Proposal: Using click activity from the Canvas learning management system to study procrastination and effort allocation in time  
Sahiti Chebolu, Luise von Keyserlingk, Peter Dayan  
  
Background

1. Procrastination literature:  
   Procrastination is widespread, affecting some 80% of students and 20% of adults (Steel, 2007). Many suffer effects on their health (Sirois, 2007) and finances  
   (O’Donoghue & Rabin, 1998), and most procrastinators wish to reduce it (O’Brien, 2002). There is no single agreed definition of procrastination, but the myriad procrastination questionnaires include at least some of the following factors: delay of actions and work, unnecessary or unreasonable delays, delaying in spite of intending differently, irrationality in the sense of failing to maximise utility, suffering consequences like missing deadlines or stress due to rushing (Lay, 1986; Mann et al, 1997; McCown et al, 1989; Steel, 2010).

Similarly, a search for mechanisms of procrastination reveals a variety of personality trait correlates, including facets of a lack of conscientiousness (such as self-control, achievement motivation, discipline etc. Lee et al, 2006), and of neuroticism (such as impulsiveness, fear of failure, low self-esteem etc. Pychyl & Flett, 2012).

In a similar vein, people procrastinate in tasks that are considered aversive, stressful or boring (Rozental & Carlbring, 2014; Shu & Gneezy, 2010; Zhang et al, 2019), but with diverse other structures and characteristics: when rewards for work are delivered immediately or after a delay; with and without deadlines; and in the presence or absence of uncertainty about aspects of the task like reward or effort timing or magnitude.

1. Taxonomy:  
   In Chebolu (2023), we aimed to tackle this heterogeneity by constructing a taxonomy of procrastination types and associated mechanisms based on principles from decision making and reinforcement learning. We proposed three main types of procrastination based on the structure of delays and underlying temporal decisions: deliberate delays leaving insufficient time to complete tasks, delaying to a later time in spite of intending to act earlier, not committing to a time of action, and engaging late due to reversing a decision to abandon the task. For each of the types, we asked what might be the reasons for the respective decisions, naturally giving rise to a classification of mechanisms. For example, why commit to a time of action that leaves insufficient time, why defect on a decision to act and why not commit to a time of action despite intending to engage?
2. Evidence:  
   We next sought empirical evidence for the various types and mechanisms of our theoretical framework. We therefore used real-world data collected by Zhang and Ma (2023). In their study, 194 bachelor students in a Psychology course at NYU had to participate in at least 7 hours of experiments over a 16-week semester (110 days) to receive course credit, with each research study requiring a minimum time of 0.5 hours or a multiple thereof (which we used to define a unit of work). The data consisted of the times at which each student completed each unit of work. In the original study, Zhang and Ma (2023) showed a correlation between students’ discount factors and the extent of their delays.

We clustered the data to find patterns of work allocation and identified some mechanisms that could account for the delays that were apparent. These include: discounting of future rewards with delay, time-inconsistent choices from non-exponential discounting or waiting for better conditions or more interesting tasks. Qualitatively, it seems as if many of these explanations could explain the same patterns in the data. Quantitative fitting proved a bit more challenging since we only had a single trajectory per person.

We would therefore very much like to analyze and model another dataset, ideally with the following characteristics: firstly, as in the Zhang & Ma (2023) dataset, there should be information about when (and how much) work has been done towards a task, along with information about task structure like deadlines, rewards and costs for finishing or not, etc.; secondly, if we had multiple trials per person, then we would hope to be able to fit individual participants effectively; thirdly, the tasks in Zhang & Ma (2023) were very easy for the students, which meant that each unit of work could be completed with full certainty once started. However, many real-life situations involve tough tasks where success is not guaranteed and here, other factors like fear of failure, anxiety, and low self-esteem can come into play.

Research questions and hypotheses

1. What data are we interested in?   
   For these reasons, the Canvas learning management system data collected under strand 2 of the UCI-MUST project is especially interesting and relevant to the goals of this project. Information about when students access course-related material, when they work on and submit their assignments coupled with information about course context like the deadlines and time available for each assignment can together inform how students distribute their efforts in time towards a deadline. Hence, data from chemistry and biology courses CHM …, CHM …, BIO … where clicks have been annotated and information about course deadlines is present is of specific interest to us in terms of analysis and modelling. In addition to these courses, we are also open to analyse click data from other courses which might also contain information we could use.
2. What do we want to do with it? Research questions?  
   Broadly, we have the following questions:   
   a. How do students allocate work over time? Are their allocation patterns consistent across trials? What mechanisms and explanations underly these decisions?  
   b. Is there any evidence for multiple types of and/ or explanations for procrastination from students’ behavior on this task?  
     
   As a first step, we propose to conduct a model-agnostic analysis of how students have allocated efforts towards a task, like an assignment or a quiz. If an assignment is done online on Canvas, then it might be possible to extract when a student has worked on the assignment. Otherwise, the click activity preceding a deadline (but after the previous deadline) can be taken as a proxy for the amount of effort applied at a given time point towards a task. Given such time courses of working per person per task, we will cluster them to characterize the different ways and styles of work allocation in the task (and compare the clusters to our findings from Zhang & Ma, 2023). Further, since multiple trajectories are available per student, it will be possible to determine how stable or variable their behavior is in time across tasks in a course or across multiple courses.

Following such a descriptive analysis of the time courses, we will turn to understand the mechanistic basis of students’ temporal decisions through computational models. As before, we will use a Markov Decision Process (or partially-observable Markov Decision Process) framework. In addition to the explanations of discounting of delayed rewards and non-exponential discount factors we will also explore other explanations conditional on the what information is available about the course:   
a. If there is information about when students access online material or when the classes take place, we can investigate delays from waiting to check if an assignment problem can be improved, or waiting to gain more information from self-learning or classes.  
b. If there are questionnaire items that query things like fear of failure on hard tasks, we can ask if this leads students to delay engaging in order to avoid information that will confirm their pessimistic beliefs.   
c. In a similar vein, students could be engaging in self-handicapping by delaying to set oneself up for failure. This allows one to preserve self-esteem by deflecting blame to an external cause (delay).

After formalizing these models, we will fit them to the data to determine which of them best explain the patterns in the data and if there are multiple models that are equally explanatory.

1. Assumptions about data:   
   a. Clicks are annotated such that it is possible to filter out clicks not related to the task or not contributing to task completion.  
   b. Click activity either directly informs us how much work is done towards the task or will allow us to infer this indirectly.

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