Studying Sustained Attention and Cognitive States with Eye Tracking in Remote Technical Interviews

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ABSTRACT

In this position paper, we argue that eye tracking can be used to understand the underlying cognitive states of a programmer during remote technical interviews, specifically programming interviews. We describe a mock-interview experiment that applies eye tracking to identify these cognitive states, and propose two computational interventions that support an interviewer and a candidate. We posit that these interventions will increase the effectiveness of remote technical interviews.

Keywords

eye tracking, technical interview, remote programming, interventions, anxiety, attention
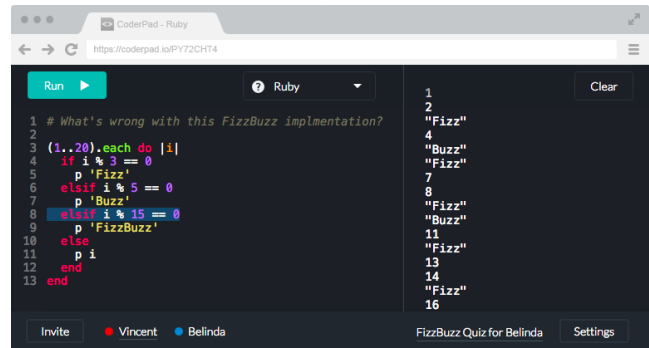
1. INTRODUCTION

A technical interview is a stage of a job interview where recruiters ask candidates technical questions pertaining to a specific field of work for a job position. For software developers, these technical interviews often include a programming portion where the applicant is asked to work through a series of programming scenarios. Technical interviews can be an expensive process. Some companies have reported that they will spend at least $100,000 per position to have current employees recruit candidates, fly candidates out for interviews, and support these candidates as they go through the onboarding process.[1]

One cost saving mechanism is to conduct interviews remotely, using commodity webcams [12] and a shared editing environment, such as CoderPad[2] (Fig. 1). However, remote technical interviews have challenges of their own. Determining what is going on during a period of silence is difficult for an interviewer and uncomfortable for a candidate. Candidates must balance the time devoted to solving problems and expressing their thought process. Interviewers may perceive extended silence as negative or assume that a candidate is stalling for time or that a candidate simply does not know how to solve a problem. However, programming is a cognitively demanding activity, and like other deep thinking tasks [4], periods of silence are absolutely necessary.

In this position paper, we propose a model for comprehending the cognitive state and attention of a programmer during a remote technical interview. The unique affordances of this mode of interviewing can add to the misinterpretation of what is going on during the deep thinking silence.

Figure 1: Online technical interview conducted using CoderPad. Vincent remotely interviews Belinda, who is debugging a FizzBuzz implementation. Figure from https://CoderPad.io/.

Performing an analysis of the different cognitive states of interview candidates can help define the challenges and benefits of remote technical interviews and how it affects their cognitive state and attention. As a result of this research, we can use these models of attention to design better interview procedures that minimize disruption to candidates while allowing interviewers to assess a candidate's thought process and problem solving speed.

2. BACKGROUND

2.1 Nonverbal Cues and Think-Aloud

Hollandsworth et al. found that interviewers place a high importance on nonverbal cues when making hiring decisions [8]. Although the content of discussion is ranked highest, nonverbal cues, such as composure and eye contact, were highly ranked as well. In remote interviews, nonverbal communication is limited when a candidate cannot be fully seen behind a phone or a computer. Not only are these cues important for assessing performance, but they help regulate disruption to a candidate's cognitive processes, including sustained attention.

Borrowing from concurrent think-aloud protocols, where eye tracking has been used, we can hypothesize that analogous techniques might apply to remote interviews. For example, Guan et al. found that retrospective think-aloud can provide information about a participant's strategies to solving a problem using eye movements [7]. One challenge with retrospective think-aloud is that a candidate may be

subject to forgetting if they are asked too late [11]. In the aforementioned study, participant strategies were determined by the "eye mind hypothesis". Just and Carpenter's eye-mind hypothesis provides support that people are paying attention to what they are looking at [9]. As eye movements are representative of what a candidate can be attending to, we can review measures of these movements to determine the cognitive load during sustained attention tasks such as programming.

2.2 Sustained Attention in Programming

Cognitive load refers to the total information demand placed on an individual [10]. Several studies have found multiple ways to measure it. One technique, pupillometry, measures changes in pupil diameter in response to changing mental workloads. With task-evoked pupillary responses such as mean pupil dilation, peak dilation, and latency to the peak, the intensity of cognitive load can be monitored[2]. Large pupil dilation is associated with high cognitive load and small pupil dilation is associated with low cognitive load. It's not ideal to interrupt a person when they have a high cognitive load as they are attempting to make sense of a lot of information. When this processing is deterred during peak processing, it can break concentration and candidates may not be able to resume processing where they stopped. Determining the intensity of cognitive load can cue the appropriate time to deter the attention of a candidate. It is ideal to switch concentration during a low cognitive load task.

Studies have shown there is a relationship between shifts of attention and saccades [5]. Saccades are involuntary actions that occur during information processing; when the information is being processed. With this information we can get a better understanding of how sustained attention shifts by saccades. In addition, studies have shown that anxious people have difficulty with attentional control through saccadic movement [13]. If saccades begin to stray from the information being processed, we hypothesize that we have a stray in sustained attention.

