It Takes Two: Momentary Co-occurrence Of Affective States during Computerized Learning

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Abstract. We investigated the incidence of momentary co-occurrence of affective states in a computerized learning environment. Novice students (N = 99) used a learning environment designed to teach the basics of computer programming. Only 46 of these students reported a sufficient number of co-occurring affective states for statistical modeling. Two co-occurring pairs of affective states occurred at rates higher than chance: Confusion/Uncertainty + Frustration and Curiosity + Flow/Engagement. We found that the co-occurrence of Curiosity + Flow/Engagement was related to success and fewer errors when testing code as well as the use of available hints and overall performance.

1 Introduction

Most research into affective states in ITSs and computerized learning systems has assumed that a student experiences one affective state at a time (see meta-analysis [1]). We expand this topic by examining co-occurring affective states, or instances when multiple affective states are experienced at the same time. Determining what affective states co-occur and how those co-occurrence patterns are related to learning is important for more effective design of intelligent tutoring systems (ITSs) that sense and respond to student affect. For example, if confusion and frustration co-occur, it is unclear whether an affect-sensitive ITS should respond to confusion, frustration, or both. We contrast previous research of co-occurring affective states (such as [2]) by focusing on affective states that are learning-centered and arguably more likely to be relavent to ITSs [3]. In particular, we investigated what pairs of affective states co-occurred and how co-occurrence related to interaction events and performance.

2 Method

Ninety nine students completed 35 minutes of problem-solving exercises with the Python computer programming language. Students were retrospectively shown synchronized videos of their face and on-screen activity and were asked to make judgments about what affective states (13 choices including Neutral) they were experiencing at various points in the learning session. With each judgment, students could also voluntarily provide a secondary, co-occurring affective state they experienced. Of 99

novice computer programming students, 46 students had at least 10 secondary affect ratings and provided usable distributions to analyze co-occurring affective states.

3 Results and Discussion

The most commonly occurring affective states (Anxiety, Boredom, Confusion, Curiosity, Flow/Engagement, and Frustration) were examined for co-occurrence using *Lift*, an association rule learning metric. Lift accounts for the prior probability of each affective state when calculating co-occurrence likelihood, and was computed for each student to ensure independence of data points. We performed one-sample t-tests comparing the Lift values of each co-occurring pair with a test value of 1 (chance). Confusion + Frustration (*Mean Lift* = 1.138, *N = 46*, *p* = .123) and Curiosity + Flow/Engagement (*Mean Lift* = 1.335, *N = 40*, *p* = .038) were the pairs that occurred above chance, through non-significantly for the Confusion-Frustration pair.

We then correlated the Lift of the two co-occurring affective state pairs with key events from the learning session. Due to the small sample size, we focused on the size rather than significance of the correlations and found that Confusion + Frustration did not appear to exhibit any meaningful trends. However, Curiosity + Flow/Engagement was associated in the expected direction with a higher proportion of Key Press events (r = .208), less hint usage (r = -.203), more error-free code (r = .314), and overall better performance (r = .226).

Though a seemingly infrequent phenomenon, co-occurring affect states do exist and have some connections to the learning process. Understanding more about the complex nature of affective states in learning environments can lead to better affect detection and thus better affective awareness in intelligent tutoring systems. Affective awareness can in turn can improve the efficacy of teaching in a world where computers play the role of teacher more and more frequently.

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