An Evaluation of Foci: a Novel Cognitive-Training Smartphone App

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ABSTRACT

Many university students face a constant barrage of distractions, ranging from environmental noise, to internal compulsions to be distracted. Current software approaches for internal distractions ineffectually scopes the problem to a lack of some essential quality, for example motivation. Our approach diverges from framing this problem as an issue of motivation, and instead frames it as cognitive training. For this reason we created a novel smart phone app *Foci* to help university students train their duration of focus and visualize their progress. We found little significance of the effectiveness of our app after conducting a non-participatory field-study. However, as our experiment ran into multiple issues with participants it largely remains to be seen if this model is promising. We believe it to be based on the feedback we received, and the participants who still continue to use Foci even though the study has ended.

1 INTRODUCTION

University students are tasked with managing a number of distractions while they engage in academic work. These distractions are both external and internal in nature. External distractions can occur from a noisy environment, technological intrusions via notifications and alarms, seeing something immediately interesting, experiencing hunger, etc. Internal distractions can be characterized as compulsions to be distracted while working. Where external distractions tend to have immediate solutions, often in the form of blocking behaviour[1], internal distractions are far more insidious and difficult to approach remedying given their subjective nature.

Interestingly, internal distractions have seen far more numerous and diverse digital panaceas than those of external distractions, ranging from time management support[1][2], coaching[3], brain training[4][5][6], productivity gamification[7], productivity and habit tracking[8][9][10][11], and goal tracking[12][13]. This list is in no way exhaustive as there are clearly a large number of approaches in dealing with internal distractions, reflecting the complex nature of this problem. There is no single fully effective method that does the job well for everyone, further burdening students with the task of finding a method that is best suited to them among the numerous available options. Furthermore, a number of these apps suffer from either trying to do too much thus over complicating their design, or over simplifying the problem as in the case of the Pomodoro technique[3]. This technique is composed of set 25-minute work intervals follows by short breaks, iterated on until a task is finished. It has been largely adopted by many practitioners, albeit with heavy modifications to suite individual needs[14]. Due to its wide adoption, it has been used in our study as the control method.

Internal distractions have been widely studied within the context of multi-tasking and cognitive load[2] by David Rock[15][16][17], within the context of task multi-tasking as the trigger for seeking technology as a source of distraction by Rosen et al[18], and the context of media-multitasking in technology as the source of distraction by Gazzaley et al[19]. The overarching theme from these authors is that our brains are fundamentally not wired to multitask, and by forcing ourselves to do so we bear a heavy cognitive load. Unfortunately for university students, being able to multi-task is a necessity of academia where the average course load per student is 4 per school term[3], and each course brings with it its own set of learning goals, deadlines, and exams. Excessive academic stress as well has seen significantly higher rates of mental health problems in the university population when compared to the general population, putting university students on average as a clinically at-risk group for psychological distress[20]. It's quite evident then that distractions can be an outlet for the cognitively over-encumbered student to disengage from their academic work, where internal distractions may be more accurately characterized as manifestations of behaviours seeking to self-soothe.

Thus, rather than focusing on eliminating internal distractions directly, our work frames the problem as one of students in need of cognitive training, similar in concept to physical training. We used the self-regulated learning model from Zimmerman et al to inform much of our work[21][22]. Zimmerman's notion of self-regulated learning is largely rooted in the social cognitive sciences. For Zimmerman, self-regulated learning takes into consideration the interactions between the person, their behavior, and their learning environment. Zimmerman et al. specify three key stages of the self-regulated learning process: the forethought stage where students prepare for their learning task, the volitional control stage where students maintain the willpower necessary to accomplish

[1] Behaviour characterized by blocking out the distraction explicitly, either by relocating or turning devices off or on silent.

[2] Cognitive load is the mental effort associated with storing and retriving information from our working memory.

[3] One school term generally runs for about 4 months.

their learning task (determined by their cognitive capacity), and the self-reflection stage where students review their own performance.

The remainder of this paper is structured as follows; *Section 2* outlines our experimental design (goals, methods, limitations, and hypotheses), *Section 3* outlines our results (quantitative and qualitative), *Section 4* presents a discussion of our findings, *Section 5* is our conclusion, and *Section 6* acknowledgements.

2 DESCRIPTION OF THE EXPERIMENT

2.1 Introduction and Goals

Our experiment was conducted as a non-participatory field-study in which participants used our app *Foci* for two days. Questionnaires were given prior to using the app and after completing their observational period, allowing us to screen and classify participants into two of our experimental conditions, explained further in *Section 2.2.1* and *Section 2.2.2*, and to gather feedback on the usability and usefulness of the app itself. The app had both an automated data email service, that emailed us use-statistics every day from each participant, as well as a fail-safe data export function in the event participants data was not coming through. The data collected is outlined in *Section 2.2.6*. The goals of our experiment are outlined as follows:

- Our first goal of our experiment was to determine the effectiveness of our app in increasing the userâĂŹs real and perceived ability to focus, as compared to standard techniques like the Pomodoro method. In this context, effectiveness was the measured number of consecutive minutes of unbroken focus, which we will call *focus capacity*.
- Our second goal was to determine how the effectiveness of our app differed between those students who fell into either the *relatively internally distracted* or *relatively externally-distracted* categories[4], depending on the nature of the distractions they perceived to be most disruptive to them.
- Our final goal was to elicit the benefit of providing additional visual cues for the progress graph in helping students to understand their studying habits.

