DEPARTMENT OF COMPUTER SCIENCE
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INTERACTION INTERRUPTED

INVESTIGATING THE EFFECTS OF NOTIFICATIONS ON FLOW EXPERIENCES AND UNDERSTANDING COMMON NOTIFICATION-HANDLING STRATEGIES

SUBMITTED AS PART FULFILLMENT FOR
MSC DEGREE IN HUMAN-CENTRED INTERACTIVE TECHNOLOGIES

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STATEMENT OF ETHICS

All aspects of this project, including the aim of the study, the experimental design and tasks to be performed by the participants were prepared and designed to adhere to the following ethical principles:

1. Do no harm.
2. Informed consent.
3. Confidentiality of data.

DO NO HARM

The purpose of this project was to investigate if flow experiences are being affected by the presence of notifications. The project also sought to learn the affective responses, anxiety, satisfaction-with-life, and common notification-handling strategies used by users in their everyday life. Therefore, the best interests of users were at the core of this study. All participants knew how long the study period would last prior to their involvement.

INFORMED CONSENT

All the participants were recruited after they willingly volunteered to participate. All participants signed an Informed Consent Form after they were briefed on the purpose and requirements of the study. They were also informed that they could withdraw from the study by simply communicating it to the researcher. All participants knew that they would be compensated with a £30 Amazon gift voucher for their participation in the study. The consent form can be viewed in Appendix 1.1

CONFIDENTIALITY OF DATA

All the data gathered during the course of this study has been treated with complete confidentiality. All the participants have been referred to anonymously in this paper, and demographic information has been presented in summary form. The only people that have seen (and will in the future see) the data in a non-anonymous format are the researcher and his supervisor.

ABSTRACT

With an increase in the demand for pervasive and ubiquitous information, notifications have gained immense popularity. These notifications are designed to provide rapid availability of information and access to nearly any instantaneous communication. Unfortunately, this instantaneous awareness of events and information comes with the price of interruption. With its nature to break the continuity of on-going processes, interruptions are responsible for the abrupt redirection of attention towards irrelevant tasks, and an increase in anxiety, annoyance and error rates. Meanwhile, at the opposite end of this disruptive spectrum of interruption, lies a state of *flow* - an autotelic experience which provides a holistic sensation of total involvement in an activity and is associated with positive affect. Though the concepts of notification and flow are fairly old, yet no attempts have been made to understand their effects on one another and the vital role they play in our everyday lives.

We addressed this issue using experience-sampling, the most reliable method for collecting information about both context and content of the daily life of individuals. We text messaged eight people six-times per day for three weeks. Using a within-participants design with three conditions of baseline, notifications turned-off, and notifications turned-on, we measured their percentage-of-time in flow, flow experiences, enjoyment, level of concentration, control, affect, potency, state-anxiety, and satisfaction-with-life. We conducted interviews at the end of each week to capture further contextual information and to understand different notification-handling strategies.

We received over 600 experience sampling responses. Results showed that the absence of notifications significantly increased the participants' percentage-of-time in flow and their level of concentration. However, contrary to what was predicted, there was no significant difference in the participants' state-anxiety, enjoyment, or satisfaction-with-life. Analysis of interviews found five key notification-handling strategies: momentary delaying of attention to notification, self-initiated technology breaks, *'glancing',* silent mode, and ignoring notifications. The results are discussed in relation to the model of interruption and psychology of multiple activities. We find that users acknowledge notifications to be disruptive, yet considered themselves to be 'habituated' to them and chose to keep them active. Thus, devising effective strategies to control notification use can help reduce its ill-effects and do more good than harm. We conclude that notifications though disruptive help in enhancing awareness of events around us; a 'necessary evil' in the present age.

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ACKNOWLEDGEMENT

I would like to express my gratitude towards Dr Christopher Power for his expert guidance and continued support in this project. I also extend my thanks to Professor Helen Petrie for sharing previous experience with similar studies. I would also like to thank the participants who agreed to spend three weeks of their time to take part in my experiment.

1 INTRODUCTION

Emails, Twitter, Facebook, Skype, Instant Messenger (IM), Instagram, Pinterest, Path, and Angry Birds, are the tip of the iceberg of the myriad applications which generate incessant 'notifications'. Imagine having few of these applications installed on your smartphone. Now, there isn't a single day when you do not hear your phone 'beep' and notify you of either a new email, or a new tweet, or a new chat message from a friend; inadvertently adding unnecessary distraction to your life making it a 'notification hell'. The purpose of notification is to alert you of an event and lure you back into whatever application they came from. Inarguably, some of the notifications can be valuable. But, attending to a notification leads to interruption. Interruption is the method of forcefully switching attention from one piece of information to another [1]. Interruptions in general are a source of user distraction, annoyance, and dissatisfaction. Further, efficiency and performance decrease when users are interrupted in their work [2], [3]. Thus, notifications are a source of interruption and inherit most of the negative qualities of interruptions.

It has been aptly said, "In modern times, hurry, bustle, and agitation have become a regular way of life …"[4]. Thus uninterrupted attention on a single task is difficult to achieve these days. But what is that *experience* that one has sacrificed? In 1975, psychologist Mihaly Csikszentmihalyi was intrigued by an opposite phenomenon, where he observed that some people performed activities with such involvement that they were often ready to sacrifice a great deal for the chance of continuing to do so. He asked a similar question, "What is this *experience* in performing the activity that makes one forget boredom and start enjoying it?" He later called this experience, '*flow*' experience and described it as a holistic sensation that people feel when they act with total involvement [5, pp. 36]. It is this flow experience that we believe is being affected by the everyday use of notifications.

Flow experience is associated with focused attention, a sense of ecstasy and serenity, great inner clarity, timelessness, and intrinsic motivation. Overall it leads to happiness [6]. On the other hand, prolonged exposure to momentary interruptions in life due to notifications, forces users to multitask, and can have deleterious effects on short-term and long-term memory; driving oneself to perhaps be less efficient in the long run even though it may sometimes feel like one is being more efficient [4], [7]. But studies have shown that people have adapted themselves to the state of being frequently interrupted by using interruption-handling strategies, which reduces the ill-effects of interruptions [8], [9].

Thus, we have identified notifications, flow, and notification handling strategies as the primary focus of our study. By collecting momentary responses from users in their natural environment for three weeks, each week under a different notification setting configuration, we aim to find the effects of notifications on everyday flow experiences, and common notification-handling strategies used in everyday life.

1.1 RESEARCH OBJECTIVES

The main research objectives for this dissertation were:

- Investigation of the impacts of notifications on the everyday lives of users, by measuring the effects of notifications on
  - Everyday flow activity and experiences,
  - Affect,
  - State-anxiety, and
  - Satisfaction-with-life
- Finding common notification-handling strategies and evaluating its efficiency in reducing the disruptiveness of notifications.

The best way to achieve the goals was to let users live their normal life and sample instances of their everyday activities. Thus, we carried out a three-week long in-the-wild study using Experience Sampling Method (ESM) to collect momentary responses from our participants. We also interviewed them once every week and gathered information on their notification handling strategies. We used a within-participants design and imposed conditions on each week that the participants were expected to comply with. Finally, we analysed all the data and discussed the results to provide conclusions and recommendations for future work.

1.2 SECTION OUTLINE

This section briefly explains the outline of this project.

1.2.1 LITERATURE REVIEW

This study starts with a literature review, defining interruption and notification followed by a theoretical explanation of interruption model and a critical discussion of previous studies on interruption. This is followed by a literature review on self-regulating strategies used in interruption handling. Finally we discuss the conceptualization and measurement of flow using the Flow Questionnaire and Experience Sampling Method (ESM).

This section also raises few questions of both practical and theoretical significance which we set out to address in our study.

1.2.2 PROBLEM ANALYSIS

Deriving from the conclusions of the Literature Review, this section introduces the research questions and proposed hypotheses of our study. This is followed by a section on in-depth problem analysis of the design of the Experience Sampling Form (ESF) and the measurement of the variables under study. It also discusses the modes of administrating the ESF and the signalling method for ESM. The final section is a notification inventory which includes all known popular forms of notifications in the mobile and laptop domain.

1.2.3 METHOD

The method section is divided into participants, ethical considerations, design, materials and procedure. It reports a detailed account of the entire three-week long experiment. The entire experiment is divided into multiple phases and the procedure section explains them in details.

1.2.4 RESULTS

This section performs the statistical data analysis of the ESM data and reports them. The results are reported under two different sections of quantitative and qualitative analysis. While the quantitative analysis section reports the findings from the ESM data, the qualitative analysis section presents the findings from the end of week interviews. Wherever necessary, while reporting the results of the qualitative analysis, reference is made to quantitative section to support the participants' claims.

1.2.5 DISCUSSION

The discussion section presents a detailed interpretation of the Results section. This section reintroduces the research questions and the hypotheses of our study. The results are explained in the light of previous research and other theoretical models drawn from the Literature Review. Some previously unexplained behaviours and observations from the Results are explained diligently taking care not to deviate from the main goals of our study.

An evaluation of the methodology of the entire study is reported which highlights the key limitations of the study and proposes changes to mitigate them in future endeavours.

1.2.6 FUTURE WORK

The Literature Review of interruptions, self-regulating strategies, and flow reveals that the topic under study is vast and has its roots spread across multiple domains in Human-Computer Interaction. Our study has made a brave attempt to unify these topics, and has hence opened up new, interesting and challenging future research questions. This section discusses some of the most pressing research questions.

1.2.7 CONCLUSION

This section summarizes the findings of the entire study.

2 LITERATURE REVIEW

This section reviews literature surrounding interruptions, self-regulating strategies, and flow. We begin with a brief overview of interruptions followed by definition of jargons specific to interruption literature. We then discuss a model of interruption that is suitable for our study, and conclude the interruption section with a critical discussion of the general studies on interruption. The second part is dedicated to discuss the studies on self-regulating strategies commonly used in interruption-handling. We conclude the literature review section with an extensive discussion on flow.

2.1 INTERRUPTION

Interruption is a discrete event during which cognitive resources (attention) are abruptly redirected to process information that is irrelevant to the on-going activity [7]. Interruptions can be both *external* and *internal*. External interruptions result from events in the environment. Internal interruptions come from a user's own thought processes, such as a new idea that draw attention from the on-going activity. Before we discuss further, we define a few commonly used terms in the interruption literature.

Tasks:

Tasks can be differentiated in varied manner. For the purpose of this study, we divide tasks into two categories – *primary* tasks and *peripheral* tasks. Primary tasks are representative of tasks often being performed with focused attention. They are also referred to as 'main tasks'. Peripheral tasks are representative of information often maintained at the periphery of user attention [3]. Instances of primary tasks could include reading a book, editing spread sheets, evaluating answer scripts, driving, filling an online registration form, photo editing, rehearsing for a play, etc. Peripheral tasks are generally instantaneous distractions such as checking Twitter feed, reading news headlines, reasoning stock market points, updating Facebook status, Instant Messaging (IM), etc.

Interrupted Tasks:

Interrupted tasks are a subset of primary tasks, whose processing have been interrupted by the arrival of a new stimuli or a new task (Interrupting Tasks).

Interrupting Tasks:

Interrupting tasks are a subset of peripheral tasks, which demand attention from the primary tasks onto themselves.

Interruption Lag:

This is a transitional interval, immediately preceding an interruption, during which the user knows of the pending interruption but is not yet engaged by it [10] (FIGURE 2.1).

Resumption Lag:

It is the time interval separating the end of peripheral (interrupting) task and the first action done on the primary (interrupted) task after completing the former (FIGURE 2.1).

Multitasking:

Multitasking is the simultaneous execution of two or more processing activities at the same time. But extensive research has shown that human beings are not really capable of multitasking. The best they can do is switch quickly from one activity to another. Actually, we can only multitask that which is automated and where thinking does not play a role (e.g., chewing gum, walking, and talking at the same time) [9].

Two other factors associated with interruptions in general are the *cost of interruption,* and the *modality of interruption.*

Cost of interruption:

Interruption is designed to introduce a new activity (interrupting task), often unexpectedly, and break the 'continuity' of processing of the on-going activity (interrupted task). As a result, conflict arises. Because of a person's limited processing and memory capacity, one suspends work on the on-going activity to attend to the newly arrived interrupting task [11]. Usually after the interrupting task has gained sufficient attention, the user re-shifts his/her attention to the interrupted task. This re-shifting of attention to the interrupted task comes at an expense and hence interruptions are considered disruptive. The disruptive cost is measured in terms of the time needed to resume the interrupted task after the interrupting task is complete [10], and along affective dimensions of annoyance and anxiety [3], [12]. Efficiency or performance in the primary task can also decrease in terms of error rate and decision-making [3].

Modality of Interruption:

Modality could have different interpretations based on context. One of them is the extent of similarity of an interrupting task to the primary task. Wang et al. [13] found that interruptions in the same modality (e.g. interrupting a visual task of pattern matching, with a visual IM conversation versus an auditory phone conversation) reduced performance more than interrupting a task with another task in a different modality.

Similarly the medium of conveying the interruption can also be considered as a modality. For instance, an alert could be a simple auditory 'beep' tone, a visual email alert on screen, a haptic feedback and/or a combination of all. These salient visual and auditory cues only attract attention and do not force immediate attention. Under the visual feedback category, several efforts have been made to deliver interesting and important information. Within the desktop environment, task tray icons, sidebar or corner applications are specifically designed to provide awareness of activity without disturbing the primary task or becoming annoying [14]. Also, transparent user interface elements as a layered object can provide awareness of other information and enhance context while minimally disrupting focused attention on standard interface objects [14], [15]. All the above methods provide peripheral awareness of notification alluring attention which may or may not lead to an interruption.

2.1.1 ALERTS/NOTIFICATION SYSTEM

With an increased usage of handheld devices, the demand for pervasive and ubiquitous information has skyrocketed. But, how can a system provide users access to additional information without requiring excessive levels or prolonged periods of users' attention. This common problem was solved by the introduction of *notification systems*. Notifications are a type of information alerts that informs the user of

an event or update [1]. The notification system attempts to deliver current, important information to the users in an efficient and effective manner [16]. They provide rapid availability of important information, access to nearly instantaneous communication and heightened awareness of the availability of personal contacts. Commonly known notification systems include Instant Messaging (IM) tools, system load monitors or alerts [16], Facebook, Twitter and other social-media applications, video calling applications, e.g. Skype, antivirus information, application updates, etc.

Notifications are meant to improve synchronous access between remote parties, called the *initiator* and the *recipient* of the notification. In this regard, notifications are interesting events because they reveal that the timespace of any recipient is not owned and controlled in the same way as their workspace, but can collide and merge with that of an initiator unexpectedly. For instance, a user (who has opted in for Facebook notifications) can receive notifications regarding a Facebook status update while editing a document. Thus the recipient has little control over the receipt of the notification. By opting in for notifications from different applications, individuals share their timespace with others which leads to frequent distractions.

Even with its negative effects, notifications are intended to be a useful service by helping users maintains awareness of events. A recent study on notifications found that users are more likely to describe social interruptive notifications with positive words than negative words [17]. A follow-up study showed that users are likely to want similar future notifications if they described their notification experiences using positive words [1]. Both of the studies used an elicitation technique that aims to get an immediate reaction rather than a thought-out response. Thus a One-Word-Response (OWR) was captured by asking a direct question, viz. "Using one word, how would you describe the notification?" The OWR was coded based on *positive* or *negative* tone of the emotion. But there were *descriptive* words as well, which had no emotional tone to them and just described the experience. Further, from the experiment design it was evident that participants had to *recall* rather than *report* their experiences. Also, the study did not employ a baseline of participant's emotional state which makes it difficult to generalize the results. Considering these limitations and identifying emotion as an important factor in the notification experience we included in our study pre-defined affective terms to be rated on a Likert scale.

2.1.2 Model of interruption

The model of interruption provides justification for the existence of interruption and resumption lag.

The presence of interruption lag can be explained based on Miyata and Norman's [11] study. They have shown the presence of task (and/or subtask) boundary in a task hierarchy where the cognitive load is less. These boundaries represent opportune moments for interruption. During a task execution, a cycle of allocation/de-allocation of mental resources occurs. Thus when a user completes a task, the cognitive system releases the mental resources, momentarily reducing workload before the cycle of allocation/de-allocation occurs for the next task. Users often work until a natural breakpoint in a task sequence before attending to peripheral information. This explains the presence of interruption lag [3], [11].

An explanation for the presence of resumption lag is that this duration is needed to collect one's thoughts [10]. Resumption lag was further explained by Altmann and Trafton in a theory of "memory for goals" [18]. According to this theory, when a user initiates a new task goal, the goal must be strengthened in memory to the point where its activation rises above old goals, making it the primary task for focused-

attention. Based on an earlier goal memories decay theory, Altmann and Trafton concluded that if a primary task is interrupted, its corresponding goal will soon decay in the memory. Combining both theories, they concluded that the interrupted primary task goal that has fallen out of active use requires some time to regain its previous activation strength state, thus taking time to recall and resume.

FIGURE 2.1 [19] shows the stages of interruption and resumption along with task threads corresponding to each stage. Initially, during the performance of the primary task, the primary task is the only task thread. At the time when an alert interrupts the primary task, users initiate two distinct threads [20]. For instance, when an email interruption is presented, the user may finish the sentence being typed before checking the email. This provides another theoretical explanation of the presence of interruption lag. After completion of the interrupting task, the user recalls the primary-task problem representation during the resumption lag and finally resumes the primary task [19], [20].

