



Full length article

## Exhibiting achievement behavior during computer-based testing: What temporal trace data and personality traits tell us?



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## ARTICLE INFO

## Article history:

Received 16 September 2016

Received in revised form

20 April 2017

Accepted 25 May 2017

Available online 26 May 2017

## Keywords:

Assessment analytics

BFI

Computer-based testing

Personality traits

Student behavior modelling

Supervised classification

## ABSTRACT

Personalizing computer-based testing services to examinees can be improved by considering their behavioral models. This study aims to contribute towards deeper understanding the examinee's time-spent and achievement behavior during testing according to the five personality traits by exploiting assessment analytics. Further, it aims to investigate assessment analytics appropriateness for classifying students and generating enhanced student models to guide personalization of testing services. In this study, the LAERS assessment environment and the Big Five Inventory were used to track the response times of 112 undergraduate students and to extract their personality traits respectively. Partial Least Squares was used to detect fundamental relationships between the collected data, and Supervised Learning Algorithms were used to classify students. Results indicate a positive effect of extraversion and agreeableness on goal-expectancy, a positive effect of conscientiousness on both goal-expectancy and level of certainty, and a negative effect of neuroticism and openness on level of certainty. Further, extraversion, agreeableness and conscientiousness have statistically significant indirect impact on students' response-times and level of achievement. Moreover, the ensemble RandomForest method provides accurate classification results, indicating that a time-spent driven description of students' behavior could have added value towards dynamically reshaping the respective models. Further implications of these findings are also discussed.

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### 1. Introduction

The introduction of digital technologies in education has already opened up new opportunities for tailored, immediate and engaging Computer Based Assessment (CBA) experiences (Bennett, 1998; Chatzopoulou & Economides, 2010). CBA is the use of information technologies (e.g. desktop computers, mobiles, web-based, etc.) to automate and facilitate assessment and feedback processes. Computerized assessment allows for monitoring and tracking data related to the context, interpreting and mapping the real current state of these data, organizing them, using them and predicting the future state of these data (Leony, Muñoz Merino, Pardo, & Kloos, 2013; Papamitsiou & Economides, 2016; Triantafyllou, Georgiadou, & Economides, 2008). On the contrary, traditional offline assessment render these facilities unattainable. However, differences in learners' behavior during CBA have a deep impact on

their educational performance and their level of achievement. Compiling learners' behavior in CBA processes and creating the corresponding behavioral models is a primary educational research objective (e.g. Abdous, He, & Yen, 2012; Blikstein, 2011; Shih, Koedinger, & Scheines, 2008).

Learner behavioral modelling can be defined as the process of information extraction from different data sources into a profile representation of learner's knowledge level, cognitive and affective states, and meta-cognitive skills on a specific domain or topic (McCalla, 1992; Thomson & Mitrovic, 2009). A learner model is a synopsis of multiple learner's characteristics – either static (e.g., age, gender, etc.), or dynamic. Performance, goals, achievements, prior and acquired domain knowledge (Self, 1990), as well as learning strategies, preferences and styles (Peña-Ayala, 2014) are among the most popular dynamic characteristics. Decisions making abilities, critical and analytical thinking, communication and collaboration skills (Mitrovic & Martin, 2006), motivation, emotions/feelings, self-regulation and self-explanation (Peña & Kayashima, 2011) are also commonly used to complement the learner's profile.

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More recently, the time dimension has been explored for modelling learner behavior. For example, [Shih et al. \(2008\)](#) used worked examples and logged response times to model the students' time-spent in terms of "thinking about a hint" and "reflecting on a hint". Other studies examined the effect of student's response times on prediction of their achievement level ([Papamitsiou, Karapistoli, & Economides, 2016](#); [Xiong, Pardos, & Heffernan, 2011](#)), explored the relationships between study-time and motivation ([Nonis & Hudson, 2006](#)), and proposed what should be adapted in the Computerized Adaptive Testing (CAT) context regarding orientation to time ([Economides, 2005](#)).

Efficient use of time is widely assumed to be a key skill for students ([Claessens, van Eerde, Rutte, & Roe, 2007](#); [Kelly & Johnson, 2005](#); [MacCann, Fogarty, & Roberts, 2012](#)), and it is summarized under the term "time management behavior". [Claessens et al. \(2007\)](#) defined time management behavior as "behaviors that aim at achieving an effective use of time while performing certain goal-directed activities" (p. 36). However, the results from empirical evidence on the relationship between students' time-management and level of achievement converge to an unclear landscape ([Claessens et al., 2007](#); [Hamdan, Nasir, Rozainee, & Sulaiman, 2013](#); [Trueman & Hartley, 1996](#)).