During the process of conducting our experiment, we faced a number of unanticipated challenges which has caused a divergence between what we had planned and what was accomplished. For completeness, we will provide labelling for points of divergence from the experimental methods outlined *Test - Part 1* via footnotes. The outcome of our divergence is summarize below.

The first major change was in our number of participants. While we did recruit 17 people who agreed to participate, only 7 completed the study to a level of adequacy such that we could consider their data. Of the remaining 11 recruited participants, we were notified by 2 that they would not be finishing the study due to their workload. The remaining 9 did not follow the procedure we had outlined for them, as as a result invalidated their data. Examples of the transgressions include: not filling out pre- and/or post-participation questionnaires, failing to enter their unique participant identifier in the app to allow us correlate their data, and those who simply did not use the app as agreed. This had serious implications for our ability to conduct our hypothesis testing, the results of which are explained in *Section 4*.

A second change relates to our labelling of users as internally-distracted or externally-distracted. We originally intended to screen for participants that clearly fell into one category over the other, and have an even number internally-distracted and externally-distracted users in each of our control and experimental groups. The reality was that of the 7 participants who completed the study, all were classified as either internally-distracted or equally between internally-distracted and externally-distracted. As a result, we have changed our categories to classify our participants as either *relatively internally-distracted*, and *relatively externally-distracted*. This name change reflects that there was less separation between the two groups than we had anticipated.

The final change was to our experimental design, we decided to include post-observation period semi-structured interviews with four out of the seven participants.

2.2 Methods

2.2.1 Participants. Our target demographic was university students. We required 20 participants to adequately cover our four between-subjects conditions. Due to limitations in controlling task adherence and completion during the field study, we accepted as many participants as we were able to recruit. As there are a number of areas that have the potential to introduce unacceptable levels of variance into our collected data, we screened participants using a pre-participatory questionnaire, along three criteria:

- Students who self-reported on a five point Likert scale that they were prone to becoming distracted while studying.
- Students who self-reported on a five point Likert scale that they were on either extrema of the scale between being *internally distracted* and *externally distracted*[5]. The intuition behind this decision was to reduce variance that would likely result from having participants too close to the center, thus ending up in different conditions despite being quite similar in their rating.
- Students who have *not* used the Pomodoro method. The intuition behind this decision was to exclude those who are familiar with the training effect we were looking to measure, thus limiting potential variability in our data[6].

To recruit our participants, we used convenience sampling from our personal network of student friends and colleagues. However, because the diversity of level of study (graduate vs. undergraduate) was not balanced, and the number of participants who responded was insufficient for our study, we conducted open recruiting by posting advertisements on both social media and university undergraduate course blogs[7]. We had in total 17 participants after our recruitment efforts.

[4] Originally our goal sought to determine effectiveness of our app between internally-distracted and externally-distracted students.

[5] We ultimately had to include those who self-reported relatively in the middle, re-normalizing the scale to draw the line for the new categories of *relatively internally-distracted* and *relatively externally-distracted*

[6] We considered making this an independent variable, but decided not to for pragmatic reasons.

[7] We originally planned to use physical advertisements around the University of British Columbia university campus, but required faster responses during recruitment given the time constraints.

2.2.2 Conditions. Our study evaluated two types of conditions, they are as follows.

Focus Set Duration Conditions

The two focus set duration types that we evaluated were as follows:

(1) *Static*: using the traditional 25 minute focus set duration, this condition was used to simulate participants using the Pomodoro method, while controlling for between app differences (ex. differences in usability, UI polish, etc.). This duration type served as our control condition.
(2) *Dynamic*: focus sets whose duration is expected to change by user manual adjustment based on their individual capacity, and by system prompts based on the success of previous focus sets. This duration type served as our experimental condition.

User Distraction Propensity Conditions

Our Empathize milestone report identified two categories of users who are prone to distractions. These were:

(1) *Relatively Internally-Distracted*: users who considered themselves to generally be more prone to distractions originating internally. Users in this category struggled with acting on desires to engage in activities other than the one they have set out to do[8].
(2) *Relatively Externally-Distracted*: users who considered themselves to generally be more prone to distractions originating in their environment, such as noise, notifications from technology, and other attention diverting triggers [9].

2.2.3 Tasks.

(1) *Primary Task*: Users were instructed to choose tasks that they deemed to require dedicated focus to complete and use our app while completing these tasks. The entire sitting was the *focus session*, during which users did a number of *focus sets* (as determined by the user).
(2) *Secondary Task*: In order to measure the effectiveness of our app, we had to establish each users baseline focus capacity before beginning any focus sessions, and after completing their observational period. This allowed us to measure differences between the participants progress in the various conditions.

2.2.4 Design. We conducted the study with a two 2×2 between subjects factorial design. Specifically, we have focus set duration types *static* and *dynamic* as a between-subjects factor, and user distraction propensity *relatively internally-distracted* and *relatively externally-distracted* as a between-subjects factor. *Focus capacity*, and *perceived ability to focus* (respectively) serve as the dependent variables. Participants were randomly assigned to one of the focus set duration type conditions, with an attempt made to achieve an even number of relatively internally-distracted and relatively externally-distracted participants in each.