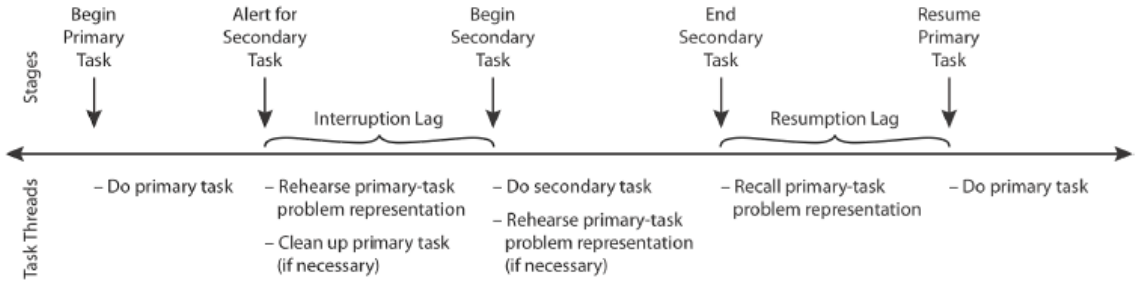


FIGURE 2.1: THE TIMELINE SHOWS THE STAGES OF INTERRUPTION AND RESUMPTION, AND THE TASK THREADS ASSOCIATED WITH EACH STAGE. [19]

2.1.3 GENERAL STUDIES ON INTERRUPTIONS

Most of the studies on interruption discuss the cost and modality of interruption. Few other studies attempt to understand the effects of interruption on long term memory. Furthermore, IM and Email interruptions have been studied the most while recent notification systems have been neglected. Below, we report these studies on interruption and critically discuss them.

Interruption is associated with negative affect, and increased error-rates. Bailey and Konstan [3] performed a controlled experiment with 50 participants to measure the effects of interruption on task completion time, error rate, annoyance, and anxiety. The experiment used a sample of primary and peripheral tasks representative of those often performed by users. Six categories of primary tasks, viz. addition, counting, image comprehension, reading comprehension, registration and selection, were used. The peripheral tasks, e.g. reading news feeds and a reasoning task, acted as interruptions for the primary task and were designed to last no longer than 20 seconds. Similar interruption experiments have been carried out earlier. But what makes this stand out from others is an attempt to measure both performance and affective dimensions by manipulating only the time at which peripheral tasks were displayed. This helped maintain a common task workload. Their results showed that when peripheral tasks interrupted the execution of primary tasks, users required from more time to complete the tasks, committed twice the number of errors across tasks, and experienced more annoyance and anxiety.

One of the critiques of the above study is the lack of ecological validity. The participants were forced to respond to the peripheral tasks as it appeared as modal windows that practically made it impossible to ignore and proceed with the primary task. The experiment did not represent the interruptions where salient visual and auditory cues are used to attract but not force user attention [3]. Though this might be difficult to achieve in a laboratory setting, we believe that it can be easily monitored in a diary study. Further, as the introduction of the peripheral task demanded immediate attention, interruption lag and interruption-handling strategies used by the participants were not accounted for. Similarly, the design of primary task prevented the measurement of resumption lag as it did not support any cues.

Interruptions have also been reported to cause memory loss. Antti and Pertti [7] performed three experiments to determine the disruptive role of interrupting messages on long-term working memory. The results showed that attending to interrupting message decreased memory accuracy. Also interrupting message was shown to be most disturbing when it was semantically very close to the main task. The hypothesis is based on a theory of long-term working memory and the authors argued that interrupting messages can both disrupt the active semantic encoding of content and cause semantic interference upon retrieval. But, similar to [3], interruptions were considered to be a discrete event during which attention is abruptly redirected to process information that is irrelevant to the on-going main task. Participants had to respond to the interruption and hence the 'continuity' of processing the main task was broken. In an ecologically valid scenario, the decision of shifting attention to another task is determined by various factors which are difficult to include in a laboratory setting. For instance, experiment results show that users who are skilled at the primary task have comparatively less memory loss than other users even when interrupted [7].

Most of the studies on interruptions in the digital space are targeted at Instant Messages (IM) and Emails. In an attempt to measure the interruption cost and its effect on memory caused by IM, Cutrell, Czerwinski and Horvitz performed a study with 16 participants from a wide age group. All of them had sufficient knowledge of chat and instant messaging system and reported having used it before. The findings of this study replicated the works of their previous research [11], [21]. It addition, they concluded that two tasks, particularly, list evaluation and search, are sensitive to interruptions coming early during these activities and can lead to user forgetting the primary goals [22]. One of the design implications of this study would be to delay the transmission of notifications in situations where a user may have just initiated a new task. To assist participants with the tasks after being interrupted, a marker in the form of a reminder button was provided. The button would point to the location where the user was before attending to the interruption (in this case IM). Though the authors did not provide any rationale behind the choice of these markers, the study showed that users were optimistic about the markers and used them often, especially earlier in the task cycle when they were interrupted.

Being connected to Information and Communications Technologies (ICTs) or in other words 'internet' enables people to stay continually updated and connected with others. Though research shows that continual connectivity enhances negotiation capabilities of management by prioritizing tasks and information; it has led to an overall loss in control [23]. Further, data reported in [23] shows that 70% of emails were attended to within six seconds of arriving. But email may not be distracting if the person quickly returned to his/her interrupted task; however, it took an average of 64 seconds to resume an interrupted task. Hence the researchers conducted an empirical study to investigate further implications

of attending to huge volumes of email. During the study, they cut off email usage for five workdays for 13 information workers in an organization. An ethnography approach along with quantitative measures such as computer log data was employed to compare two conditions – normal email usage and the experimental condition of email cut-off. The results clearly showed the benefits of not being continually connected with emails. On an average, without email, people multitasked less (lower frequency of shifting between tasks) and had a longer task focus. Also the measured stress (used heart rate monitors) was lower without emails. One of the limitations of the study, as reported by the authors, was the unintentional bias towards the selection of the participants, who might have had 'concerning' attitudes toward their email workload and multitasking in the workplace [23]. In this study, a restricted definition of interruption was used which made it difficult to conclude the effects of general notifications on everyday tasks.

Office workers often interleave multiple tasks. Although this switch among tasks is in a self-guided manner, significant portion of task switching is caused by external interruptions. In order to understand the characterisation of office workers' multitasking behaviours and the effect of interruptions on task switching, Czerwinski, Horvitz, and Wilhite [24] performed a week-long (only working days were included) diary study on 11 information workers whose occupation spanned a spectrum of domains. Microsoft Excel XP™ spreadsheets were used to collect the data. Columns were created for the dependent variables, some of which included 'Time of Task Start', 'Difficulty Switching to the Task', and 'Number of Interruptions Experienced'. The researchers were careful not to instruct the participants about what they should consider tasks to be. This helped in understanding the granularity of the tasks at which 'switches' occur. Interestingly, Email was considered a task that had to be dealt with repeatedly throughout the day. The authors found that nearly 40% of the task switches were self-initiated and 19% of the task switches included moving on to a new task that was on a to-do list. Telephone calls prompted 14% of the reported task switches, while meetings and appointment reminders accounted for only 10%. This study successfully reveals the type and complexity of activities performed, the nature of the interruptions experienced, and the difficulty of shifting among numerous tasks among office workers.

Though rich information was produced from the above diary study, there was no clear indication of 'what constitutes an interruption'. The definition was open to interpretation by the participants which indicates that the study tried to encompass all forms of interruptions; external and internal. This led to a very coarse granularity of interruption categories (e.g. new tasks on to-do list, telephones, etc.). The study captured different tasks but failed to identify the source of interruptions in any of the cases. For instance, participants had reported switching to a task that was on their to-do list. Though this information was captured in the spreadsheets, the event that led to this task switch was ignored. Thus there was insufficient data to comment on the effects of interruptions on tasks. It can be argued that this type of fine grained analysis and data collection would require more effort from the participants and would be costly. Furthermore a diary study may be the right tool for this purpose. But we believe that with the right measurement tools, the benefits of discovering the source of interruptions can outweigh the above limitations.

Interruptions, being common in workplace have been studied for long. In the mid-1990s, O'Conaill and Frohlich [25], conducted an observational study of workplace communication. Two office workers were shadowed with a video camera for an entire working week. Contrary to the belief that interruptions are a

nuisance for the recipient, the results showed over 20% of the recipients were solely benefitted from the interruption. Over 40% of the cases were found where both the initiator of the interruption and its recipient was benefitted. However, in just over 40% of interruptions the recipients did not resume the work they were doing prior to the interruption. It can be assumed that the return to the primary task was affected because some component of the task or surrounding context had been forgotten[7], [24] , or because it became too difficult in some way to resume given the competing demands of the distraction caused by the interruption.

2.1.4 SUMMARY

The discussion in this section has provided sufficient information on the disruptive nature of interruption. The studies have mainly targeted students and office workers. From all the studies discussed so far, it is evident that the participants or in general the recipients of the interruption had very little or no control on avoiding being interrupted. Beyond doubt, the studies provide a clear insight into the world of interruption. But, at the same time they fail to address the common issue where the recipient is at freedom to decide if he/she wants to be interrupted by the interruption; i.e. by choosing to attend to the interrupting stimuli or ignoring it. Hence given an option to control the task-switch during interruption (in our case incoming notifications), the recipient is expected to devote less time to multitasking, in turn reap the benefits of undivided attention. This requires some amount of self-control on the part of the recipient, or put differently required the use of self-regulating strategies. We discuss them in the next section.

2.2 SELF-REGULATION STRATEGIES

Self-regulation is defined as the sum of regulatory functions (thought, affect, behaviour, or attention) that help individuals to guide their intentional goal-directed activities over time and contexts [26, pp. 25 footnote 1]. In an academic environment, students may exercise control over the regulatory functions thus modulating their behaviour to achieve goals. This approach is termed as self-regulation strategies (SRS). A study on IM use [8], found three key SRS – ignoring interrupting stimuli (e.g. incoming messages), denying access (e.g. changing IM availability options to busy, invisible, etc.), and digital or physical removal (logging off the application or staying physically away from computer system). Apart from these, the study also found two different approaches to self-regulation – the preventive approach and the recuperative approach. The preventive approach consisted of creating routines and practices around IM use that would help regulation, and the recuperative approach consisted of changing behaviours after overuse had occurred.

Experiment by Wang et al. [27], shows that shift between primary tasks and peripheral media related tasks is driven by cognitive needs at that moment rather than emotional needs. But this media multitasking does not satisfy the cognitive needs and it is the emotional gratifications which are obtained despite not being actively sought after. This helps explain why users of digital media increasingly multitask at the expense of learning [27], [28]. Studies by Cades et al. [29], [30], indicate the presence of a learning curve and practice effect with time where users get better at dealing with interruptions (facilitates resumption). But this effect is limited to a specific primary and interrupting task pair, and not practice with interruptions in general.

Controlling the usage of notifications is a self-regulating strategy (SRS). As explained, self-regulation refers to those processes, internal and/or transactional, that enable an individual to guide his/her goal-directed activities over time and across changing circumstances (contexts) [26]. SRS could be particularly relevant in the context of daily notifications use and productivity, because evidence shows that interruptions at certain points in a task have little effect on performance [31], whereas the contents of the interruptions and their introduction at other times can significantly shift the focus of attention away from efficient task completion causing disruption [8], [11], [31]. Therefore, the use of strategies to regulate one's use of notifications and to time them appropriately will play an important role in maintaining a desired level of productivity.

In the above context of notifications and SRS, IM is a major source of interruption and demands self-regulations from the user as its nature makes it difficult to ignore incoming messages. The social norms of IM require users to respond quickly, even when responding might not be convenient, because the sender knows that the recipient is online and potentially available for communication. Generally, IM windows pop up automatically, notifying the user of the event and capturing attention, and creating an urge to reply. This disruptive nature of IM has been extensively studied by researchers and results have shown that the relevance (content) and timing of interruption (when to receive the messages) significantly affects the productivity of the primary task [31]. For instance, when users were interrupted with an IM at the beginning of the task, they were faster at disengaging from the primary task and switching to the IM than when interrupted at other temporal positions. Other studies have generalized the distraction caused by IM based on multitasking [8]. Participants from previous studies have reported multitasking while using IM—for example, doing homework while indulged in IM with friends [8]. This distraction caused by multitasking is subjective and largely dependent on the content of the IM.

Similar to IM, Social Networking Sites such as Facebook and Twitter, also generate notifications. The criteria for generating notifications is governed by the various features of Facebook which primarily including tagging of photos, new comments, status updates, sharing of links, and other notices. A study on task-switching showed that participants averaged less than six minutes on the primary task prior to switching [28]. The switching was most often initiated by interruptions due to technological distractions including social media updates (e.g. Facebook) and texting. They further found that even a positive attitude toward technology did not affect being on-task. But participants with strategies on handling interruptions were more likely to stay on-task than others. This study was performed with middle school, high school and university students and focused on only one aspect, i.e. studying. The students were observed in their home-study environment for only 15 minutes, which is a very short period to evaluate any strategies. As 'studying' was the primary and the only task, the strategies used by the students do not reflect the true interruption-handling strategies but rather focuses more on the learning strategies. Further, as it was an observational study, the presence of the observer might have influenced the participants' behaviour making them more vigilant and in turn inflating the time on the primary task before switching to a peripheral task. It was also assumed during the study that the social communications received via messages and Facebook updates were unrelated to the primary task which might not have been true in all the cases. Keeping aside the limitations, the study proposes that students should be provided short 'technology breaks' to reduce distractions. In our study we have tried to find out the importance of these self-initiated 'technology breaks' in everyday life by asking participants to turn-off their notifications for a week.

Survey research and laboratory based studies have shown that an increase in media multitasking (facebook and instant messaging in particular) leads to lower grade point averages in schools, colleges and universities [9], [32], [33], [34], [35]. In contrast, preliminary results in a study by Shah et al. [36] showed that rich use of Facebook enhances the academic performance. Also an extensive presence on Facebook helps develop the student's social capital in terms of number and quality of connections, relationships and interactions. Similarly, in another study involving Tunisian students [37], the researcher found no significant relationship between multitasking involving facebook usage and academic performance. This dilemma of multitasking and their effect (both adverse and beneficial) on academic performance was partially resolved in a study by Rouis et al.[38]. The study shows the role of personality traits of students involved in multitasking and their grade points. Not only does it corroborate the results that multitasking is disruptive for learning but also conclude that college students involved in multitasking with extroverted personalities show poorer academic performance than those with introverted personalities. The introverted individuals moderated their level of self-regulation to achieve this. Also the psychological attitude of students towards their university helps them regulate their multitasking, and they subsequently choose to make it a beneficial leisure activity [37].

2.2.1 SUMMARY

The studies discussed in this section showed the importance of interruption-handling strategies in everyday life. The target population under study was mostly students.

Having discussed the underlying theory behind interruptions and their handling strategies, we now turn our focus onto a domain that is entirely devoid of interruptions. This domain deals with a state of undivided attention, and where there is little or no distinction between self and environment, and between stimuli or response. This state is overly sensitive to external interruptions. Even internal interruptions, such as a question flashing through a person's mind, "What am I doing here?", or "Should I be doing this?", interrupts this state [5, pp. 38]. This peculiar dynamic state is referred as *flow,* and we discuss it in the next section.

2.3 FLOW

It might be surprising that certain people give up material pleasures such as money, power, and prestige, for the subtle experience of performing enjoyable acts – an immersive enjoyable experience which is typical of play. A typical category of these people are 'artists'. Their process of physical involvement in their acts is so enjoyable that they are often ready to sacrifice a great deal for the chance of continuing to do so. Their activity implied the importance of intrinsic motivation. It was this peculiar observation that intrigued Mihaly Csikszentmihalyi and he searched for an answer to 'what is this experience in performing the activity that makes one forget boredom and start enjoying it?' He later went on to discover what he termed as '*flow*' experience. He describes it as the autotelic experience that is poised between boredom and anxiety, a holistic sensation that people feel when they act with total involvement [5, pp. 36].

One of the primary elements of flow is the *merging of action and awareness*. When awareness is split by perceiving activities from outside, flow is interrupted. Interruptions as subtle as questions that flash through a person's mind, such as, "Am I doing well?", "Should I be doing this?" can cause a breach in awareness in turn disrupting flow [5, pp. 38-39]. A second characteristic of flow is the *centering of*

attention on a limited stimulus field. In other words, it is the narrowing of consciousness, and any intruding stimuli must be kept out of attention [5, pp. 40].The other characteristics of flow experience include loss of *self-consciousness*, *control over action and environment*, and *clear and unambiguous feedback to one's actions*. It must be noted that a person in flow does not necessarily stop to evaluate the feedback, as the action-reaction pair is well practised to be automatic. A final characteristic of flow is its *autotelic* nature, i.e., it appears to need no goals or rewards external to itself.

Though the flow experiences were well defined, the requirements of the activity which induced flow experiences were not. Csikszentmihalyi found that a flow state can occur when both *challenges* of the activity and *skills* of the user are high, medium, and low. In all these cases, there is an equivalent ratio of perceived challenges from the activity to perceived skills in carrying out the activity. The basis of the model lies in the identification of flow as congruent skills and challenges, both high and low. He formally represented this using a flow model.

