of the early examples of this type of system is Affective AutoTutor [16] which detects specific emotions (i.e., boredom, confusion) based on conversational modeling, facial cues, and body language and alters the dynamics of the tutoring session to react to the learner through dialog moves designed to address specific affective states.

With respect to mind wandering, Drummond and Litman [17] attempted to identify episodes of “zoning out” while students were engaged in a spoken dialog with an ITS. Students were periodically interrupted to complete a short survey to indicate the extent to which they were focusing on the task (low zoning out) or on other thoughts (high zoning out). J48 decision trees trained on acoustic-prosodic features extracted from the students’ utterances yielded 64% accuracy in discriminating high vs. low zone-outs. The next step in this line of research would be for the ITS to respond when zone-outs are detected. A system called GazeTutor [8] attempted this by using eye tracking to assess a lack of attention and responded with interventions to re-engage learners. Thus, based on affect detection methodologies, systems are able to identify and respond to affective states to increase learning.

1.2 The Current Project

An alternative to reacting to affective states as they arise is to implement Proactive strategies that attempt to create or foster affective states that would be beneficial for learning. Here, we focus on engagement since it is a necessary condition for learning. Engagement is considered to have three components: a cognitive, an affective, and a behavioral component [18]. The affective and behavioral components have been extensively studied in previous ITS research (e.g., [19,20]); hence, our present