We also ran a two-tailed independent samples t-test, and a two-tailed one sample t-test to measure the significance of difference in *perceived helpfulness of visual cues* with *relatively internally-distracted* and *relatively externally-distracted* as a between-subjects factor in the first case.

[8]Originally *internally-distracted*
[9]Originally *externally-distracted*

To collect the required data, we provided the same pre-observation period and post-observation period questionnaires to all participants in order to measure their perceived ability to maintain focus, distraction propensity, and perceived helpfulness of visual cues. The focus capacity of each participant was measured in the app, at the beginning and end of the observation period.

2.2.5 Procedure. Participants were given the following procedure for completing their two day observation period:

(1) Read the orientation in the e-mail body.
(2) Complete initial questionnaire, located here: https://ubc.ca1.qualtrics.com/jfe/form/SV_86ULGeFN53GEDKR
(3) Opt in for user testing at: https://play.google.com/apps/testing/com.teamfoci.foci
(4) Download the app from the Google Play store at: https://play.google.com/store/apps/details?id=com.teamfoci.foci
(5) Open the app. Click on the 3 vertical dots in the top right corner of the main screen.
(6) Press *'Set user ID'*, and enter the ID number you were given on your questionnaire form, and then press *'OKAY'*.
(7) Over a 2 day period you will use the app while engaging in school related tasks that you deem as requiring focus to complete.
    (a) **Day 1**: Before we train your ability to focus, we first have to determine how long you can currently remain focused for (we call this your *baseline focus*). Please set aside 1.5 hours for this - actual time to complete baseline test may be less. Do this as follows:
        (i) From the home screen, press 'Determine Baseline Focus'
        (ii) In the 'minutes to study for...' field, enter the amount of time you estimate that you can maintain your focus without becoming distracted (up to 25 min max.). This will be the amount of time for your focus set, which we call the *focus set duration*.
        (iii) Over the next 3 focus sets, adjust your focus set duration according to any changes you perceive in your ability to maintain your focus. For example, if you were not distracted for the previous focus set, consider increasing the focus set duration. If on the other hand you were not able to remain focused for the current focus set duration, you can decrease it accordingly.
    (b) **Days 1 - 2**: Use the app while studying, but only increase or decrease focus set duration when prompted to by the app.
    Note: some users will have a fixed focus set length of 25 minutes, and will not receive prompts by the app to change the focus set duration. This is normal and is done for experimental reasons.
    (c) On day 2 set aside 1.5 hours (actual time to complete baseline may be less), re-establish your focus capacity by:
        (i) Using your knowledge gained over the past 3 days,
        (ii) From the home screen, press 'Determine Baseline Focus'
        (iii) the 'minutes to study for...' field, enter the amount of time you estimate that you can maintain your focus without becoming distracted (up to 25 min max.).

(iv) Over the next 3 focus sets, adjust your focus set duration according to any changes you perceive in your ability to maintain your focus. For example, if you were not distracted for the previous focus set, consider increasing the focus set duration. If on the other hand you were not able to remain focused for the current focus set duration, you can decrease it accordingly.

(8) Complete final questionnaire, located here: https://ubc.ca1.qualtrics.com/jfe/form/SV_3l87XNoccZE4UkZ

In addition to the above procedure, we conducted 4 semi-structured interviews to get a better sense of participants experience with the app. We chose participants for the interviews based on their distraction propensities, leaning towards a balanced representation between relatively internally-distracted and relatively externally-distracted. The outline for our questions are as follows:

(1) How does this application affect your focus capacity based on your experience?
(2) How do you think about the visual cue in the progress graph we showed in the questionnaire?
(3) What is your general experience of using our application?
(4) What did you like/dislike the most or what bothers?, and why?
(5) Do you have any features that you think it would be helpful to be added in this kind of application?
(6) What kind of tasks did you use the application for?

2.2.6 Apparatus. The apparatus for our experiment was the *Foci* app itself. The Foci app was built around the concepts of *focus sessions* and *focus sets*, which were in turn largely informed by Zimmerman's first stage of his self-regulated learning model[22]. Users specify how many focus sets they planned to complete, the duration of focus periods for these focus sets, and the duration of the accompanying breaks, within a given focus session. We built an immediate feedback model into Foci using Zimmerman's third stage of his self-regulated learning model, where the success of each focus set was self-reported within the app at the conclusion of each focus period. Upon the completion of 3 successful focus sets, users were prompted to increase their remaining focus periods by 5 minutes, thus explicitly training cognitive capacity using the model of physical training, motivated largely by Zimmerman's second stage of his self-regulated learning model [10].

Included in the app was an insights portion that displayed to users histograms of their focus training progress over time. These graphs included: total study hours per day, average study hours per session, and total number of sessions per day. These as well were motivated by Zimmerman's second stage of his self-regulated learning model.

In addition a top-level menu was coded into the app, consisting of a summary of the instructions given to participants, our contact information, the course code this experiment related to, the ability to set the participant ID code, and a data export option in the case of data transmission failure.