Csikszentmihalyi's definition focuses upon the congruence of a person's skills in a given activity, and their perceptions of the challenges of the activity. The person's evaluation of the skills and challenges is typically thought of relative to other activities the person performs, rather than on an absolute scale. Though the earlier definition of flow considered low skills and low challenge to be a flow experience, empirical studies showed otherwise. The modified definition states that there is a critical value that skills and challenges must be above to induce flow. Thus, it is not simply the fact that skills and challenges are congruent, they must also be high. A tabular summary of 16 different definitions of the term 'flow' can be found in [39, Table 1].

2.3.1 Measurement and conceptualization of flow

The definition of flow has changed very little since Csikszentmihalyi's original formulation in 1975. Although there is a strong agreement among researchers on the definition, the same cannot be said about its methods of measurement. Though there is no gold standard for flow measurement, the main methods being used today include the Flow Questionnaire (FQ), the Experience Sampling Method (ESM), and the standardized scales of the componential approach [40], [41]. This rest of the section explains two of the above methods – the FQ and the ESM. Their underlying conceptualization, and their strengths and limitations have also been discussed. The findings from this chapter suggest that none of these three main measurement methods is overall superior to the others. Each one has pros and cons and the choice of one over the other would depend on the context the researcher is interested in. While the FQ is suited for measuring flow in special endeavours, the ESM captures flow in daily experiences, and the componential approach is used when flow is treated as a multidimensional state-trait variable and administering ESM is not feasible [42].

2.3.2 The Flow Questionnaire: Capturing Flow in Special Endeavours

Csikszentmihalyi [5], conducted a wide range of interviews with participants from varied occupational backgrounds. These interviews generated a lot of textual descriptions of the flow experience in various domains of human endeavour. From these the most clear and perceptive descriptors of flow were then selected and optimized to create the first flow measurement method; the Flow Questionnaire(FQ) [42], [43]. The FQ proposes definitions of flow and asks respondents to recognize them, describe the situations

and activities in which they experience flow, and rate their subjective experience when they are engaged in flow-conducive activities.

FIGURE 2.2 shows the first 3 key sections of the FQ [42]. Section 1 provides three quotations that vividly describe the flow experience. Participants are asked to read each of the three quotations and then indicate in Section 2 if they ever experienced something similar. This requires just a yes/no answer and hence allows classifying participants into flow-ers (i.e., those who experienced flow in their lives) and non-flow-ers (i.e., those who did not experience flow in their lives). The rest of the sections in the FQ are directed only to flow-ers. Section 3 uses an open-ended question to ask them to freely list their flow-conducive activities. Section 4 (not included in FIGURE 2.2) asks participants who reported two or more flow-conducive activities to select one activity that best represents the experience described in the quotations, i.e., the best flow-conducive activity. Section 5 (not included in FIGURE 2.2) asks flow-ers to rate their subjective experience when they were engaged in the best flow-conducive activity using Likert scales. The primary variables of flow theory, "challenges of the activity" and "your skills in the activity" are measured. Expressions that had emerged from previous interviews, such as "I get involved" and "I enjoy the experience and the use of my skills", are also used in the Likert scales. The FQ responses were analysed using an early three channel flow model.

The Early Three Channel Model:

The first graphical model of the flow state was represented by Csikszentmihalyi in 1975 [5]. The FQ was the first to approach the empirical study of flow as represented by this three channel model. The model partitions the world of experience in three main states—flow, anxiety, and boredom. These are represented as non-overlapping areas of a challenge by skill Cartesian space. The basis of the model lies in the identification of flow as congruent skills and challenges, both high and low. Thus a flow state can occur when both challenges and skills are high, when both are medium, and when both are low. In all these cases, there is an equivalent ratio of perceived challenges from the activity to perceived skills in carrying out the activity. Similarly, the anxiety state occurs when the perceived challenges from the activity exceed the perceived skills in carrying out the activity, while the boredom state occurs when the perceived skills in carrying out the activity exceed the perceived challenges from the activity [42]. FIGURE 2.3 shows a graphical representation of this model. The arrows within FIGURE 2.3 map a sample pathway that an individual might take during a flow-conducive activity.

Strengths and Weaknesses:

The strengths and weaknesses of the FQ are determined with respect to the three channel model. The following section lists three main strengths and weaknesses of the FQ.

First, the FQ can be used to estimate the prevalence of flow, i.e., the percentage of people in specific populations that experience flow in their lives. This allows studying differences in prevalence across age groups, occupations, gender or cultures. The prevalence property of FQ is based on the fact that it provides an unambiguous and clear definition of flow. The diagonal region is well defined and has a single interpretation. The quotations used in the FQ (FIGURE 2.2) explicitly capture action and awareness, (e.g., "I don't see myself as separate from what I am doing"), centring of attention (e.g., "my concentration is like breathing I never think of it"), loss of self-consciousness (e.g., "I am less aware of myself and my

problems"), and implicitly autotelic nature, and feeling of control [42]. In brief, it captures all of the flow constructs.

Second, unlike other approaches (the ESM and the componential approach), the FQ does not "impose" flow onto participants. For instance, non-flow-ers (participants who did not recognize the proposed flow quotations) could obtain an artificial flow score simply because they indicated some level of concentration or absorption— which per se do not signify flow when engaged in the target activity. But as FQ differentiates between flow-ers and non-flow-ers, it does not inflate the prevalence rates. Therefore, FQ is a preferred as a more valid method for measuring the prevalence of flow [42].

1. Please read the following quotes:

   My mind isn't wandering. I am not thinking of something else. I am totally involved in what I am doing. My body feels good. I don't seem to hear anything. The world seems to be cut off from me. I am less aware of myself and my problems.

   My concentration is like breathing, I never think of it. When I start, I really do shut out the world. I am really quite oblivious to my surroundings after I really get going. I think that the phone could ring, and the doorbell could ring or the house burn down or something like that.

   I am so involved in what I am doing. I don't see myself as separate from what I am doing.
2. Have you ever felt similar experiences?
3. If yes, what activities were you engaged in when you had such experiences?

FIGURE 2.2: KEY SECTIONS (PARTIAL) OF A FLOW QUESTIONNAIRE [42]

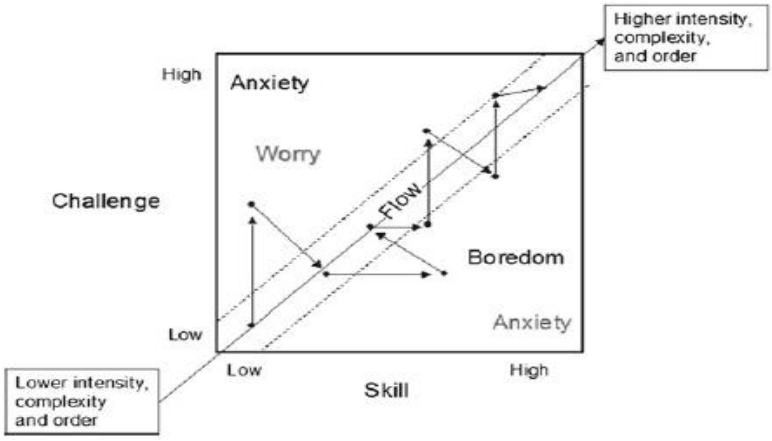


FIGURE 2.3: THE EARLY THREE CHANNEL MODEL

Finally, FQ asks flow-ers to rate their subjective experiences, and perceived challenges and skills when they were engaged in a flow-conducive activity. This creates an excellent environment to test whether flow occurs when challenges and skills are in equivalent ratios and if subjective experience is more positive in the flow state than in the anxiety and boredom states.

With its well established strengths it becomes difficult to construe any weakness in the FQ. But a closer examination reveals the pitfalls. First, the flow quotations do not necessarily constitute a single description of the flow state. For instance, these quotations have been divided into two separate sections, viz. one designed to measure a *shallower* flow and the other a *deeper* flow [42]. They differ from each other in that they emphasize the condition of isolation from the environment that is central to the construct of flow. FIGURE 2.4 shows examples of the two different quotations. Results reported in [42] shows that both deep-flow and shallow-flow are distinct phenomena with the former being less prevalent due to stronger sense of isolation from the environment. Thus, mixing the shallow and deep flow quotations creates uncertainty as to exactly what the participant experiences.

Second, the FQ does not provide any straightforward assessment of how the perceived challenges of the activity and the perceived skills in the activity influence the occurrence of the flow state [42]. The average rating captured by the FQ is open to the risk of being affected by the frequency with which flow, anxiety and boredom – each defined by challenge to skill ratio – is experienced during the activity. Hence it is not a preferred tool for testing the core constructs of flow.

Finally, another pitfall of the FQ, though considered to be minor, is that it fails to measure the intensity of flow in flow-conducive activities. As reported earlier, people experience flow only a percentage of time when they perform flow-conducive activities. Anxiety and boredom also constitute a part of this experience. Hence, although the FQ contains scales to measure flow, it does not allow a direct measurement of the intensity of flow in that activity itself.

Shallow Flow

"My mind isn't wandering. I am totally involved in what I am doing. I am not thinking of something else. My body feels good. I don't seem to hear anything. The world seems to be cut off from me. I am less aware of myself and my problems."

"My concentration is like breathing, I never think of it. When I start, I really do shut out the world."

"I am so involved in what I am doing. I don't see myself as separate from what I am doing."

Deep Flow

"I am really quite oblivious to my surroundings after I really get going."

"I think that the phone could ring, and the doorbell could ring or the house burn down or something like that."

FIGURE 2.4: QUOTES CORRESPONDING TO SHALLOW AND DEEP FLOW EXPERIENCES

2.3.3 EXPERIENCE SAMPLING METHOD: CAPTURING FLOW IN DAILY EXPERIENCES

In the early 1970s Mihaly Csikszentmihalyi, with the original intent of measuring flow asked participants to write down their daily experiences and their most enjoyable moments into diaries. But the dairy study generated dry and generalized themes as people summarized the events of their day without much discrimination. Later, in 1977, to overcome the pitfalls of the diary study, the Experience Sampling Method (ESM) was created [44, pp. 6-8]. With the introduction of ESM, the empirical test of flow theory in respect to everyday life experience became possible [45]. ESM proved to be a means for collecting information about both the context and content of the daily life of individuals, and an opportunity to examine fluctuations in their stream of consciousness. In other word, it is designed to infer the time-budget (i.e., the sequence and times in which individuals are in specific states) in everyday life and the associated variation of subjective experience [42]. The ESM also has a strong ecological validity as the participants respond to the questionnaire in their natural environments.

The ESM consists of administering a questionnaire to a sample of participants repeatedly over random time intervals during their daily activities. Participants carry on them a pager that randomly generates electronic signals to which they respond by filling an ESM form. The original form of the ESM [45] called the Experience Sampling Form (ESF) contains 13 categorical items and 29 scaled items. The categorical items serve to reconstruct the activity (main activity, concurrent activities, and content of thought), the context (date, time beeped, time filled out, place, companionship, and influential facts which have occurred since the last pager signal), and some aspects related to motivation and interest. These categorical items are mostly open-ended and have to be coded by the researcher after collecting the data. The scaled items are designed to measure the intensity of a range of subjective feelings. They are based on the conditions required for flow and experience during flow. Of the 29 items, 16 are 10-point scales coded from zero (0= not at all or low) to nine (9= very or high). They measure the following variables: concentration, difficulty in concentrating, feeling good, feeling self-conscious, feeling in control, living up to one's expectations, living up to the expectations of others, physical discomfort, *challenges* from the activity, *skills* in the activity, importance of the activity to oneself, importance of the activity to others, importance of the activity to one's overall goals, success in the activity, wish to be doing something different, and satisfaction. The remaining 13 scaled variables are Likert scales which contains the mood variables. The positive (and negative) poles of these variables are alert (drowsy), happy (sad), cheerful (irritable), strong (weak), active (passive), sociable (lonely), proud (ashamed), involved (detached), excited (bored), open (closed), clear (confused), relaxed (tense), and cooperative (competitive). The ESF used in this study borrows its contents largely from the original ESF [45], but has been modified to suit the purpose of the study. The design of the modified ESF that is used in this study is explained later under the Problem Analysis (section 3).

The ESM produces multiple assessments of a single individual. This allows for the observation of within-person changes in subjective experience across many contexts of life. The data set created is uniquely identified by the combination of an ID number, the date (day, month and year) and the time of the signal. Such files are referred to as response-level or beep-level data files; as they are a collection of moments in time in the lives of several individuals. The sheer volume of the response-level data set can be overwhelming. On the other hand demographic information (e.g. gender, age, ethnicity, or annual income) are not likely to change at all over the period of the study, and thus do not need to be asked each time a person is signalled. These are called person-level data and can be matched to the response-level data set

using the participant's ID number. Quite often the response-level ESM data are aggregated to the level of the person. Thus a data set would now represent a person-level data rather than at a response-level. In this aggregated file only variables that can be meaningfully consolidated (by mean, sum, percentage) are retained; the context-specific information from the response-level data is lost.

As explained earlier, the three channel model had its pitfalls, which needed to be overcome. Hence, a quadrant model of flow was introduced. Later this model was extended to represent an octant model.

The Quadrant Model:

Though the three channel model had a theoretical root, empirical studies with ESM showed the presence of another channel. The empirical evidence suggested that the low challenge/low skill activities are opposite to flow activities, and that a four channel model is more appropriate than the three channel model. The new model partitions the world of experience into four main states, viz. flow, anxiety, boredom, and apathy. These are represented as quadrants of a challenge by skill Cartesian space in which both axes variables are standardised (using Z-scores), with the zero value representing the weekly mean. The original claim from the three channel model (FIGURE 2.3) that flow occurs when challenges and skills are in equivalent ratios independent of their level of intensity was discarded in favour of a more complex representation, i.e. the *quadrant model* or the four channel model. Thus, a fourth quadrant termed 'apathy' was introduced which is posited to be the least positive of the four states. Therefore, in the new model, flow is defined as high skills and high challenges, and apathy as low skills and low challenges [39]; and in order to achieve flow two conditions need to be satisfied, viz. (a) a balance between challenge and skills, and (b) both challenges and skills are greater than the individual's weekly average [42]. FIGURE 2.5 represents the four quadrants of the quadrant model.

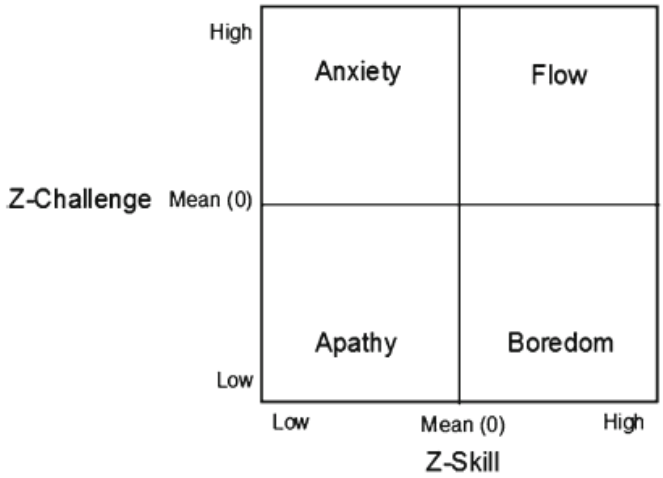


FIGURE 2.5: THE QUADRANT MODEL OF FLOW

The Experience Fluctuation Model or The Octant Model:

The Experience Fluctuation Model, also known as the octant model was proposed by Massimini and colleagues [46]. It was an attempt to provide a more accurate and realistic classification system for flow measurement. As the name suggests, the model partitions the world of experience into eight main states

that are represented as arc sectors ("channels") of 45° each of a challenge by skill Cartesian space in which both axis variables are standardized (using Z-scores), with the 0 value representing the weekly mean. The octant model, similar to the quadrant model, represents flow as a state where perceived challenge and skill are greater than the weekly average. But, in contrast to the quadrant model, it provides a narrower operationalization of the construct of challenge/skill balance and a better detailed characterization of non-flow states.

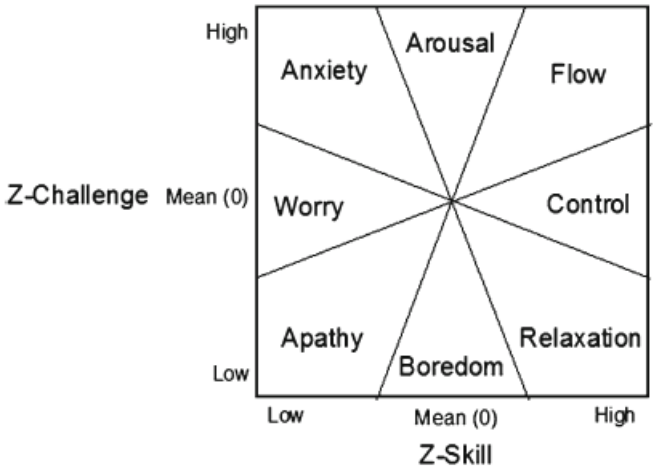


FIGURE 2.6: THE EXPERIENCE FLUCTUATION MODEL OR THE OCTANT MODEL OF FLOW

Strengths and Weaknesses:

The strengths and weaknesses of the ESM are determined independently as well as in respect to the above two model, i.e. the quadrant model and the experience fluctuation model.