In addition, blink rates can demonstrate the interest in a task. Chan et al. found that blink rates were highly associated with disinhibition signs during sustained attention tasks [3]. Graham et al. found that blinks become larger, starting from a full open eye to completely close, and faster when the reflex-eliciting stimulus is attended than when attention is directed elsewhere [6]. In this context, blinks can monitor a candidate's sustained attention and aid in understanding the underlying cognitive mechanisms of a programming interview.

With these features of pupil movement we can determine the sustained attention of individuals during programming experiences and determine when the appropriate time to deter their attention.

3. INTERVENTIONS

To assist in our investigation of remote technical interviews, we propose two interventions that if added to remote programming tools, might reduce disruption to a candidate, while allowing interviewers to have a better comprehension of a candidate's mental state.

Blackouts: A good interviewer might allow some time for a candidate to reflect on a problem in isolation, without worrying about the presence of a interviewer pressuring a candidate. For example, an interviewer might say, "now that I have explained the problem, I will put the phone down and walk out for about 4 minutes to allow you to digest the problem." For coding activities, having your live state exposed to an interviewer can cause constant anxiety about making mistakes in front of others. This blackout intervention captures the benefits of a "walk-out" during remote interviews by only refreshing a candidate's screen in predetermined time intervals. Refreshing the screen allows an interviewer to monitor the progress of a candidate's code while allowing a candidate to have moments to reflect. During the blackout period a candidate can complete short programming tasks in a time-boxed manner, without the constant pressure of being scruitnized on every character typed on the shared screen of an interviewer.

Remote Focus Lights: When driving in a car, passengers are better able to sense when a driver is busy than someone having a phone conversation with the driver. In remote interviews, a candidate may be in a mental state with high cognitive load but is not easily observable by an interviewer. For example, when editing a document, an interviewer may use typing as a cue for when not to interrupt. However, if a candidate is reflecting on a problem or reading code while deep in thought, that information is not easily accessible to an interviewer, but still reflects a high cognitive load. The remote focus light intervention indicates when a candidate is currently involved in a high mental workload to indicate when not to interrupt (🔴 — red light) and when a candidate is accessible for questions (🟢 — green light). The measurements of high and low cogntivie load will be collected through pupillary movements and reflected through the focus light visible to an interviewer.

4. RESEARCH QUESTIONS

Through studying cognitive states, we can identify the circumstances under which some interviews are more effective than others. As a starting point for model building, we ask three research questions:

RQ1 *How is the performance of a candidate reflected in their cognitive states during a technical interviews?*
In order to confirm variations of how interviews vary with introducing interventions, we must first confirm how cognitive states are demonstrated in a standard technical interview.

RQ2 *Is a candidate able to sustain their attention to the programming issue less when an interviewer has increased view of their actions?*
There is a limit on how much an interviewer can see a candidate with the blackout feature. With this research question we investigate how candidate-managed visibility affects the candidates performance.

RQ3 *How does an interviewer's access to a candidates's cognitive state affect a candidate's performance?*
The focus light intervention will provide an interviewer with knowledge of the varying cognitive states of a candidate. With this research question we investigate how this feature affects a candidate's performance as they are studied by an interviewer.

5. PROPOSED STUDY

To understand the impact and effectiveness of our interventions on the remote technical interview process, we propose an experiment involving an interviewer and a candidate that simulates a typical remote interview setting (Fig. 1). During the experiment, we instrument an eye tracker to collect gaze data on pupil dilation, saccadic movement, fixations, which correlate with measures on attention and cognitive load.

We envision four experimental conditions:

C1 No interventions. A control condition in which no interventions are present. This provides a baseline that is representative of how remote interviews are conducted today.

E2 Blackout-only. The candidate has access to the blackout feature, but an interviewer has no interventions available to them.

E3 Focus light-only. The interviewer has a remote indicator of the focus light state of a candidate, but a candidate has no interventions available to them.

E4 Both blackout and focus light. The candidate has access to the blackout feature, and an interviewer has a remote indicator of the focus light state of a candidate.

This experimental design allows us to measure the anxiety of candidates with and without blackout capability, and, through the focus light capability, measure the effect of asking questions to a candidate under high and low periods of cognitive loads. We hypothesize that in all intervention conditions, a candidate will have reduced anxiety and increased sustained attention. A candidate will be more comfortable knowing an interviewer has more knowledge of when to solicit interview questions and power to control when an interviewer can see their work. Furthermore, these conditions enable us to assess the ability of a candidate and interviewer in regulating their activities, both as independent interventions and finally as a co-intervention.

In conducting this experiment, we may encounter challenges with recreating the intensity of an interview environment which may play a role in the success of candidates. However, we can combat this challenge by having candidates use their own personal computer as they would during standard remote technical interview; placing them in a familiar setting. This would help recreate an atmosphere similar to a real remote technical interview. This will also reduce the costs of having to send a candidate an eye tracking device as studies have shown ways to leverage the use of web cameras to conduct eye tracking experiments[1].

6. CONCLUSION

Remote technical interviews allow candidates to be evaluated at a lower cost to the company. But what else is lost when removing the fully visible aspect of the interview process? Furthermore, programming is a cognitive intensive task that defies expectations of constant feedback that today's interview processes follow. This has left a gap in understanding what goes on during the programming interview process and how to properly assess programming skills of candidates to succeed at these interviews. With the proposed study, we will be begin to comprehend the cognitive state and sustained attention of candidates during remote technical interviews to refine the interview process.

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