Data regarding app use was stored in SQLite databases on users phones, and an automated email service that ran quietly in the background parsed and sent database reports to us daily. The daily database reports are described in detail below:

- *Baseline Reports* In baseline reports, participants who followed instructions would begin by running their baseline test first, which was comprised of three sequential sets of focus and break periods that allowed participants to adjust their focus duration to a comfortable amount, thus gauging their initial level of ability to focus. Baseline reports were sorted by user ID tags and collected data on the the date the baseline tests were performed, the minutes taken for each focus and break period as well as their start and completion times, and the self reported success for each set.
- *Session Reports* In session reports, the data gathered was primarily summary information collating the data across each focus set within a single session. Session reports were sorted by user ID tags and collected data on the date the focus session was performed, the start time of the session and the time of completion after all focus sets were finished, how many minutes participants input for their focus periods, the number of focus sets participants promised to complete and how many they actually completed for that session, and the total number of self reported successes and failures across all focus sets in that session.
- *Focus Set Reports* Focus set reports were sorted by user ID tags, and gathered information about the session ID they belonged to, the minutes taken for each focus and break period as well as their start and completion times, and the self reported success for the set.

We used a simple external mic and laptop setup for recording the semi-structured interviews, and transcribed them using the commercially available *Descript* tool.

2.2.7 Independent and Dependent Variables.

- *Focus capacity*: The duration of unbroken focus a user is able to maintain in minutes. This was measured for all participants at the beginning and end of their observation period, by having the user complete an *establish baseline focus* secondary task. While there was a qualitative element to our measurement technique, it was the best way we could approximate this metric within a field setting.
- *Perceived ability to maintain focus*: Self-reported evaluation of a participants ability to maintain their focus during studying. This was measured in two questionnaires; given before and after participants observation period. Specifically, participants reported their ability to focus on a 9 point Likert scale, with *I can almost never focus while studying* on one end, and *I can almost always focus while studying* on the other.
- *Perceived helpfulness of the visual cues*: The post observation questionnaire given to participants included a graph of the time spent for their focus sets with highlights showing the best day or times to study based on their feedback for each session. Users were asked to measure the helpfulness of having these visual cues (i.e., highlights) in understanding their study habits using a 5 point Likert scale.

2.2.8 Hypotheses.

[10] Rather than starting at 20 push-ups, one would begin at a comfortable number and gradually increase this over time.

- $H1_1$: **Focus capacity will increase more after training with dynamic focus set duration than with static focus set duration.**
  Support for this hypothesis came from the observation and interviews conducted during previous milestones, which suggested that students may desire to focus but don't know where to start. Given that baseline abilities to focus were not near the standard times of 25 min, an adaptive period suggested itself. As this was the basis of our design direction, it was important that this be investigated.
- $H2_1$: **Users will report a higher level of perceived ability to focus after training with dynamic focus set duration than with static focus set duration.**
- $H3_1$: **Users who classify themselves as *relatively internally-distracted* will experience a greater increase in focus capacity than those who classify themselves as *relatively externally-distracted*[11].**
- $H4_1$: **Both *relatively internally-distracted* and *relatively externally-distracted* users will find the visual cues showing the best day or time in the progress graph helpful for understanding their study habits[12].**
  This hypothesis was based on the self-regulation learning (SRL) model [21] which promotes students monitoring their studying progress and strategies, reflecting on them to create better studying plans. Sitzmann and Ely found that the SRL model can increase students' attention and motivation[23]. During prototype testing we asked participants what specific features they would want to see for understanding their studying habits. Two out of the three participants suggested a feature showing the best time or day to study based on analytic focus data. Hence, we decided to provide this functionality for providing insights to users regarding their studying habits, highlighting the best day or time of day in progress histograms using self-reported in app focus set success rating data. Through the user evaluation we wanted to know the effectiveness of this feature in helping participants better understand their studying habits.
- $H5_1$: ***Relatively internally-distracted* users will find the visual cue in the progress graph be more helpful than *relatively externally-distracted* users in understanding their studying habits[13].**
  Since the SRL model increases internal motivation to study, which we assumed was a key solution for internal distractions, we hypothesized that the visual cues mentioned above would be more beneficial for the users who were more relatively susceptible to internal distractions.

2.3 Problems/Limitations

The limitations to our planned experiment fell into one of two categories: confounding variables, and construct validity concerns.

Confounding Variables

- **Participants individual differences in natural ability to focus**: the ability to focus was likely quite varied among participants, but since the purpose of our app was to train focus capacity, it was reasonable to assume that the training effect would be high by design, and made a within subjects design meaningless for the focus set duration type condition.
  Plan to address weakness: We randomly assigned individuals to focus set duration conditions.
- **Inability for task control**: This presented a serious limitation, as variability in focus capacity was likely task dependent. However, controlling for the task was not suitable for our field study, given that the purpose of our app was to train the user's ability to focus on the tasks that were important to them. The alternative was to conduct our study in a controlled lab setting, but this was not suitable given the nature of activity we were supporting.
  Plan to address weakness: We recruited a large number of participants to reduce variability in tasks being done during their observation period, and instructed users to only use the app when focusing on a scholastic task that they perceive as important. In addition, we asked participants in the post-questionnaires what tasks they used the app for as to take account of this confounding effect.