The ESM is a more complex measurement method than typical standardized questionnaires that are administered on a single occasion. This has its own benefits and pitfalls. On the positive side, the ESM collects a rich set of response-level and person-level data allowing investigation of a wider range of phenomena. On the negative side, the data collected using the ESM are prone to biases from the individuals that need to be carefully controlled for in the statistical analysis [42]. This problem was addressed by Csikszentmihalyi and Larson using individual standardization. Standardization was done using z -scores in lieu of raw scores which removes individual differences in scaling under the assumption that participants experienced the same overall level of challenge throughout the week of the study [45].

The very design of ESM allows participants of defer filling out an ESF after receiving a signal or not to fill it out at all if the activity they are engaged in at the time of signal does not allow it. This creates a bias in the total number of response-level data points collected from the participants. But it can be overcome by aggregating suitable variables (person-level data set).

Strengths and Weaknesses of the Quadrant model: The strength of the quadrant model lies in its simple classification system as it allows performing simple tests of the core predictions made by flow theory [42], [44]. As an oversimplification it can be said that the subjective experiences are the dependent variable, while the researchers can have different independent variables that suits their purpose. The

quadrant model is sometimes considered to be too optimistic and its estimates may not always concur to that derived from the FQ. It is also an approximate classification system that includes medium-challenge/high-skill and high-challenge/medium-skill points under flow conditions.

Strengths and Weaknesses of the Experience Fluctuation model (Octant Model): The main strengths of the octant model lies in its rich and robust empirical findings. Results from the studies undertaken by the researchers in Milan [44, pp. 142] [46] support the hypothesis that in the situations defined as high-challenge/high-skill, the quality of subjective experience is significantly better than average. Furthermore, each time the values of the subjective experiences did not fall in the high-challenge/high-skill category, it fell in an adjacent sector that was well defined theoretically [42]. But the octant model shares the same weaknesses as that of the quadrant model. Both are classification systems, and hence they do not allow testing the implicit assumptions underlying the classification itself [42].

2.3.4 SUMMARY

This section on flow has shown that since the inception of the flow theory, two main methods for measuring flow, viz., the FQ and ESM are the most popular and frequently used. Each of these methods is used in conjunction with one or more models which are interpretations and simplifications of the flow theory. The methods have their own benefits and pitfalls. Overall, while the FQ proved to be an excellent measurement tool for calculating the prevalence of flow in a sample population for a specific endeavour, the ESM turned out to be superior to the FQ for testing hypotheses concerning the effects that challenge, skill, and their balance have on flow. Drawing from these conclusions and carefully weighing the pros and cons, the Experience Sampling Method (ESM) was chosen for the investigation of flow for the purpose of this study.

2.4 SUMMARY

We have discussed with criticism three different yet interlinked phenomena, which have merged to form the core theme of our study – effects of notifications on flow experiences and common notification-handling strategies. During the discussion we identified few gaps in the literature. Though interruption and flow have been studied for a long time, to the best of our knowledge they have never been studied together in a naturalistic setting. Strategies referred in the literature have only been considered for students. Furthermore, emails and IM have gathered too much attention, while notification – the source of interruption in the present age, has not been studied in the context of interruption in everyday life.

We take into account all the above issues and intend to address them in our study. The section on Problem Analysis explains our approach to address these issues.

3 PROBLEM ANALYSIS

Based on the literature review, we had identified key gaps which had not been answered. They were:

- Role and impacts of notifications on everyday flow activity and flow experiences. This included,
  - Affect
  - State-anxiety
  - Overall satisfaction-with-life
- Common strategies used to manage notifications in everyday life

From the above we derived precise research questions that would be the goal of our study. The research questions were as follows;

- **RQ1:** Is the daily flow experience being affected by the presence of notifications?
- **RQ2:** Is there an increase in state-anxiety due to the presence of notifications?
- **RQ3:** Does the prolonged use of notifications affect subjective well-being?
- **RQ4:** Do people use strategies to handle notifications in their everyday life?

Deriving from the literature study, our hypothesis for the above research questions RQ1, RQ2, and RQ3 were as follows;

- **H1:** It is predicted that there will be an increase in the percentage-of-time in flow in the absence of notifications condition.
  - **H1.1:** It is predicted that there will be an increase in Enjoyment in activity in the absence of notifications condition.
  - **H1.2:** It is predicted that there will be an increase in Concentration in activity in the absence of notifications condition.
  - **H1.3:** It is predicted that there will be an increase in positive Affect in the absence of notifications condition.
  - **H1.4:** It is predicted that there will be a decrease in Potency in the absence of notifications condition.
- **H2:** It is predicted that there will be a decrease in State-anxiety in the absence of notifications condition.
- **H3:** It is predicted that there will be an increase in Satisfaction-with-life in the absence of notifications condition

In order to answer the above research questions, we performed a problem analysis of the techniques to be used in the study.

3.1 DESIGN

Experience Sampling Method (ESM) was the preferred method for this study as it is inherently designed to capture individuals' representation of experience as it occurs, within the context of everyday life (section 2.3.3). According to the hypotheses of this study, the dimensions of experience were likely to fluctuate over the course of the experiment as they are context-dependent. We used standardization to overcome this issue. As we were interested in within individual changes under different experimental

conditions, we decided that the experiment should be a within-participants design with 3 conditions, each applicable for a different week. The 3 conditions were:

- Week1: This was the baseline condition. During this week participants were asked to lead their usual lives.
- Week2: This was the not-interrupted condition. During this week participants were asked to turning-off all the known notifications on their digital devices (smartphones, tablets, laptops, and/or desktop).
- Week3: This was the interrupted condition. During this week participants were free to turn-on any notification (as per their wishes).

After deciding the structure of the study, we dissected ESM to meet our study needs.

3.1.1 COMPUTERIZED VS. PAPER-AND-PENCIL METHOD

In some of the earliest ESM studies participants responded to the ESF in paper-and-pencil format [44, pp. 35] (pp.35). But paper-and-pencil format have few drawbacks when compared to computerised data entry method. One of the common drawbacks is that the participant is required to carry the ESFs around everywhere (mostly). Another drawback concerns getting the data into a useable electronic format by hand, introducing considerable cost, time delay, and risk of human error. Hence, with the advancement of technology researchers have eliminated these concerns and have started collecting data electronically using palmtop computers and Personal Data Assistants (PDAs). Another advantage of computerized data collection method is that it provides better control over the timing of participants' responses. In paper-and-pencil method, participants have been known to falsify information about the time when they responded to a signal. Computerized methods also allow for greater flexibility in item presentation order and have also been empirically found to have higher compliance rates [44, pp. 36-38]. Thus, we decided to have computerised ESF for our study.

3.1.2 SIGNALLING EQUIPMENT AND SCHEDULE

The success of ESM lies in signalling the participants when to respond to an ESF. The signalling equipment used in the 1980s was predominantly pagers that beeped or vibrated in response to a radio signal. Later, data bank watches were introduced which had the capacity to store several hundred pre-programmed signals and could be tailored to individual schedules. With the onset of PDAs the ESF data entry and signalling was considerably made easier and convenient [44, pp. 36-38]. Today, reminders and programmable smartphones are used to signal participants. For the purpose of our study we decided to use SMS texts to signal participants.

In ESM, three broad signalling schedules are used. Interval-contingent sampling refers to a signalling schedule where participants complete ESFs at the same time every day or at regular intervals. In event-contingent sampling participants are instructed to complete an ESF following a particular event of interest. The third category and the most commonly used scheduling method is the signal-contingent sampling. Here participants are signalled at random intervals of time over the course of the study [44, pp. 40]. Signal-contingent sampling was the preferred choice of signalling for the purpose of our study. The schedule was designed keeping in mind the length of the ESF. It was decided that 6 signals per day would

be sufficient for this study. Hence, we decided to send 6 SMS texts per day between 10am and 11pm over 3 weeks. Text-messages would occur at random times within 130-minute windows per day.

3.1.3 Design of Experience Sampling Form

Measuring Flow conditions and experience:

The design of the Experience Sampling Form (ESF) is based on the research goals of this study. A typical ESF captures both the external (date and time of the day, physical location, activities, and companions) and internal (thoughts and subjective feelings) dimensions of experience. The choice of ESF for measuring flow is largely inspired by the ESF provided in [45].

A standard set of questions was used to capture the external dimensions on our ESF. To minimize the efforts at the participants' end, questions for the date and time of the signal (when beeped) and the time they responded to the signal were dropped. This information would be easily available at our end as a computerised method was used for filling the ESF. The second component of interest was the participant's location, indicated by the question 'As you were beeped, where were you?' Again, to minimize any time loss in entering text for this question, three most commonly used coded categories were provided as multiple-choice options. They included 'Home', 'Office/Work', and 'Restaurant/Bar'. An 'Other' text box was also provided for participants' choice of location name. The third external dimension was the participant's primary activity, indicated by the question 'As you were beeped, what was the main activity you were doing?' As this was an open-ended question, three examples were provided to help the participant formulate the answer. The example were from previously used codes available in [44, Appendix B]. As mentioned earlier, multitasking is a common occurrence in this information age. Hence, our ESF had a question giving the participants an opportunity to report their peripheral activity. Common examples were provided for the same. The fourth and the final external component captured by the ESF is companionship. A check-list of possibilities such as 'Alone', 'Friends', 'Mother', 'Father', 'Sister/Brother', 'Spouse', 'Co-worker', 'Girl/Boyfriend', and 'Classmates/peers', was provided to record the answer for this question.

Along with the external dimensions, the ESF also contained a carefully chosen set of internal dimensions of experience that was tailored to capture the flow 'conditions' and 'experience' in our participants' daily life. As discussed earlier, flow is mostly operationalized using challenges and skills. They define the conditions in which flow experience is most likely to occur. Hence, two separate 10-point Likert-scale questions (ranging from low to high), viz., 'Challenges of the activity' and 'Your skills in the activity', was used to directly measure these variables.

It was also important to measure the flow experience separately from the flow conditions. Flow experience is typically operationalized as a continuum based on the sum of three variables, viz. 'Concentration', 'Enjoyment', and 'Interest' [44, pp. 96]. Along with 'Interest' which measures the cognitive experience, our questionnaire also included scales for the measurement of 'Excitement' for emotional experience and 'Motivation'. For instance, 10-point Likert-scale questions such as 'How well were you concentrating?', 'Do you wish you had been doing something else?', and 'Were you enjoying yourself with the activity?', respectively measure concentration, motivation and enjoyment. The other components of flow as per [41], which were measured in our study were, sense of control over one's actions (Were you in control of the situation?), loss of self-consciousness (How self-conscious were you?), loss of time

awareness or time acceleration (Were you completely aware of how fast the time was passing?), clear proximal goals (How important was this activity in relation to your overall goals?), unambiguous feedback (Were you successful at what you were doing?).

Two other aspects of flow experience are affect and potency. Positive affect was measured using three variables, 'Happy', 'Sociable', and 'Irritated' (reversed), on a 7-point Likert-scale ranging from 'not at all' to 'very much'. On the same Likert-scale, potency variables, viz., 'Alert', 'Passive' (reversed), 'Strong', and 'Excited', are also measured. It must be noted that the grouping of these composite variables have been found to be internally consistent from previous studies [44, pp. 117 Table 6.1], [45, Table2].

As the signals (SMS text in our case) are sent after random intervals of time, there are chances that rich information can be missed between two consecutive signals. Hence, an open ended question, i.e. 'If you felt a strong emotion since the last SMS, what did you feel and why did you feel that way?', was added to get a better sense of these 'missed' events. It can also provide an understanding of situations or emotional states that could have affected the way participants were experiencing the current situation. An example was provided that combined the 'feeling' and the 'reason' for the same in a single sentence. For instance, 'I felt happy and relieved because I completed my assignment in time.'

Measuring State-anxiety:

State anxiety was one of the factors that we assumed would be affected during the three-week study. Although anxiety is a by-product of the measurement of flow (anxiety is defined by high challenges and low skills), we preferred to use a specialized tool for its measurement. The Spielberger State-Trait Anxiety Inventory (STAI) is the most frequently used measures of anxiety in psychology research. But the major drawback of STAI is its length, being 40 items long (20 items for state anxiety and 20 items for trait anxiety). This posed a major barrier to its use in our ESF, which was being designed to be as concise and non-intrusive as possible; as our participants would be filling an ESF several times a day for three weeks. Also the full length STAI contains seemingly repetitive items which can pose a challenge to non-native English speaking participants. These problems were largely overcome by using a six-item short form of STAI (STAI-6) developed by Marteau and Bekker [47]. STAI-6 produces scores similar to those obtained using the full 20-item STAI (correlation, $r = .95$ and reliability coefficient, $\alpha = .82$). Hence, the STAI-6 anxiety measurement was added to the ESF. It contained six statements, viz. 'I feel calm', 'I feel upset', 'I feel content', 'I am tense', 'I am relaxed', and 'I am worried'; each to be marked on a 4-point Likert-scale containing values 'not at all', 'somewhat', 'moderately', and 'very much'. This made it possible to capture an individual's state-anxiety experience along with the anxiety conditions, viz. challenges and skills.

Lastly, we were interested in obtaining the number of times a participant was interrupted in the past 15 minutes. We had reasons to believe that this information would vary across the three conditions imposed each week for the three-week period. Hence a multiple choice question was targeted to collect this data. The ESF used in the study can be viewed in Appendix 2.7.

Having designed the ESF, it was now important for us to decide a flow model for our flow measurements. The next section discusses the choice of model and the measure technique.

3.2 MEASUREMENTS

The ESM was designed to reflect the parameters of experience during each week, through various levels of perceived challenges and skills. Theoretically, the ratio between these two variables serves as an indication of the presence of flow (as conditions of flow are defined by high-challenge and high-skill). But as reported earlier during the discussion of strengths and weaknesses of ESM (section 2.3.3), the data gathered exhibits potential source of bias that needs to be controlled for in data analysis. The scaling of the 'Challenge' and 'Skills' variables differs between participants due to individual differences in response to the scaled items. Some participants consistently describe their action opportunities as very high, whereas others rate them consistently low. This problem is addressed using standardization, i.e. for a given participant, a vector of raw scores of the variables 'Challenge' and 'Skills' across all the response-level data for the three-week period is converted into Z-scores[1]. The resulting vector is a value of z -score for that observation and represents the extent, measured in standard deviation units, to which that observation departs from the weekly mean of that variable for that participant. Using Z-scores makes it possible to compare how different individuals deviate from their own average set-point on the Challenge and Skills variable in different circumstances [44, pp. 10-11].

3.2.1 MEASUREMENTS OF FLOW CONDITIONS

The flow condition is theoretically defined as perceptions of challenge and skills that are above average. Hence, each participant's vector of raw scores of challenge and skill is individually standardized. These resultant scores (z-skills and z-challenges) is then divided into one of the four categories or 'quadrants' depending on whether challenges and skills are above the individual's average (i.e. have positive Z-scores) or not. This measurement is based on the Quadrant model of flow (FIGURE 2.5). The Quadrant model partitions the world of experience into four main states; flow, anxiety, apathy, and boredom. The mapping of these states onto the Cartesian plane is given below:

- positive z-skills and positive z-challenges (flow)
- negative z-skills and positive z-challenges (anxiety)
- negative z-skills and negative z-challenges (apathy)
- positive z-skills and negative z-challenges (boredom)

This Quadrant model has been used in several flow studies [44, pp. 94] [46]. It is evident from the discussion of this model that it treats flow as a relatively common experience accessible to all individuals. Hence, sometimes a more restrictive cut-off value of 0.5 instead of 0 for the Z-scored challenge and skill variables is chosen. But we did not opt for this and decided to have 0 as the cut-off.

Another narrower variation of the Quadrant model is the Experience Fluctuation Model (octant model) that divides the experience Cartesian space into 8 channels (FIGURE 2.6). The various combinations between the level of perceived challenges and skills are reported in terms of eight different ratios between the individuals' standardized challenge and skill scores:

- high challenges and average skills (arousal)

[1] A Z-Score is a statistical measurement of a score's relationship to the mean in a group of scores.

- high challenges and high skills (flow)
- average challenges and high skills (control)
- low challenges and high skills (boredom)
- low challenges and average skills (relaxation)
- low challenges and low skills (apathy)
- average challenges and low skills (worry)
- high challenges and low skills (anxiety)

The average challenges and average skills correspond to the point of origin of two Cartesian coordinates, with challenges on the ordinate and skills on the abscissa.

Based on the requirements of our study and the complexity of the two models we decided to use the quadrant model for our measurement of flow.

For instance, if a participant responds to 40 ESFs in a week and our calculation from his/her ESFs suggests 6 instances of flow experience, then the percentage-of-time in flow will be 15%. This percentage-of-time in flow data is used for inferential statistics to perform repeated-measures ANOVA.

3.2.2 Measurement of Flow Experience:

Along with the conditions of flow, we were also interested in measuring the flow experience. The primary targets were the flow constructs as defined by [41]. Based on the tailored design of our ESF, the individual questions were mapped onto their corresponding flow construct that they were supposed to capture. For instance, one of the flow components, 'focused concentration on the present activity (concentration)', was captured through the question 'How well were you concentrating?', which was answered on a 10-point Likert-scale. A weekly average of each variable for each participant is calculated to be used in data analysis..

As ESM generates momentary situational data, we were certain that the mood terms would easily tap into an individual's daily life experiences. Previous studies on flow [44], [46], [48], and ESM have successfully grouped these composite variables of mood based on factor analysis. For the purpose of this study 'Affect' comprising of the items 'Happy', 'Sociable', and 'Irritated (reversed)'; and 'Potency' comprising of 'Alert', 'Strong', 'Excited', and 'Passive (reversed)', is measured. The single variables such as 'Enjoyment', 'Concentration', and 'Control' are also measured.