### 1.1. Related work & motivation of the research

Explaining students' time-management according to behavioral models enhanced with personality aspects is expected to provide additional evidence towards better understanding when they actually exhibit achievement behavior. According to [Pervin and John \(2001, p. 10\)](#), "personality represents those characteristics of the person that account for consistent patterns of feeling, thinking, and behaving". In a sense, personality could be defined as the set of the individuals' characteristics and behaviors that guide them to make decisions and act accordingly under specific conditions ([Chamorro-Premuzic & Furnham, 2005](#)). Researchers have concluded to five factors that describe personality traits ([Costa & McCrae, 1992](#); [John & Srivastava, 1999](#)). According to the Big Five model, these factors are: a) agreeableness, b) extraversion, c) conscientiousness, d) neuroticism, and e) openness to experience.

A search in literature revealed that there is limited evidence that agreeableness is relevant to time management behavior ([Claessens et al., 2007](#); for conflicting evidence see; [MacCann et al., 2012](#)). Moreover, researchers found that extraverts showed faster response times than introverts ([Dickman & Meyer, 1988](#); [Robinson & Zahn, 1988](#)), while others reported no overall differences between groups ([Casal, Caballo, Cueto, & Cubos, 1990](#)). Yet, in a study of undergraduate students, it was found that highly conscientious students use their time more efficiently ([Kelly & Johnson, 2005](#)). It was also found that conscientiousness was a significant predictor of test performance, and time-on-task fully mediated the conscientiousness–performance relationship ([Biderman, Nguyen, & Sebren, 2008](#)). [Van Hoye and Lootens \(2013\)](#) found that highly neurotic individuals is less likely to use time management strategies, while, individuals high on openness find it difficult to manage their time effectively to complete tasks.

From the above derives that the experimental results regarding the relationships between personality traits and time-management skills are inconclusive. Thus, additional research is required, and different research approaches should be considered. Recent advances in the field of assessment analytics, triggered our interest on exploiting analytic methods in this case as an alternative research methodology. Assessment analytics concern applying fine-grained analytic methods on multiple types of data, aiming to support teachers and students during the assessment processes. This is a repetitive procedure that continues by making practical use of

detailed student-generated data captured by CBA systems, and providing personalized feedback accordingly ([Ellis, 2013](#)).

Moreover, when it comes to Computer-Based Testing (CBT) procedures – which is a typical, popular and widespread method of online assessment – it would be worthwhile to have in-depth knowledge of students' behavior in the testing environments, and understand how this affects their achievement level. In turn, this insight will contribute to the improvement of the testing services at a larger scale. This is the first study – to the best of our knowledge – that exploits assessment analytics methods for associating personality traits with response-times for modelling examinees' achievement behavior during CBT.

Despite the criticism on interpreting students' logged data into actual learning behaviors, a large body of literature has provided empirical evidence of strong correlation between them ([Jo, Kim, & Yoon, 2015](#); [Romero, López, Luna & Ventura, 2013](#)). In our approach, the choice of the accumulated response times to code time-management behavior is justified because these variables could facilitate multiple purposes: providing analytics related to time-management for increasing students' awareness on how they progress on each item compared to the rest of the class during testing, identifying the actual difficulty of an item for further adapting the test to examinee's abilities on-the-fly, making possible the detection of unwanted examinee behavioral patterns (such as guessing or slipping) via process mining methodologies, to name a few. Moreover, the mechanisms for tracking temporal data are cost-effective, consume low computational resources, and can be easily implemented in any CBA system.

### 1.2. Objectives, research questions and suggested approach

This paper's objective is to carry out an experimental study in order to contribute towards exploiting assessment analytics methods for deeper understanding the examinee's time-spent behavior during CBT according to the five personality traits. The main focus of this study is on exploring the use of time-driven assessment analytics with the Big Five Inventory (BFI - [John & Srivastava, 1999](#)) to explain achievement behavior in terms of personality and response times on task-solving. This is expected to further improve student models for guiding personalization of testing services. As such, we also aim to investigate assessment analytics capabilities on classifying students, and contribute to creating enhanced student models. Thus, the research questions are twofold:

**RQ1:** Which is the effect of the five personality factors on time-spent behavior during CBT?

**RQ2:** How accurately can we classify the students during testing according to their personality traits and behavior expressed in terms of response-times?

In order to answer these research questions we conducted an experimental study with the LAERS assessment environment (please, see section 2.1). One hundred and twelve (112) undergraduate students from a Greek University enrolled in a CBT procedure. Partial Least Squares (PLS) was used to explore the relationships between the included factors and evaluate the structural and measurement model, and Supervised Learning Classification algorithms were used to compare the obtained classification results based on students' level of achievement, i.e. using as class labels the students' score classes. The low misclassification rates are indicative of the accuracy of the applied method. Thus, temporal factors that imply students' behavior should be further explored regarding their added value towards modelling test-

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