Construct Validity

- **Measurement of focus capacity**: Our method for testing a given users focus capacity was at best an approximation of actual focus capacity. We considered using other standard measurements such as a Continuous Performance Test[24], however all variations of this test require participants to execute tasks entirely unrelated to the ones we were trying to support (i.e. school related work), and most variations of this test also require in lab administration. For this reason, despite the inherent weakness of our measurement, it was suitable for informing our goals.
- **Reporting error for distraction propensity**: as we were relying on the participants to self-report, there was a chance that they would do so incorrectly, or that their chosen category was different from reality.
  Plan to address weakness: We asked various questions in our pre-questionnaire to determine distraction propensities. We asked how frequent each kind of interruption occurred, how long it took for participants to re-focus after each kind of interruption occurred, and what kind of interruption they needed the most help to prevent.

3 RESULTS

3.1 Quantitative Results

Of the 7 participants, 3 were randomly assigned to the static duration, of which 2 were categorized as being relatively internally-distracted and 1 was categorized as being relatively externally-distracted. The remaining 4 participants were randomly assigned to the dynamic duration, of which 1 was categorized as being relatively internally-distracted and 3 were categorized as being relatively externally-distracted. Overview summaries of measurements taken across participants are summarized in Table 1 and Table 2.

[11] Originally internally-distracted and externally-distracted.
[12] Originally internally-distracted and externally-distracted.
[13] Originally internally-distracted and externally-distracted.

ID	Duration	Propensity	# Focus Sets	△ Perceived	△ Baseline
1	static	rel. internal	5	+44p	-1.7min
3	dynamic	rel. external	5	-9p	+9min
4	dynamic	rel. internal	14	+20p	+10.6min
12	dynamic	rel. external	24	+0p	-7.5min
14	static	rel. external	12	+4p	+0min
18	static	rel. internal	2	+20p	+35min
21	dynamic	rel. external	2	-30p	+1.7min

Table 1: Data for participant conditions, changes in self-reported perceived ability to focus prior to and after the study recorded through questionnaires, and changes in average baseline measurements prior to and after the study recorded through the app.

Conditions	Avg. # Focus Sets	Avg. △ Perceived	Avg. △ Baseline
Static	6.333	+22.667p	+11.1min
Dynamic	11.25	-4.75p	+3.45min
Rel. Internal	7	+28p	+14.633min
Rel. External	10.75	-8.75p	+1.05min

Table 2: Summary statistics split on *duration conditions* and *propensity conditions*.

We ran a 2×2 ANOVA test of the dependent variable *focus capacity*, and found a test statistic of $F_{1,6} = 0.032$ for the independent variable *duration* which corresponds to a p-value $p = 0.869$, as well as a test statistic of $F_{2,6} = 0.896$ for the independent variable *propensity* which corresponds to a p-value $p = 0.414$. We also found a test statistic for the interaction effect between both of these independent variables with regard to the dependent variable *focus capacity* of $F_{3,6} = 0.066$ which corresponds to a p-value $p = 0.814$. These results are summarized in Table 3.

Source	Sum of Square	df	Mean Square	F	Significance
Duration	8.765	1	8.765	0.032	0.869
Propensity	241.965	1	241.965	0.896	0.414
Duration * Propensity	17.875	1	17.875	0.066	0.814
Error	810.172	3	270.057		

Table 3: SPSS result for the factorial 2×2 ANOVA test of the dependent variable *focus capacity*.

We also ran a 2×2 ANOVA test of the dependent variable *perceived ability to maintain focus*, and found a test statistic of $F_{1,6} = 1.169$ for the independent variable *duration* which corresponds to a p-value $p = 0.359$, as well as a test statistic of $F_{2,6} = 5.170$ for the independent variable *propensity* which corresponds to a p-value $p = 0.108$. We also found a test statistic for the interaction effect between both of these independent variables with regard to the dependent variable *focus capacity* of $F_{3,6} = 0.035$ which corresponds to a p-value $p = 0.864$. These results are summarized in Table 4.

Source	Sum of Square	df	Mean Square	F	Significance
Duration	296.824	1	296.824	1.169	0.359
Propensity	1313.294	1	1313.294	5.170	0.108
Duration * Propensity	8.824	1	8.824	0.035	0.864
Error	762.000	3	254.000		

Table 4: SPSS result for the factorial 2×2 ANOVA test of the dependent variable *perceived ability to maintain focus*.

We ran a one sample t-test, first calculating summary statistics for *perceived helpfulness of visual cues* at a mean of 68.1429 with standard deviation 23.82875. The calculated test statistic was found to be $t_6 = 2.014$ and the critical right-tailed t-value found to be $t_6 = 1.44$ at an alpha of 0.10. These results are summarized in Table 5 and Table 6.

	N	Mean	Std. Deviation	Std. Error Mean
Perceived Helpfulness	7	68.1429	23.82875	9.00642

Table 5: Statistics for the dependent variable *perceived helpfulness of the visual cues*.

Test Value = 50						
	t	df	Sig. (2-tailed)	Mean Difference	90% Confidence Interval of the Difference	
					Lower	Upper
Perceived Helpfulness	2.014	6	0.091	18.14286	0.6418 – 35.6440	

Table 6: SPSS results for the one sample t-test for the dependent variable *perceived helpfulness of the visual cues*.