3.2.3 Measurement of State-Anxiety

The state-anxiety is measured using the STAI-6 questions. Three of these variable ratings require reversal so that higher an individual's STAI-6 score, higher would be the state-anxiety. The average STAI-6 score for the response-level data for an individual is calculated by averaging the 6 variables (with 3 ratings reversed). Similar to the flow measurement strategy, the sum of the averages of the STAI-6 scores is calculated for a given week. This weekly STAI-6 score is later used for data analysis.

3.2.4 Design and measurement of satisfaction-with-life

The satisfaction with life scale was developed by ED Diener and colleagues in 1985 to measure the global life satisfaction [49]. The scale does not assess satisfaction with life domains such as health or finances but allows subjects to integrate and weight these domains in whatever way they choose. It uses 5 items to

calculate the overall score. They are, (i) "In most ways my life is close to ideal", (ii) "The conditions of my life are excellent", (iii) "I am satisfied with my life", (iv) "So far I have got the important things I want in life.", and (v) "If I could live my life over, I would change nothing". These items are rated on a 7-point Likert scale with values ranging from 1 ("1= strongly disagree" to "7= strongly agree"). Scores on the SWLS can be interpreted in terms of absolute as well as average life satisfaction. A score of 20 (or average score of 4) represents the neutral point on the scale, the point at which the respondent is about equally satisfied and dissatisfied. Scores between 21 and 25 represent slightly satisfied, and scores between 15 and 19 represent slightly dissatisfied with life. Scores between 26 and 30 represent satisfied, and scores from 5 to 9 are indicative of being extremely dissatisfied with life.

3.3 DESIGN OF END OF WEEK INTERVIEW QUESTIONS

The end of the week interview questions were mainly focused on collecting contextual information from participants for that week and their notification-handling strategies. The a priori themes of the interview questions are summarized in TABLE 3.1. The themes reflect our research goals and add rich contextual information and explanation of the observations from ESM.

Themes	Week1	Week2	Week3
Flow activities	✓	✓	✓
Flow interrupted	✓		✓
Flow experience	✓	✓	✓
Notification-handling strategies	✓	✓	✓
Resumption lag	✓	✓	✓
Perceived sense of accomplishment, anxiety, awareness	✓		✓
Goals	✓	✓	✓

TABLE 3.1: A PRIORI THEMES OF END OF WEEK INTERVIEWS

Interview questions were designed such as to reconstruct a past experience and its context that the participants would have had experienced during that week. For instance, "Please tell me about a recent situation where you were focused on an activity.", maps onto our Flow activities theme. Questions such as, "How did you feel when you were interrupted by the incoming notification?", "How did you respond to that notification? (Actions that you took)", "Did you feel frustrated or at-ease when you received the notification?", "Which application generated the notification?", "Can you tell me why you had the notification settings turned on for this application?", "If you ignored the notification, how did you feel? Why did you ignore? OR, you attended to the notification, how did you feel? Why did you attend to it?"; would help create a past experience.

The end of week interview forms for Week1, Week2, and Week3 are given in Appendix 2.3, 2.4, and 2.5 respectively.

We have successfully performed a problem analysis on the techniques of measurement of the dependent variables in our study. But, for the purpose of our study, it is important that we have a proper definition of the term 'Notification'. Previous studies have defined it as a type of alerts that informs the user of an event or an update [1] and they are mostly associated with either IM [8] or Emails [23]. This partial understanding of notifications can impact our study as we plan on having *all* notifications turned-off during our not-interrupted condition of Week2. Hence we performed an extensive research and created a vast repository of notifications. We have covered the major smartphones, tablets, laptops and desktop operating system platforms in our research. We provide a summary of our notification inventory in the next section.

3.4 NOTIFICATION INVENTORY

Notifications deliver current, important information to the users in an efficient and effective manner. They provide rapid access to nearly instantaneous communication and heightened awareness of the availability of personal contacts. This section attempts to cover the various notification types currently available across multiple platforms. Two popular desktop platforms, MAC OS and Windows, and two widely used mobile platforms, iOS and Android; have been targeted. The major part of the chapter consists of images to help recognise the type of notification. Though every attempt has been made to cover most of the notification types, it must be noted that this collection is far from being exhaustive due to the wide and currently evolving scope of notifications.

3.4.1 MAC OS

Notification Center in Mac OS provides an elegant and unified view of new stuff that pops up from Mail, Calendar, FaceTime, Game Center, Messages, Reminders, updates from the Mac App Store, and other third-party applications. One can access Notification Center from anywhere, anytime, including full-screen apps. All images used in this section are from [50].

Notification Center:

In Notification Center (Figure 3.1), one can view the most recently added items. Clicking an item directly opens up that associated application. MAC typically uses three different ways to convey the notifications – Banners, Alerts, and Badges.

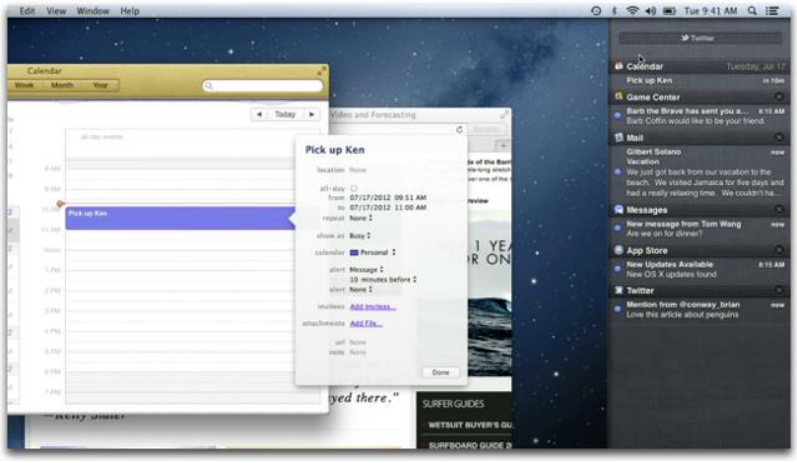


FIGURE 3.1: NOTIFICATION CENTER IN MAC OS

Banners:

Banners are a type of notifications delivery and display method, which slide down from the upper right corner of the Mac for a short period of time, and then slide off screen to the right (Figure 3.2). On the left is the icon of the application that generated the banner. The rest of the banner contains a brief message from the application. Clicking on the banner directly opens up the associated application. To dismiss a Banner without interacting with it, a two finger swipe to the right is required.

Alerts:

Alerts are important announcements that appear the same way as banners (Figure 3.2). They remain on the screen until an action is taken. Again, to dismiss an Alert without interacting with it, a two finger swipe to the right is required.

Badges:

A red badge with a number will appear on the upper-right of an application dock icon to indicate how many new items are available for it (Figure 3.2).

FIGURE 3.2: BANNERS (LEFT), ALERTS (MIDDLE), AND BADGES (RIGHT) IN MAC OS

3.4.2 IOS

Notifications are a way for iOS applications to provide alerts, updates, and related information.

Notification center:

When using iOS 5 or later, one can view notifications in the dedicated Notification Center by swiping down from the top of the screen (Figure 3.3) [50]. But the Notification Center cannot be accessed from the lock screen. One must swipe on a notification in the lock screen to open that related application. Notification settings can be accessed using *Settings > Notifications.*

If there are large number of applications which could send frequent notifications (for example, Mail with high-traffic email accounts, Twitter apps, and so on), iOS device wakes up frequently to display that notification thus providing audio and visual clues/stimuli. This can be disabled using *Settings > Notifications > <app name>* and turning-off *View in Lock Screen* for that app. iOS applications (also called apps) can provide three types of notifications – Alerts, Banners, and Badges.

FIGURE 3.3: NOTIFICATION CENTER ON IPAD (LEFT) AND IPHONE (RIGHT)

Banners:

The concept of Banners is borrowed from MAC OS and has the same purpose in iOS (Figure 3.4).

Alerts:

Alerts display a notification on the screen and prompts user input (Figure 3.4).

Badges:

It displays an image or a number on the application icon to indicate how many new items are available for it (Figure 3.4).

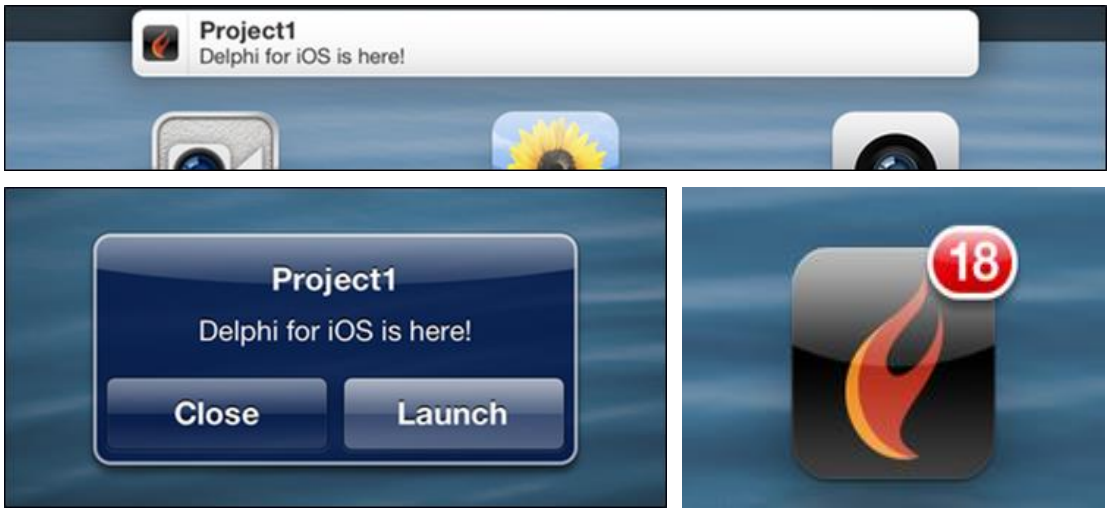


FIGURE 3.4: BANNER NOTIFICATION ON IPAD (TOP), ALERT NOTIFICATION (LEFT) AND BADGES ON IPHONE (RIGHT)

3.4.3 ANDROID

Android provides a technical definition of a notification; a message that is displayed to the user outside of the application's normal user interface. When turned-on, the notification first appears as an icon in the notification area. To see the details of the notification, the user must open the notification drawer by pulling it down (Figure 3.5). Both the notification area and the notification drawer are system-controlled areas that the user can view at any time. They are also accessible from the lock screen. Notifications in the notification drawer can appear in one of two visual styles – normal view and big view, depending on the version and the state of the drawer. All images in the section are from [51]

FIGURE 3.5:ANDROID NOTIFICATIONS AS SEEN IN THE NOTIFICATION AREA (LEFT) AND NOTIFICATION DRAWER (RIGHT)

Standard or Normal view:

This is the standard view of the notifications in the notification drawer. The callouts in Figure 3.6 refer to the following: (1) Content title, (2) Large icon, (3) Content text, (4) Content info, (5) Small icon, and (6) Time the notification was issued.

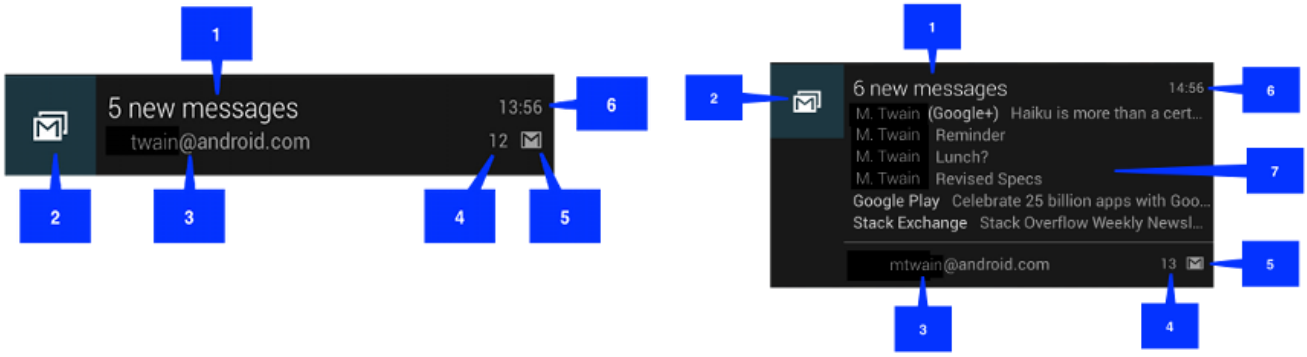


FIGURE 3.6: ANDROID NOTIFICATIONS IN NORMAL VIEW (LEFT) AND BIG VIEW (RIGHT)

Big view:

A notification's big view appears only when the normal notification is expanded, which happens when the notification is at the top of the notification drawer, or when the user expands the notification with a gesture. Expanded notifications are available starting with Android 4.1 [51]. Figure 3.6 shows an inbox-style notification. The big view shares most of its visual elements with the normal view. The only difference is callout number 7, the details area. Each big view style sets this area in a different way.

3.4.4 WINDOWS 7

Under Windows, notification informs users of events that are unrelated to the current user activity, by briefly displaying a balloon from an icon in the notification area. The notification could result from a user action or significant system event, or could offer potentially useful information from Microsoft Windows or an application. The information in a notification is useful and relevant, but never critical. Consequently, notifications don't require immediate user action and users can freely ignore them [52]. All the images in this section are from [52].

In Windows Vista and later, notifications are displayed for a fixed duration of 9 seconds. Notifications aren't displayed immediately when users are inactive or screen savers are running. Windows automatically queues notifications during these times, and displays the queued notifications when the user resumes regular activity. Consequently, users don't have to do anything to handle these special circumstances. Figure 3.7 shows the notification for a successful Wi-Fi connectivity and successful new updates installed.

FIGURE 3.7: WINDOWS 7 SUCCESSFUL WIFI CONNECTION (LEFT) AND SUCCESSFUL UPDATES INSTALLED (RIGHT) NOTIFICATIONS

Further examples:

As the battery power becomes lower, Windows warns users of weak battery power using a notification. This notification appears while users still have several options. Users can plug in, change their power options, wrap up their work and shut down the computer, or ignore the notification and continue working. As the battery power continues to drain, the notification's text and icon reflect the additional urgency. However, once the battery power becomes so low that users must act immediately, Windows power management notifies users using a modal message box (Figure 3.8).

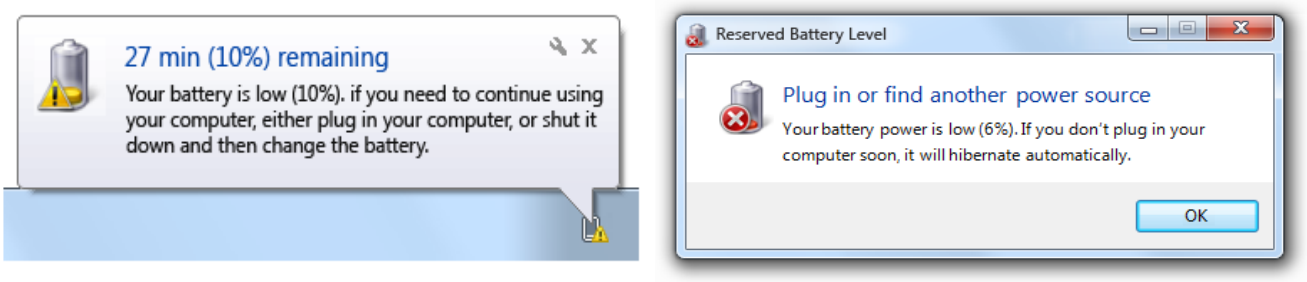


FIGURE 3.8: WINDOWS 7 BATTERY LOW NOTIFICATION AND ALERT

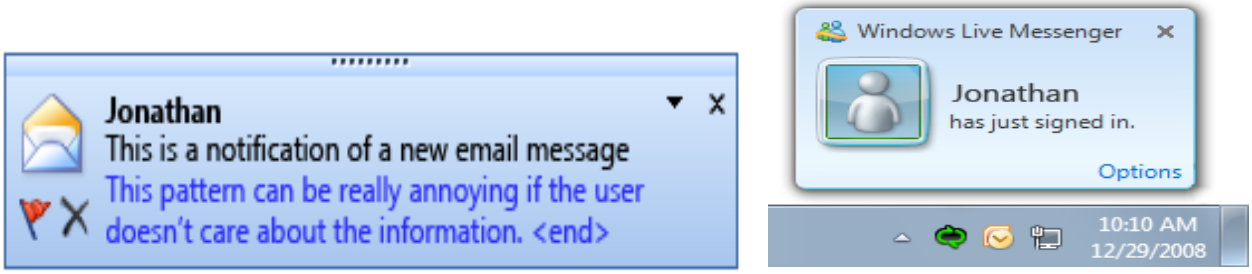


FIGURE 3.9: WINDOWS 7 OUTLOOK NEW EMAIL (LEFT) AND WINDOWS LIVE MESSENGER (RIGHT) NOTIFICATION

Notifications in general notify users of potentially useful, relevant information. They can be information of marginal relevance if it is optional and users opt in. For instance, users are notified when a new e-mail message is received. In the next example, users are notified when contacts come online and they chose to receive this optional information.

3.4.5 WINDOWS 8

There are two distinct notification styles in Windows 8. One is Live Tiles and the other one is Toast Notifications.