Finally we ran an independent samples t-test on *propensity*, first calculating summary statistics for *perceived helpfulness of visual cues*. For *relatively internally-distracted* we found the mean score for perceived helpfulness of visual cues to be $\bar{x}_int = 55.0000$, and for *relatively externally-distracted* $\bar{x}_ext = 78.00$, with standard deviations $\sigma_int = 32.78719$ and $\sigma_ext = 10.80123$. Using LeveneâĂŹs test at an alpha of 0.05 we have assumed equal variances. We calculated a test statistic of $t_5 = -1.347$, and found a critical right-tailed t-value of $t_6 = 1.94$ at an alpha of 0.05. These results are summarized in Table 7 and Table 8.

	Propensity	N	Mean	Std. Deviation	Std. Error Mean
Perceived Helpfulness	Rel. Internal	3	55.0000	32.78719	18.92969
Perceived Helpfulness	Rel. External	4	78.0000	10.80123	5.40062

Table 7: Group statistics for the independent samples t-test for the dependent variable *perceived helpfulness of the visual cues*.

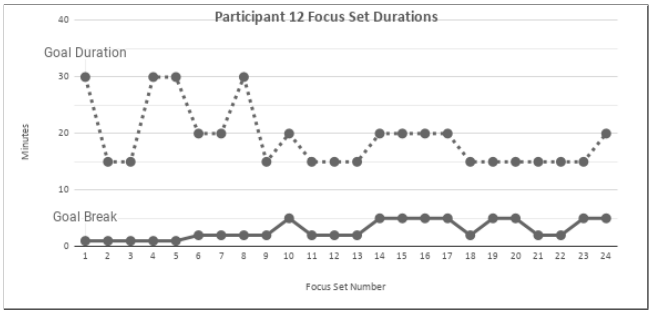

Figure 1: Participant 12's focus and break period durations measured for each of their focus sets.

3.2 Qualitative Results

We present our qualitative results, organized by hypotheses, as labelled quotes taken from questionnaire text inputs and interviews, and general themes.

$H1_1$: Focus capacity will increase more after training with dynamic focus set duration than with static focus set duration.

General theme: the app was not helpful in increasing focus capacity, rather it served as a reminder to continue working.

- *Interview, P1 (static, rel. internally-distracted*: "...cause it feels like it's a really a reminder system saying 'oh you're in the work mode right now', just keep working."

t-test for Equality of Means									
		Levene's F	Levene's Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	95% Confidence Interval of the Difference
									Lower – Upper
Perceived Helpfulness	Equal variances assumed	3.265	0.131	-1.347	5	0.236	-23.00000	17.07825	-66.90104 – 20.90104
Perceived Helpfulness	Equal variances not assumed			-1.168	2.329	0.348	-23.00000	19.68502	-97.21619 – 51.21619

Table 8: SPSS results for the independent samples t-test for the dependent variable *perceived helpfulness of the visual cues.*

- *Interview, P1 (static, rel. internally-distracted*: "it's a persistent layer of reminding you that you're in a work mode."

$H2_1$: Users will report a higher level of perceived ability to focus after training with dynamic focus set duration than with static focus set duration.

General theme: All users in both static and dynamic treatments found having timed work and rest periods helpful. There was no distinction however for dynamic durations specifically.

- *Text, P12 (dynamic, rel. externally-distracted*: "it seemed to be helpful... it sort of encouraged me to challenge myself to see how long I could try and stay focused. So, I'd say it affected my focus for the better."
- *Text, P18 (static, rel. internally-distracted*: "it seems like a task, which is to focus in the session, so that it makes me much more concentrative when I am working. When I succeeded, I would be happy otherwise I would be upset or disappointed for myself."

$H3_1$: Users who classify themselves as *relatively internally-distracted* will experience a greater increase in focus capacity than those who classify themselves as *relatively externally-distracted.*

General theme: relatively internally-distracted participants noted that the app made them more self-aware regarding their propensity for distraction.

- *Interview, P1 (static, rel. internally-distracted*: "the application did help to serve as a reminder to just keep going on your task.... It's kind of like having a sticky note on your laptop that says don't slack off."

General theme: relatively internally-distracted participants noted that their issue in focusing was neither boredom nor anxiety.

- *Interview, P1 (static, rel. internally-distracted*: "But it's not like I wanna do my work. Postponing the work is probably my baddest habit. Once you're in the zone, then you're in the zone. To get warmed up to it. I think that's the hardest part."
- *Interview, P1 (static, rel. internally distracted*: "Even with that 25 minutes, you might be distracted reading an abstract too long like that, but if you have a timer. Then you know 'oh god, I'm reading this things too long, I should maybe move on,' and I'll move on to pick up the pace."

General theme: The ability to specify a desired duration is important.

- *Interview, P14 (static, rel. internally-distracted*: "The one thing I want to have is a functionality to set the time. For example, I wanted to make my focus session for an hour."
- *Interview, P14 (static, rel. internally-distracted*: "So that's the moment when it takes a lot of my time and energy to identify what to do first what to do next and based on the timelines when it is to be delivered or something."

$H4_1$: Both *relatively internally-distracted* and *relatively externally distracted* users will find the visual cues showing the best day or time in the progress graph helpful for understanding their study habits.

General theme: nearly all participants found these visual cues helpful for understanding their study habits.

- *Interview, P21 (dynamic, rel. externally-distracted*: "I did like the fact that it was collecting data on my studying habit."

General theme: insights can be more helpful with further work.

- *Interview, P1 (static, rel. internally-distracted*: "The things I wrote it will be helpful if it has some knowledge of my schedule, and then it might be more helpful. For example, for Tuesday, when I'm on campus, I'm less productive, because of the virtue of meetings or stuffs to do that are not my main task."
- *Interview, P14 (static, rel. internally-distracted*: "If the system is giving me those recommendations by just like observing my activity and how much I'm getting distracted and all that. That's also good."
- *Interview, P14 (static, rel. internally-distracted*: "if it is recording the moment that I am not focusing on and it is showing me then I can compare my progress like how good I was over a week and how I performed and how much I improved but for example after a week or after a month, I can see the graph and I can relate my progress."
- *Interview, P14 (static, rel. internally-distracted*: "if you're saying okay, I was doing some writing task here and my focus was very good then I can relate. Oh, yeah. I am good in writing. Maybe that's why I liked it. I don't remember like if you ask me what I did last Thursday the last Friday, I don't remember you're showing me a graph of I was so good."
- *Interview, P21 (dynamic, rel. externally-distracted*: "I did like the fact that it was collecting data on my studying habit."

$H5_1$: *Relatively internally-distracted* users will find the visual cue in the progress graph be more helpful than *relatively externally-distracted* users in understanding their studying habits.

General theme: almost all participants found this useful in understanding their studying habits, regardless of group.

4 DISCUSSION

4.1 Interpretation of Results

$H1_1$: Focus capacity will increase more after training with dynamic focus set duration than with static focus set duration.

Our 2×2 ANOVA test of the dependent variable *focus capacity* found no significance with regard to focus set duration conditions *static* and *dynamic*. However, one interesting finding that relates was evidenced in Participant 12's plotted focus set durations. Since this participant used the app the most out of all other participants, and was in the dynamic treatment, we closely looked at their data for possible trends. In Figure 1, we see a highly random exploratory phase at the start of using the app, in which the participants focus period durations ranged from 15 minutes to 30 minutes. Subsequently, we see a gradual flattening out of their focus durations, which we speculate may be due to the learning effect; that is, we believe the participant to have gained insight into their own learning. We expect that an initial exploratory phase, followed by self-realization of cognitive upper limits, may not be uncommon, and would be interested in seeing whether the participant would have begun to gradually increase their focus durations from this point forward. However, as the study ended, we were unable to do so.

$H2_1$: Users will report a higher level of perceived ability to focus after training with dynamic focus set duration than with static focus set duration.

The 2×2 ANOVA test of the dependent variable *perceived ability to maintain focus* found no significance with regard to focus set duration conditions *static* and *dynamic*. However, it is worth noting that one participant remarked that they felt challenged in a productive manner by the app, and sought to see how long they could focus for. This idea of being challenged by an app may be an interesting avenue for further study within our problem scope.

$H3_1$: Users who classify themselves as *relatively internally-distracted* will experience a greater increase in focus capacity than those who classify themselves as *relatively externally-distracted.*

Our 2×2 ANOVA test of the dependent variable *focus capacity* found no significance with regard to distraction propensity conditions *relatively internally-distracted* and *relatively externally-distracted*. However, we would like to note that two of our participants had remarked to some degree that their issue focusing was not entirely boredom, nor anxiety. This supports our initial conceptual models constructed during the investigative stage of our study into current literature, and we are hopeful will bode well for results when we re-conduct this study.

$H4_1$: Both *relatively internally-distracted* and *relatively externally distracted* users will find the visual cues showing the best day or time in the progress graph helpful for understanding their study habits.

Our one sample t-test of the dependent variable *perceived helpfulness of visual cues* found significance with regard to distraction propensity conditions *relatively internally-distracted* and *relatively externally-distracted*. We can see the 2-tailed t value of this test lies at $t_6 = 2.014$ which is greater than the critical right-tailed t-value $t_6 = 1.44$ at an alpha of 0.10, as well, the reported lower and upper means are ordered properly in the right direction to support this finding.

$H5_1$: *Relatively internally-distracted* users will find the visual cue in the progress graph be more helpful than *relatively externally-distracted* users in understanding their studying habits.

The independent samples t-test on *propensity* we ran calculated a test statistic of $t_5 = -1.347$, and found a critical right-tailed t-value of $t_6 = 1.94$ at an alpha of 0.05. This did not find any significance at a 95% confidence interval as the t-value in the two-tailed test is less than the critical right-tailed t-value at an alpha of 0.05. We would like to note that it may well be the case that progress visualizations are a universally supported method of communicating data such as progress. Moving forward, we may approach this hypothesis in the future by examining a finer grain look at varying types of visual cues.