Live tiles:

The Live Tiles notifications are limited to Windows 8 modern applications in Start Screen and they show the updates like new emails and photos on the Start Screen tiles itself.

FIGURE 3.10: WINDOWS 8 LVE TILE NEW EMAILS AND BIRTHDAY REMINDERS (LEFT) AND MULTIPLE LIVE TILES (RIGHT)

Toast notification:

The Toast notification is available throughout Windows in both modern user interface and desktop mode, and provides a pop-up notification on the top-right corner of the screen. These notifications are from applications most of the times and are used to mark an event associated with Windows which might concern the user. Quick updates and detail status updates can also appear on the lock screen of the PC

FIGURE 3.11: WINDOWS 8 TOAST NOTIFICATIONS (LEFT) AND WINDOWS 8 LOCK SCREEN NOTIFICATIONS

4 METHOD

The experiment was designed to answer the following research questions:

- **RQ1:** Is the daily flow experience being affected by the presence of notifications?
- **RQ2:** Is there an increase in state-anxiety due to the presence of notifications?
- **RQ3:** Does the prolonged use of notifications negatively affect subjective well-being?
- **RQ4:** Do people use strategies to handle notifications in their everyday life?

4.1 PARTICIPANTS

The target population under study included individuals who generally have multiple notifications turned-on on their digital devices. A screening interview was conducted by the researcher to include participants with sufficient digital literacy and a fair understanding of notifications. Nine participants were finally chosen to take part in the experiment. All were students from The University of York studying a variety of subjects at post-graduation and doctoral level. Their ages ranged from 22 to 28 with a median age of 24. In terms of gender, there were 8 female and 1 male participants. All the participants owned a laptop and a smartphone and were comfortable using them. Seven of the participants did not have English as their first language, although they did show a fair command over both spoken and written English. The first language of the other 2 participant's was English. All the participants were paid £30 as monetary compensation for their participation in the study.

4.2 ETHICAL CONSIDERATIONS

All the participants were informed that their participation would be voluntary and the entire study would last for three weeks. As a part of the study, they shared their email addresses and mobile phone numbers with the researcher and gave consent to receive 6 SMS text messages every day for a three week period. They all agreed to the messaging time window of 10 AM to 11 PM. Participants were also assured that their mobile phone numbers would be only used for sending text messages related to the study and for no other purpose.

Participants were aware that their interviews with the researcher would be only audio recorded. It was emphasized that there would be no video recordings.

The participants who did not have English as their first language were explained the contents of the ESF in a detailed manner and were encouraged to ask if in doubt.

All the participants signed an Informed Consent Form after they were briefed.

4.3 DESIGN

The experiment was an in-the-wild study, with a within-participants design with 3 conditions, each applicable for a week. The study spanned over a period of 3 weeks. Every day for the next 3 weeks, participants completed an ESF when signalled via SMS text. The 3 conditions were:

- Week1: This was the baseline condition. During this week (henceforth Week1) participants were asked to lead their usual lives.

- Week2: This was the not-interrupted condition. During this week (henceforth Week2), participants were asked to turning-off all the known notifications on their digital devices (smartphones, tablets, laptops, and/or desktop).
- Week3: This was the interrupted condition. During this week (henceforth Week3), participants were free to turn-on any notification (as per their wishes).

The data from the ESF were used as the dependent variables in the study. The main dependent measures were,

- Percentage-of-time in flow
- Enjoyment, Concentration, Control, Affect, and Potency
- State-anxiety, and
- Satisfaction-with-life

At the end of each week, interviews were conducted to collect qualitative information for the purpose of the study.

4.4 MATERIALS

The ESM study required a signalling device and a platform (computerised) to enter data into ESFs. During the study, SMS text messages were used to signal the participants when to respond to an ESF. An online paid texting service called Skype[2] was used to send the SMS texts. The Skype application was installed on the researcher's laptop. The laptop had a 14.1-inch display and was operating on Windows 8 operating system. The SMS text contained a link to the digital ESF. All the participants used their personal devices (smartphones, tablet, laptops, and/or desktop) to fill in the ESF.

Interviews were conducted either in the Computer Lab of The Department of Computer Science or in the JB Morrell Library at The University of York. All interviews were audio recorded using a voice recording application installed on a 7-inch Google Nexus Tablet running Android version 4.2.

4.5 PROCEDURE

The ESM was a three-week long study. The entire study period was divided into 3 phases.

4.5.1 PHASE1: SCREENING INTERVIEW

The screening interview was a one-to-one discussion session. The screening interview form is available in Appendix 2.1. Each participant was allotted a time and a room. During the discussion, the participants shared their daily notification usage and handling with the researcher. The researcher also showed them the notification repository to help them understand the notion of notifications in a better manner. Participants also indicated the approximate number of notifications they had received in the past 1 hour. Participants were informed that they had to turn-off all their notifications for an entire week. All the participants who had attended the screen interview, agreed to take part in the study. An overview of the

[2] Skype is a premium voice-over-IP service and instant messaging client developed by the Microsoft Skype Division.

study was provided to the participants. Participants were also informed that they would be financially compensated with a £30 Amazon gift voucher. The participants then signed the Informed Consent Form and were formally invited to attend the orientation meeting.

4.5.2 Phase 2: Orientation Meeting

It is well known that the ESM is a complex study and participants require some training in understanding the process [44, pp. 52]. Hence the participants from the screening interview were invited to a one-to-one orientation meeting with the researcher. The participants who were unable to attend the meeting, met personally with the researcher at their own convenience.

All the meetings took place in the Master's Laboratory at the Department of Computer Science at The University of York. The researcher began with a general description of the study taking care that the hypotheses were not revealed. The participants then provided their mobile phone number and were reassured about confidentiality. The researcher then sent a test SMS text to the number and verified that the participant received it and was aware of it. Once the participants were comfortable with the signalling method, they were asked to fill a sample ESF on the researcher's laptop. The participants were encouraged to ask questions related to the ESF, whenever the items seemed to be confusing or they were unable to comprehend the meaning of any particular word. Help was offered along the way in an unobtrusive manner. Once the ESF was completed, the researcher spent about 2-3 minutes to review it entirely to look for slips or errors. Wherever necessary, the researcher brought up the ESF and provided few pointers on how to answer a question in the future reports. As the ESF was administered online, participants were encouraged to bookmark the ESF web link onto their browsers (As a precautionary measure the ESF web link was included in the SMS text). The number of signals per day, though already informed during the screening interview, was reiterated for clarity.

Once the participants were comfortable with the ESF and agreed to comply with the needs of the study, a final demonstration of the signal (SMS text) was given and they were reminded to fill the ESF as soon as possible after receiving the SMS. Before leaving, the participants were provided with a participant slip which contained important links and contact information of the researcher. They were also informed of th the end of the week interview schedule. Each meeting lasted for approximately 30 minutes.

4.5.3 During week1, week2, and week3

During each week, irrespective of the experimental conditions, the researcher sent 6 SMS texts to the participants per day. The SMS texts were sent once every 130 minutes on an average. The Skype application provided delivery notifications to the researcher when a participant received the SMS text. The researcher noted all the delivery times for data analysis.

4.5.4 Phase 3: End of week1 Interview

Having collected a week's response in ESFs, it was crucial for the study to capture qualitative data through interviews. The purpose of these interviews was not just to collect an explanation of a participant's weekly activities, but also to establish a relationship of trust to ensure that the participants remain in the study.

The first interview was held at the end of Week1 in the Master's Laboratory. Participants were seated next to the researcher and the recording device was placed in front of them. During this session, open

ended questions were asked. Participants shared instances of their Week1 experiences. The questions were formulated based on a first-hand interpretation of the response-level data of that participant for Week1. The end of Week1 interview form is given in (Appendix 2.3).

At the end of the interview, participants were asked to turn-off all incoming notifications. The devices included mobile phones, laptop/desktop, tablet and any other electronic device capable of generating push-notifications. All participants complied. Researcher was able to confirm this for the participants' smartphones. The participants who were unaware of the process of turning off their notifications were provided a guide to help them with it (Appendix 2.6). Participants were reminded that their SMS services must remain active as usual. It was reiterated that they were not forbidden from using the applications. It was only the notifications that were being turned off and they would be at complete liberty to open any application at any time and check the status therein. Before leaving the participants also filled the Satisfaction-with-life scale (SWLS) form for that week (Appendix 2.6). The entire session lasted for approximately 20 minutes.

4.5.5 Phase 4: End of week2 Interview

The entire setting was similar to that of Week1. Participants shared their Week2 experiences based on the questions in the end of Week2 interview form (Appendix 2.4). Participants also filled the SWLS form. The entire session lasted for approximately 15 minutes.

4.5.6 Phase 5: End of week3 Interview and debriefing

The interview at the end of Week3 coincided with the debriefing meeting. The setting was similar to that of Week1 and Week2. Participants shared their experiences based on the questions in the end of Week3 interview form (Appendix 2.5). Participants were asked if they felt any overall changes in their lifestyle and if responding to ESFs had caused any major problems. Information related to the different notifications which the participants turned-on during the week (Week3) were also noted. This was the final interaction with the participants. The participants also filled the SWLS form. After the interview, participants were asked to fill a demographics questionnaire. Once the questionnaire was completed, participants were fully debriefed on the purpose of the study. They were also promised that the results of the study would be made available to them via their email IDs at a later period of time. As a token of appreciation for their participation, participants were thanked and paid £30 Amazon gift vouchers as monetary compensation. The entire session lasted for about 30 minutes.

5 RESULTS

5.1 ATTRITION AND COMPLIANCE

One participant did not complete the study due to undisclosed personal reasons. As the methods section notes, participants received a text message directing them to complete one Experience Sampling Form (ESF) once every 130 minutes on average (the text message was delivered randomly within this 130-minute window). A response within this window was considered 'compliant' if it was answered before participants received a subsequent text-message directing them to complete the next form. If more than one response was received within one signalling window, it was considered non-compliant and that entire response was discarded.

Per week, during Week1 and Week2, 336 text messages (7 days x 6 messages per day x 8 participants), and during Week3, 288 text messages (1 day x 6 messages per day x 8 participants + 6 days x 5 messages per day x 8 participants) were sent out. FIGURE 5.1 shows the total number of responses received per week. The average response rate across the three week period was 65.42% (range: 40.83% - 91.67%), resulting in a total of 628 responses. FIGURE 5.2 shows the total number of compliant responses at a participant level. The average compliance rate was 96.97% (range: 91.23% - 100%), resulting in a total of 609 valid responses. Henceforth, responses will refer to compliant responses only.

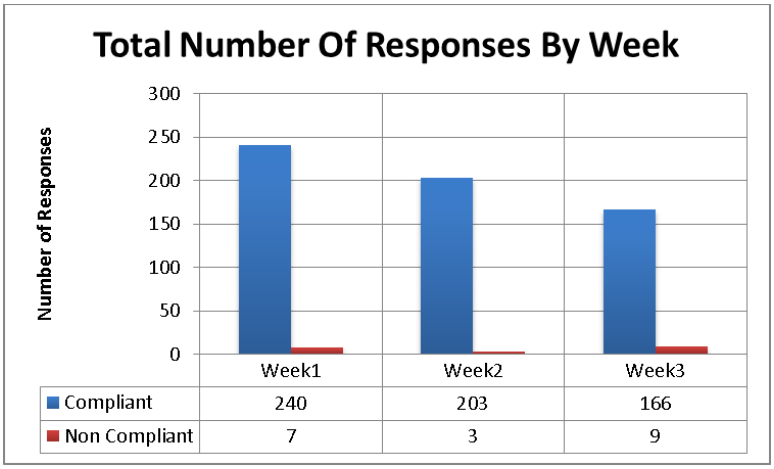


FIGURE 5.1: TOTAL NUMBER OF COMPLIANT AND NON-COMPLIANT RESPONSES DURING WEEK1, WEEK2, AND WEEK3

5.2 QUANTITATIVE ANALYSIS

The data analysis was performed using the statistical package IBM SPSS Version 21. A one-way repeated measures ANOVA was conducted to compare the effects of notifications on percentage-of-time in flow, Enjoyment, Concentration, Affect, Potency, State anxiety, and Satisfaction-with-life, in baseline (Week1: notifications turned-on), not interrupted (Week2: notifications turned-off), and interrupted (Week3: some notification may or may not be turned-on) conditions.

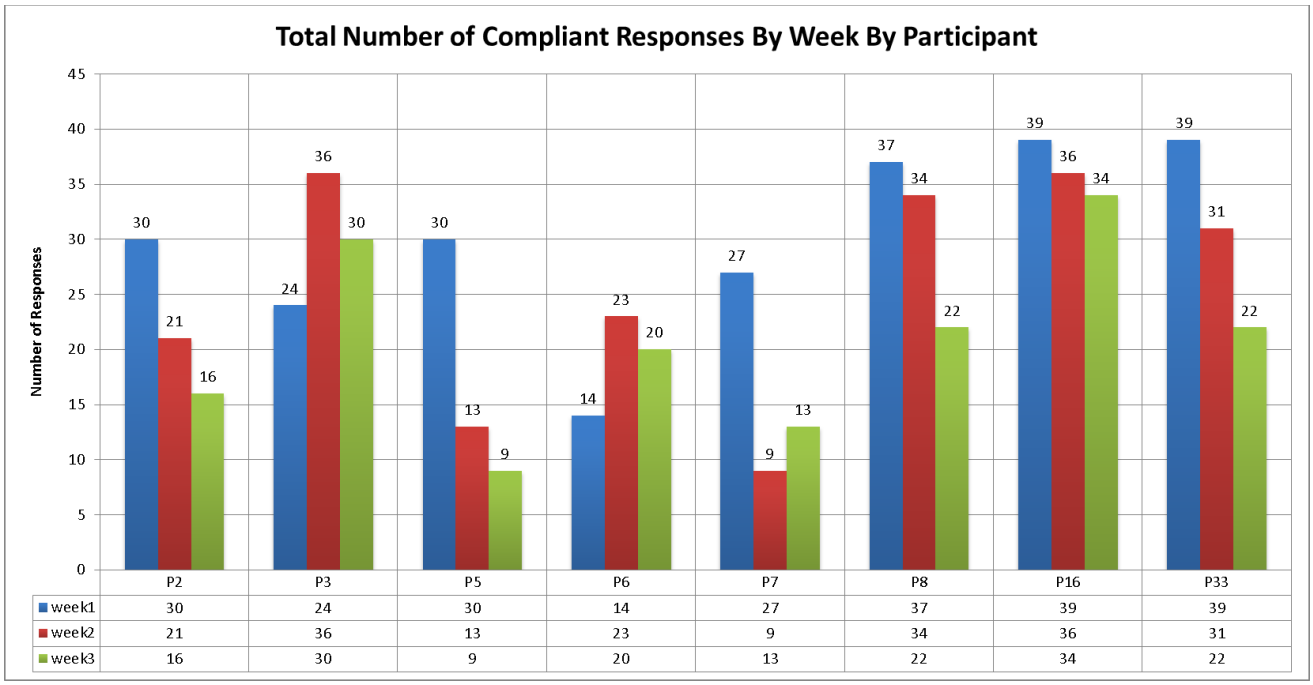
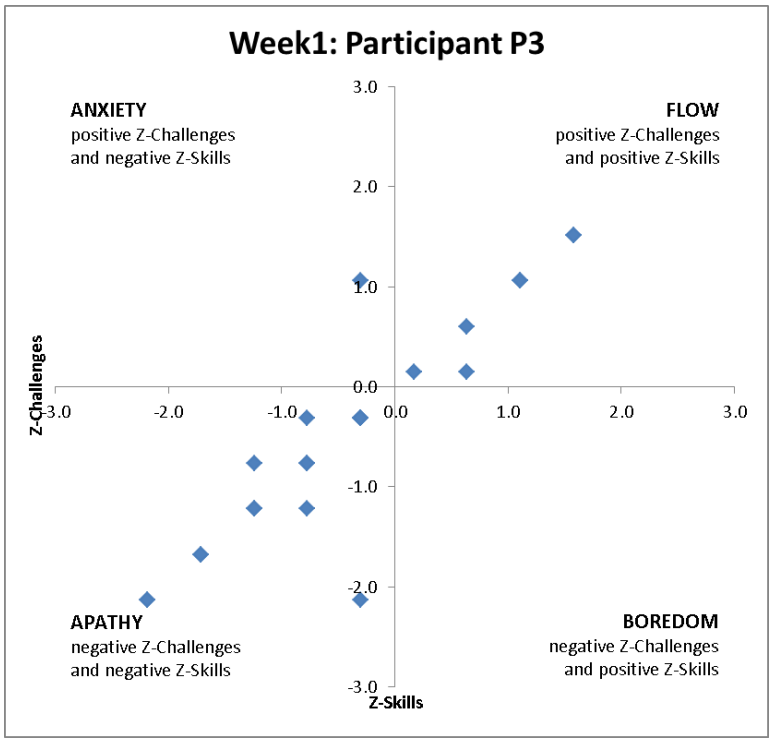


FIGURE 5.2: TOTAL NUMBER OF COMPLIANT RESPONSES BY PARTICIPANTS DURING WEEK1, WEEK2, AND WEEK3

5.2.1 FLOW

Flow is described as an autotelic experience that is poised between boredom and anxiety (section 2.3). Based on this theoretical definition of flow and using The Quadrant Model (refer *The Quadrant Model*) for measurement of flow conditions, the percentage-of-time in flow was calculated (section 3.2.1).