4.2 Relation to Other Works

Our app most closely resembles *Focus Timer - Focus Enhancer* developed by Real Number Works Inc[11]. Focus Timer offers the following features:

(1) Easy measuring for measuring the actual time users spend focusing, the only caveat is needing to place the smart phone face down.
(2) Analyze and manage charts and statistics on collected focus data to help users understand their focus patterns and manage them.
(3) Super focus mode blocks notifications from users phones while they engage in training their cognitive capacity.
(4) Weekly goals allow users to both specify and accomplish their goals.

Focus Timer differs from Foci in a number of crucial ways that makes Real Number Works Inc.'s app more robust than ours. First, Focus Timer provides more informative insights into users studying patterns, a request made by some of our participants. Foci was unable to block notifications from apps external to it, something that Focus Timer is able to do. Lastly, the timer is automated and triggers once the smart phone is placed face down, automatically stopping when flipped face up. This forces users to leave their phones alone

while training their cognitive capacity, while also reducing potential errors from users not following given instructions which we have seen in our study is not uncommon. While Foci did encode fail-safes in the form of persistent time stamps with each piece of recorded data to mitigate users potentially abusing the stop and start timer functions, this ended up not being an issue once we went over the data. In fact, we found that only one participant exceeded their duration of focus, which we calculated by taking the difference between starting and finishing time stamps and comparing these to user-specified durations. After contacting the participant to clarify this piece of data, they informed us that they had in fact fell asleep with the app in the middle of a focus session, which was corroborated by the exceeding duration of multiple hours. However, it can still be concluded that Focus Timer is more effective in this regard.

The two ways in which Foci differs from Focus Timer in support of Foci is in our use of the training model and feedback model. Focus Timer does not prompt users to increase their focus period durations, whereas Foci does. This training model helps users in two important ways. First, it naturally helps users accomplish their tasks given the increased time to do so. Secondly, it helps users explicitly train their cognitive capacity, using albeit a relatively simple heuristic, allowing for a more robust conceptual model of what the app is in fact intended for. The feedback model we use is informed by the third stage of Zimmerman's self-regulated learning model. By immediately prompting users to reflect on completed focus sets, Foci enforces consistent reflection as users are in the middle of completing a focus session. This allows users to reflect on short-term failures and successes, adapting their remaining focus sets to better suite their immediate needs.

As the apps are currently, Focus Timer is indeed the more effective app as it allows for more refined specifications of use. However, as we have seen in many of the apps available on the market they do not go beyond reporting tracked data. Plans for Foci development in the future include heuristics to go over gathered data and provide expert curated feedback concerning best time of day and location to train or work on cognitively burdensome tasks, effective study strategies and scheduling to address user weaknesses, and goal-setting tips.

4.3 Limitations

There were a number limitations in our study, most egregious were our threats to validity. These are enumerated below:

(1) **Internal Validity**: conducting our study as a non-participatory field study attached to the phones of participants, we were able to observe participants through recorded data (and lack of) in their natural settings. While we understood that this may have still posed a risk due to the Hawthorne effects persistent nature when any data is recorded, we have come to realize that the Hawthorne effect in fact lies on a spectrum between two extrema, where study participants may over police their behaviour in response to being observed on one extrema, or completely disregard any policing behaviour on the other end, even socially expected forms of self-policing such as following through on given word. Unfortunately the majority of participants stopped short after completing the pre-questionnaire, and never actually used our app. Additionally, from those participants who did complete their observational period there were a number who misused the app by forcefully terminating it consistently, which was most likely the fault of our user interface design blocking back navigation while committed to a study session, who failed to properly complete their pre-questionnaire, who failed to input their participant ID into the Foci app, or failed to complete their baseline measurements. This further limited the pool of available data we could use, and unfortunately invalidated much of our work.
(2) **Statistical Validity**: while we did conduct our planned statistical analysis, there were numerous violations of assumptions regarding the normal distribution of data, equal variances, and we had a number of outliers in our data as well. There was not much we could do once we had the limited amount of data unfortunately, and so we still conducted our statistical analyses fully expecting to fail to reject most if not all of our null hypotheses.
(3) **External Validity**: due only for the fact that our gathered data was quite limited in amount as well as quality in some instances, our results do not generalize. However, as a successful study remains to be seen we have room in the future to conduct our experiment once more with a more informed perspective on effective strategies.

4.4 Future Work

Foci will need to be refined further, and this study ran for a period of at least 3 months with a participant pool of at least 60, to gather sufficient quality data on participant progress with respect to our hypotheses.

Refinements made to the Foci app will necessarily have to automate the timers start and stop functionality, provide more robust visualizations into focus insights, block phone notifications, provide a mechanism for recording and achieving short-term and long-term goals, enforce participant ID entry, enforce baseline measurements, address back button navigation issues, and streamline the user interface.

Once the study is ran once more and we are able to gather sufficient data to better reason about our hypotheses, and assuming we are able to find support for our study goals, plans for a third iteration of field-study experimentation of Foci include a heuristic component to provide expert feedback to users. The goal after this milestone would naturally be deployment to the market.

5 CONCLUSION

Our study failed to find any significance between our hypotheses outside of the helpfulness of visual cues. This was largely the fault of our user interfaces design relying on participants adherence to given instructions. We are hopeful however that conducting further studies of Foci in the field, using what we have learned through this study, will garner useful insights regarding the potential relationships between student cognitive training and internal distractions.

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