First, each participant's vector of raw scores of challenge and skill was individually standardized with z-scores using SPSS. These resultant scores (z-skills and z-challenges) were then divided into one of the four quadrants depending on whether challenges and skills were above the individual's average (i.e. have positive Z-scores) or not (section 3.2.1). FIGURE 5.3 shows the graphical representation of z-skills and z-challenges for Week1 on z-skills and z-challenges Cartesian plane for participant P3. Plotting of the z-scores onto the Cartesian plane was a many-to-one mapping, as multiple z-scores had same values. For instance, in the data set shown in FIGURE 5.3 the z-skills and z-challenges set *(1.6, 1.5)* (highlighted) occurs more than once, but is represented as a single point on the Cartesian plane. Hence, along with a graphical representation, a manual check was done to count the total number of *flow* states. FIGURE 5.4 shows the result after the manual check was performed for participant P3 for Week1. A similar manual check procedure was followed for each of the participants for their data sets for all the three weeks. FIGURE 5.5 shows the graphical representation of the data set and the manual check result for Week1 for participant P5.

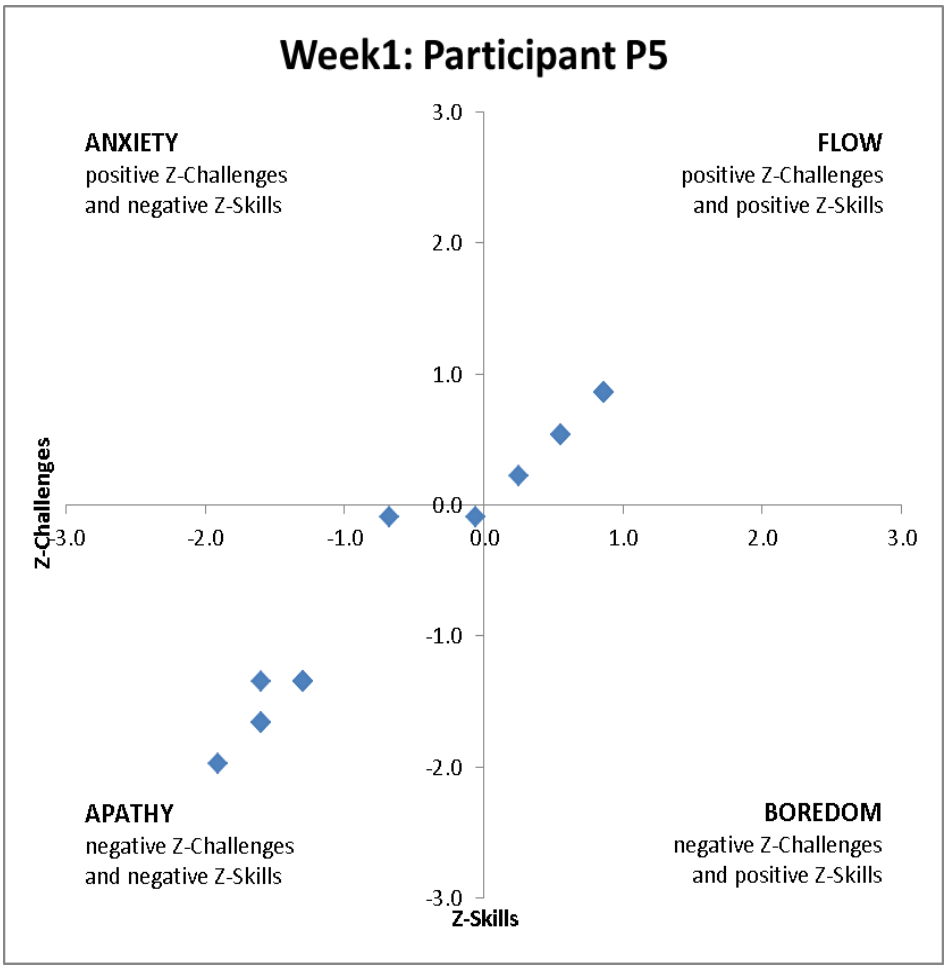


Week1: Participant P3			
Skills	Challenges	Z-Skills	Z-Challenges
0	0	-2.2	-2.1
0	0	-2.2	-2.1
1	1	-1.7	-1.7
1	1	-1.7	-1.7
2	2	-1.2	-1.2
2	2	-1.2	-1.2
2	3	-1.2	-0.8
3	2	-0.8	-1.2
3	4	-0.8	-0.3
3	3	-0.8	-0.8
3	3	-0.8	-0.8
4	7	-0.3	1.1
4	0	-0.3	-2.1
4	4	-0.3	-0.3
4	4	-0.3	-0.3
4	4	-0.3	-0.3
4	4	-0.3	-0.3
5	5	0.2	0.1
6	5	0.6	0.1
6	6	0.6	0.6
7	7	1.1	1.1
7	7	1.1	1.1
8	8	1.6	1.5
8	8	1.6	1.5

FIGURE 5.3: THE QUADRANT MODEL OF FLOW: GRAPHICAL REPRESENTATION OF THE Z-SCORES OF CHALLENGES AND SKILLS OF PARTICIPANT P3 FOR WEEK1 (LEFT), AND RAW SCORES AND Z-SCORES OF CHALLENGES AND SKILLS OF PARTICIPANT P3 FOR WEEK1

Week1: Participant P3			
Z-Skills	Z-Challenge	Quadrant	Frequency
-2.2	-2.1	Apathy	
-2.2	-2.1	Apathy	
-1.7	-1.7	Apathy	
-1.7	-1.7	Apathy	
-1.2	-1.2	Apathy	
-1.2	-1.2	Apathy	
-1.2	-0.8	Apathy	
-0.8	-1.2	Apathy	
-0.8	-0.8	Apathy	16
-0.8	-0.8	Apathy	
-0.8	-0.3	Apathy	
-0.3	-2.1	Apathy	
-0.3	-0.3	Apathy	
-0.3	-0.3	Apathy	
-0.3	-0.3	Apathy	
-0.3	-0.3	Apathy	
-0.3	1.1	Anxiety	1
0.2	0.1	Flow	
0.6	0.1	Flow	
0.6	0.6	Flow	
1.1	1.1	Flow	7
1.1	1.1	Flow	
1.6	1.5	Flow	
1.6	1.5	Flow	

FIGURE 5.4: MANUAL CHECK TO CALCULATE THE TOTAL NUMBER OF FLOW OCCURRENCES DURING WEEK1 FOR PARTICIPANT P3



Week1: Participant P5			
Z-Skills	Z-Challenge	Quadrant	Frequency
-1.9	-2.0	Apathy	14
-1.6	-1.7	Apathy	
-1.6	-1.7	Apathy	
-1.6	-1.7	Apathy	
-1.6	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-1.3	-1.3	Apathy	
-0.7	-0.1	Apathy	
-0.1	-0.1	Apathy	
0.2	0.2	Flow	21
0.6	0.5	Flow	
0.6	0.5	Flow	
0.6	0.5	Flow	
0.6	0.5	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	
0.9	0.9	Flow	

FIGURE 5.5: THE QUADRANT MODEL OF FLOW: GRAPHICAL REPRESENTATION OF THE Z-SCORES OF CHALLENGES AND SKILLS OF PARTICIPANT P5 FOR WEEK1 (LEFT), AND MANUAL CHECK OF Z-SCORES OF CHALLENGES AND SKILLS OF P5 FOR WEEK1 (RIGHT)

Using the above method, the total number of flow conditions was calculated of each of the participants. A total of 193 flow conditions were reported, which accounts to 31.7% of the total responses (N= 609). Studies which used The Quadrant Model for the measurement of flow (reported in [44]), show that both U.S. adults and teens spent around 33% of their time in flow [44, pp. 142]. When using the restricted 8-channel model, researchers in Milan have found Italian teenagers to be in the flow condition about 20% of the time[44, pp. 142]. Other researchers, using a slightly modified form of the 8-channel model have found British teens to spend 24% of their time in flow condition. FIGURE 5.6 shows the total number of flow activities for each of the 8 participants for Week1, Week2, and Week3.

After calculating the count of flow conditions for each participant for each week, the percentage-of-time in flow was calculated using the EQUATION 5.1.

$$\%\ time\ in\ flow = \frac{total\ number\ of\ flow\ conditions\ during\ the\ week}{total\ number\ of\ responses\ during\ the\ week} \times 100$$

EQUATION 5.1: CALCULATION OF PERCENTAGE-OF-TIME IN FLOW

For instance, during Week1, participant P3 was in a flow state for 7 times (FIGURE 5.6) and had completed 24 ESFs (FIGURE 5.2). Hence, the percentage-of-time in flow during Week1 for participant P3 is given by;

$$\%\, time\ in\ flow = \frac{7}{24} \times 100 = 29.2\,\%$$

FIGURE 5.7 shows the percentage-of-time in flow for each of the 8 participants for Week1, Week2, and Week3.

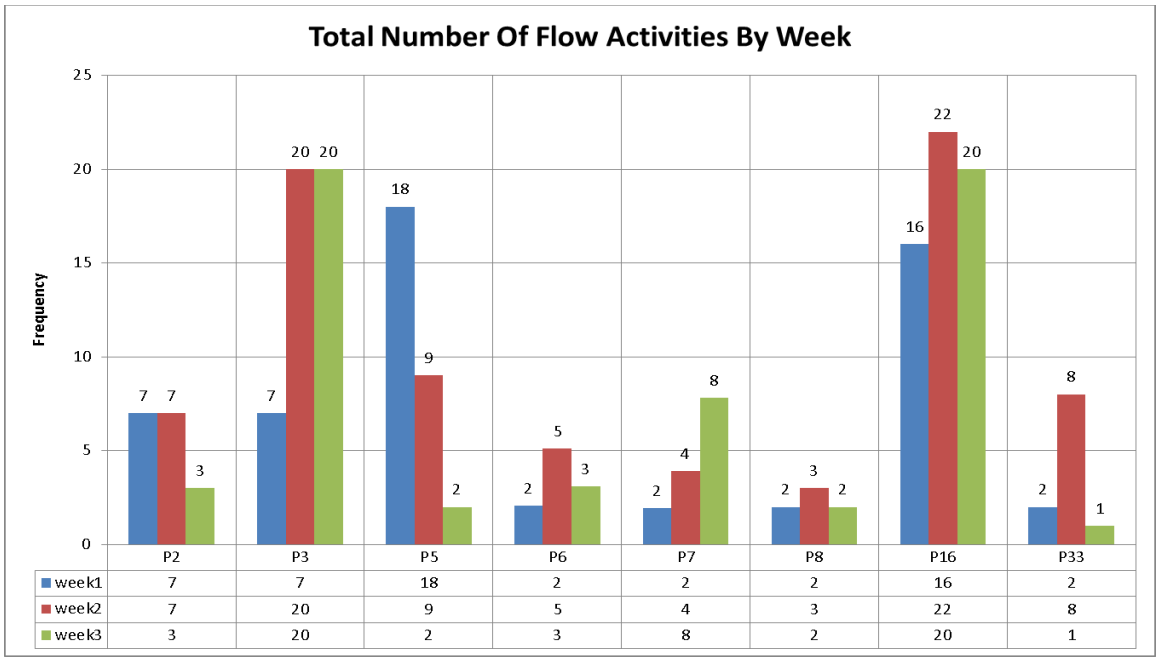


FIGURE 5.6: TOTAL NUMBER OF FLOW ACTIVITIES DURING WEEK1, WEEK2, AND WEEK3, GROUPED BY PARTICIPANT ID

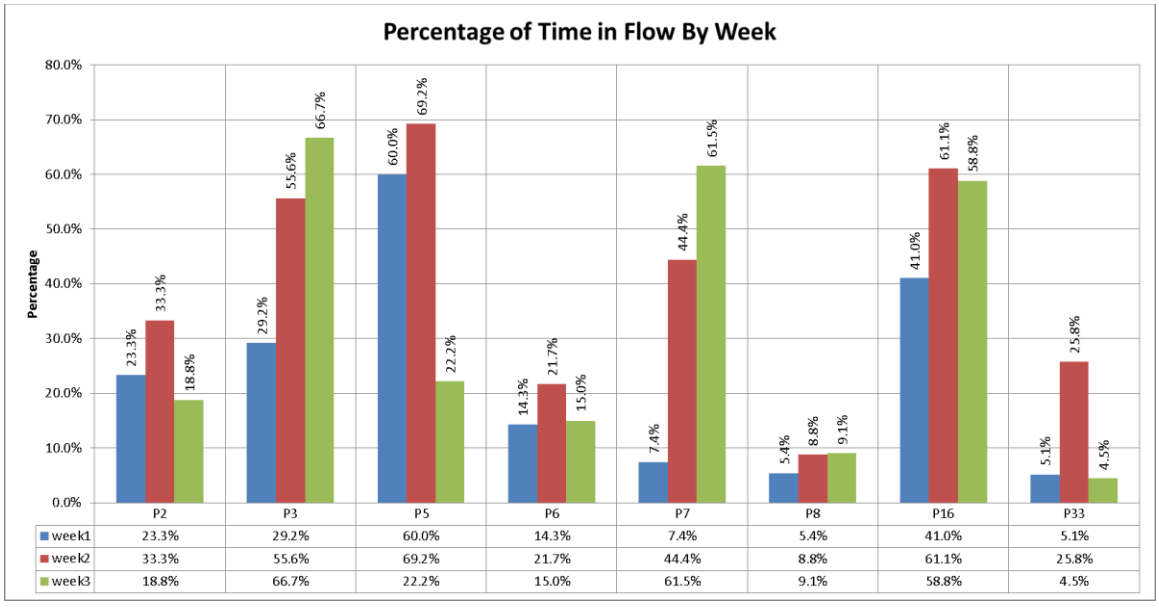


FIGURE 5.7: PERCENTAGE-OF-TIME IN FLOW DURING WEEK1, WEEK2, AND WEEK3, GROUPED BY PARTICIPANT ID

Once the percentage-of-time in flow was calculated, a one-way repeated measures ANOVA was conducted to compare the effects of notifications on percentage-of-time in flow, in baseline (Week1: notifications turned-on), not interrupted (Week2: notifications turned-off), and interrupted (Week3: notification may or may not be turned-on) conditions. TABLE 5.1 summarizes the percentage-of-time in flow during Week1, Week2, and Week3 for all the participants, and their weekly mean and standard deviation.

Percentage-of-time in Flow			
ID	**Week1**	**Week2**	**Week3**
2	23.3	33.3	18.8
3	29.2	55.6	66.7
5	60.0	69.2	22.2
6	14.3	21.7	15.0
7	7.4	44.4	61.5
8	5.4	8.8	9.1
16	41.0	61.1	58.8
33	5.1	25.8	4.5
Mean	**23.2**	**39.9**	**32.1**
Std. Dev.	**19.6**	**21.1**	**25.7**

TABLE 5.1: PERCENTAGE-OF-TIME IN FLOW DURING WEEK1, WEEK2, AND WEEK3

There was a significant effect of notifications on the percentage-of-time in flow, Wilks' Lambda = .170, $F(2, 6) = 14.62$, $p = .005$. Three paired samples t-tests were used to make post hoc comparisons between conditions.

The first paired samples t-test indicated that there was a significant difference in the percentage-of-time in flow for baseline (Week1) (M=23.21, SD=19.56) and not interrupted (Week2) (M=39.98, SD=21.09) conditions; $t(7) = -4.18$, p[3] = .004.

The second paired samples t-test indicated that there was no significant difference in percentage-of-time in flow for not interrupted (Week2) (M=39.98, SD=21.09) and interrupted (Week3) (M=32.07, SD=25.72) conditions; $t(7) = -.895$, p = ns. The third paired samples t-test was also not significant; no significant difference in the percentage-of-time in flow for baseline (Week1) (M=23.21, SD=19.56) and interrupted (Week3) (M=32.07, SD=25.72) conditions; $t(7) = 1.11$, p = ns.

The above results suggest that the absence of notifications does have an effect on the percentage-of-time one is in flow. Specifically, the absence of notifications during Week2 resulted in participants spending significantly more time in flow compared to the baseline condition of Week1. However, there was no significant difference between Week2 and Week3 or Week1 and Week3.

[3] For post hoc comparisons using paired samples t-test, 0.017 was used to determine the statistical significance, rather than .05

A closer inspection of FIGURE 5.7 shows that the percentage-of-time in flow for all the participants increased during the 'not interrupted' condition of Week2 as compared to the baseline condition of Week1. For the other two conditions (Week2 and Week3, and Week1 and Week3), participants can be divided into two groups based on their percentage-of-time in flow during Week2 and Week3, and during Week1 and Week3. It is the presence of these groups within the participants which led to non-significant results. FIGURE 5.8 shows the percentage-of-time in flow for the 2 groups; Group 1 comprises of participants who had a greater percentage of flow experience during the 'not interrupted' condition of Week2 compared to 'interrupted' condition of Week3, while Group 2 consists of participants who had a greater percentage of flow experience during the 'interrupted' condition of Week3. FIGURE 5.9 shows 2 groups; Group 3 comprising of participants who had a greater percentage of flow experience during the 'interrupted' condition of Week3 compared to the baseline condition of Week1, while the participants in Group 4 had a greater flow experience during Week1 as compared to Week3.

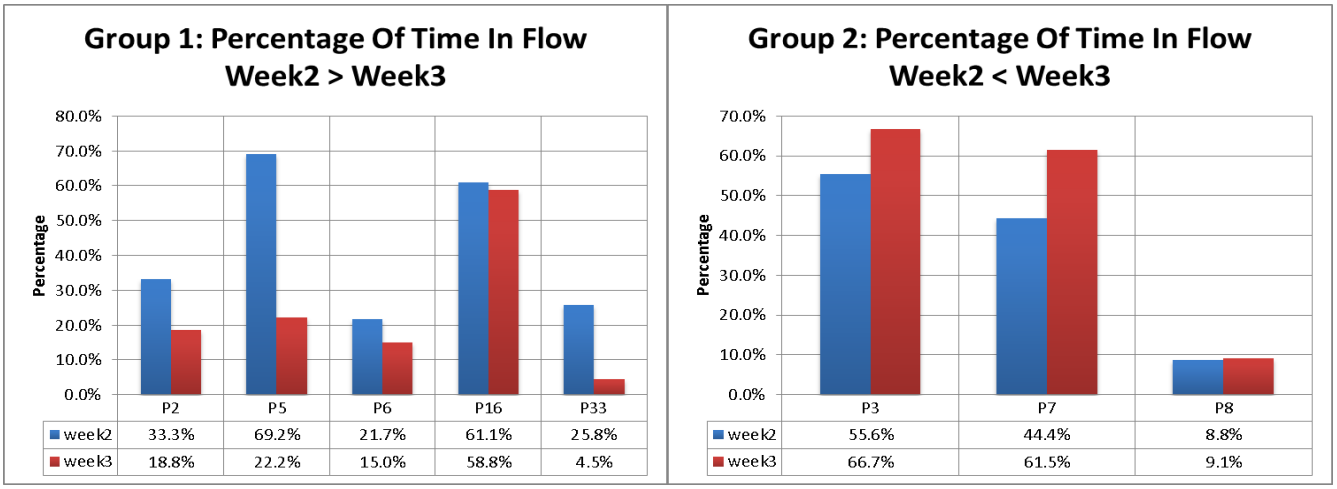


FIGURE 5.8: GROUPING PARTICIPANTS BASED ON THE PERCENTAGE OF TIME IN FLOW DURING WEEK2 AND WEEK3. GROUP 1 COMPRISES OF PARTICIPANTS WHOSE PERCENTAGE-OF-TIME IN FLOW IN WEEK2 IS GREATER THAN PERCENTAGE-OF-TIME IN FLOW IN WEEK3 (LEFT). FOR THE PARTICIPANTS IN GROUP 2, THE REVERSE IS TRUE (RIGHT).

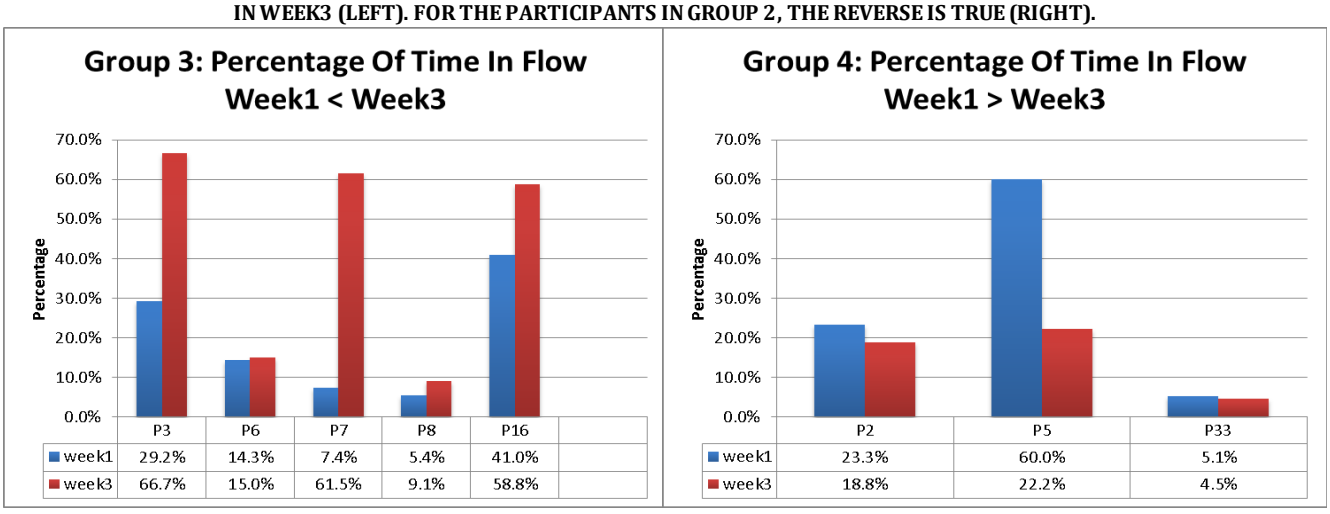


FIGURE 5.9: GROUPING PARTICIPANTS BASED ON THE PERCENTAGE-OF-TIME IN FLOW DURING WEEK1 AND WEEK3. GROUP 3 COMPRISES OF PARTICIPANTS WHOSE PERCENTAGE-OF-TIME IN FLOW IN WEEK1 IS LESS THAN PERCENTAGE-OF-TIME IN FLOW IN WEEK3 (LEFT). FOR THE PARTICIPANTS IN GROUP 2, THE REVERSE IS TRUE (RIGHT).

The behaviour of the participants of Group 1 concurs with our hypothesis of reduced percentage-of-time in flow when in the interrupted condition of Week3. Group 3 shows a trend which was also predicted; participants will be more in flow during Week3 compared to Week1 as unwanted and less frequently used notifications would be in a turned-off state leading to less interruptions. On the other hand, Group 2 and Group 4 contradict the hypothesis. We suspect two inter-dependent reasons for this reverse behaviour. First, the activities which led to flow experiences during each week might have changed. Thus, for a given participant, activities which did not induce any flow experiences during a week may start to induce flow in another week. Second, there might have been a significant change in the participants' lifestyle which affected the frequency of flow-inducing activities.

The main activity that a participant was engaged in when signalled, was captured in the ESF using an open ended question. Emergent coding scheme was used to code the main activity data. Preliminary analysis of all the responses (N= 609) produced 30 categories of activities which were reported by the participants as their main activity. A second analysis was done to group trivial activities together. Other activities which had few occurrences were also grouped together to produce logical super-categories. FIGURE 5.10 shows the final set of 16 categories with their corresponding frequency of occurrences. The 2 compound categories which include other sub-categories have been decomposed in FIGURE 5.11 and FIGURE 5.12

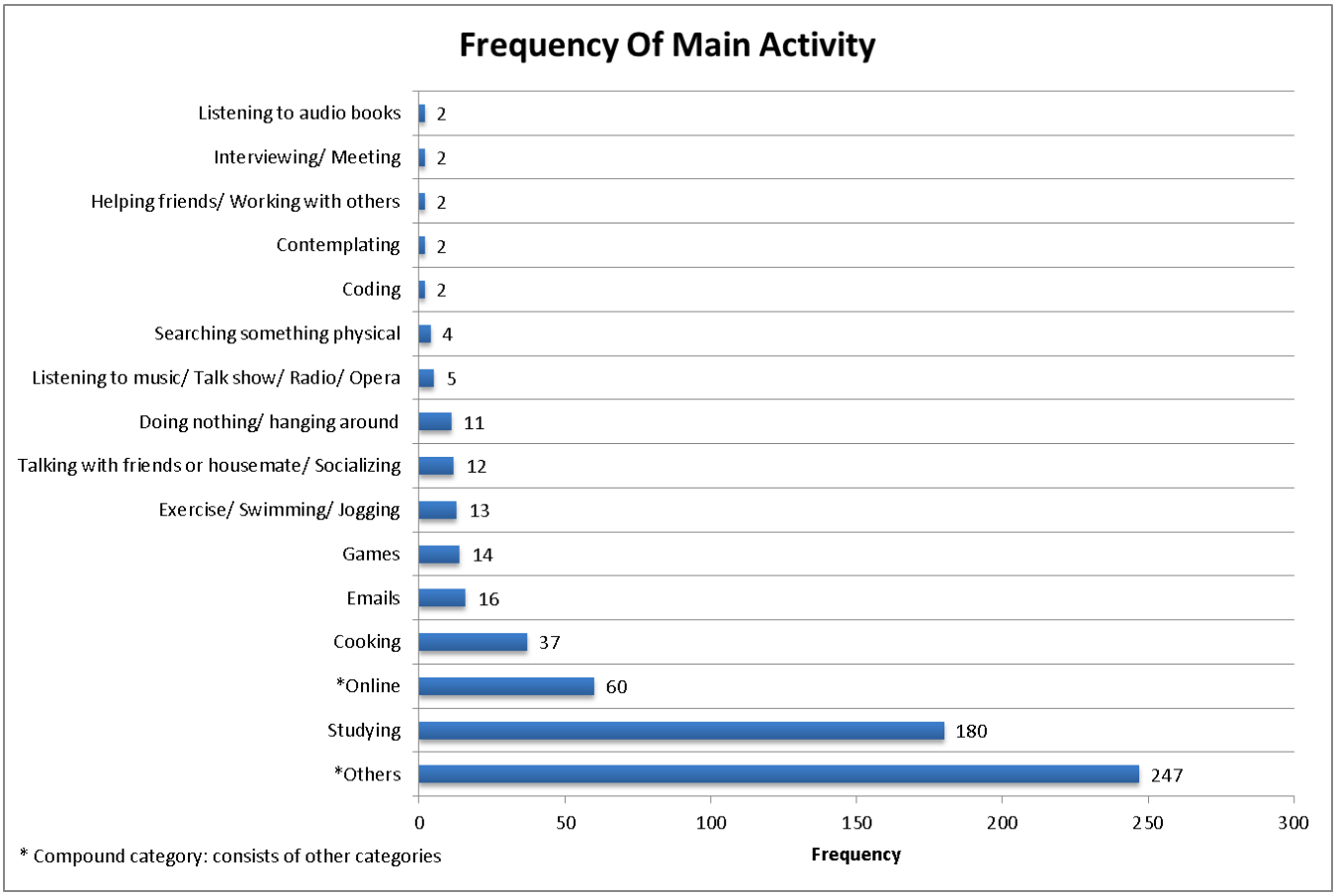


FIGURE 5.10: EMERGENT CODING OF MAIN ACTIVITY WITH THEIR RESPECTIVE FREQUENCY OF OCCURRENCES

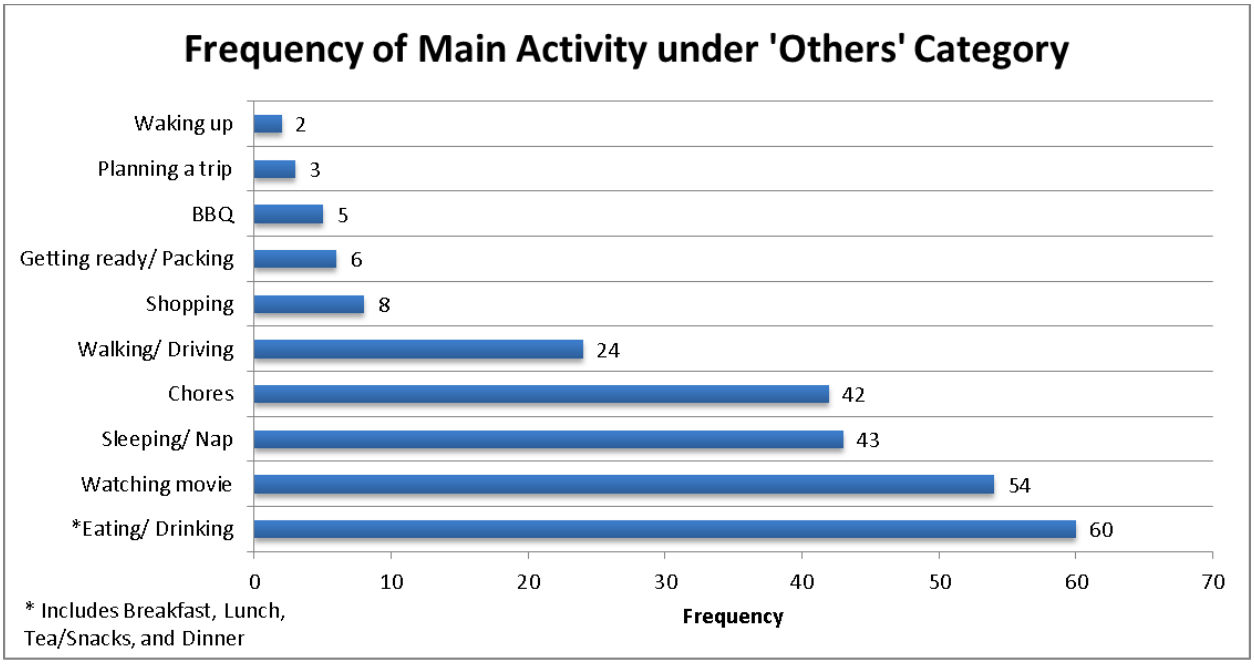


FIGURE 5.11: NUMBER OF OCCURRENCES OF MAIN ACTIVITIES UNDER 'OTHERS' CATEGORY

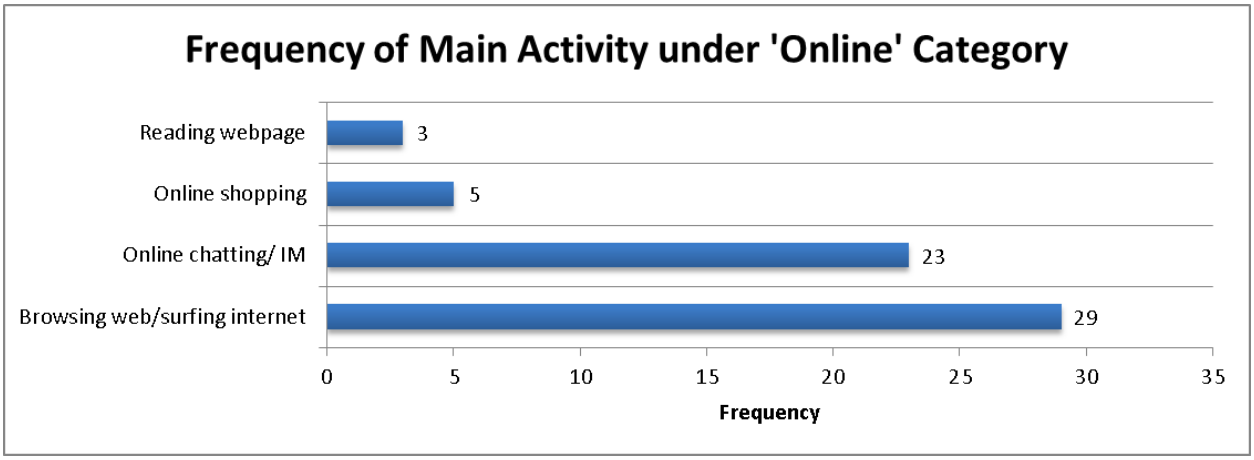


FIGURE 5.12: NUMBER OF OCCURRENCES OF MAIN ACTIVITIES UNDER 'ONLIINE' CATEGORY

Though the participants recorded a variety of main activities, only a small subset of these activities was able to induce flow state. The 7 main activities which induced flow are shown in Figure 5.13. The main activity 'Studying' accounts for 62.2% of the total flow activities. It is followed by the super-category of 'Others' which accounts for 14% of the total flow activities.

A further breakdown of Figure 5.13 generates Figure 5.14 which provides a comparison of the frequency of different flow activities per week grouped by participants. Using the participant IDs from Group 1 and Group 3, and data from Figure 5.14, FIGURE 5.15 - FIGURE 5.18 compares the frequency of each of the flow activities performed by the participants for that group.

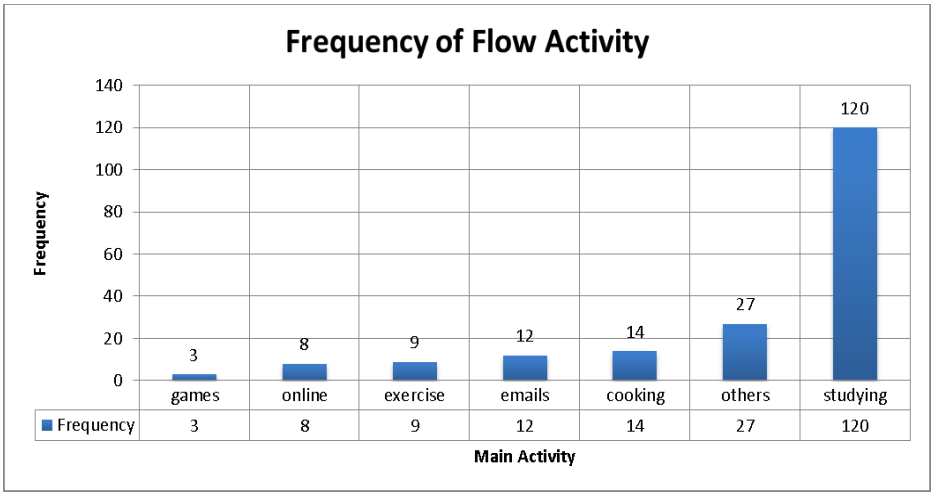


FIGURE 5.13: FREQUENCY OF MAIN ACTIVITIES THAT INDUCED FLOW CONDITION (HIGH SKILLS AND HIGH CHALLENGES)

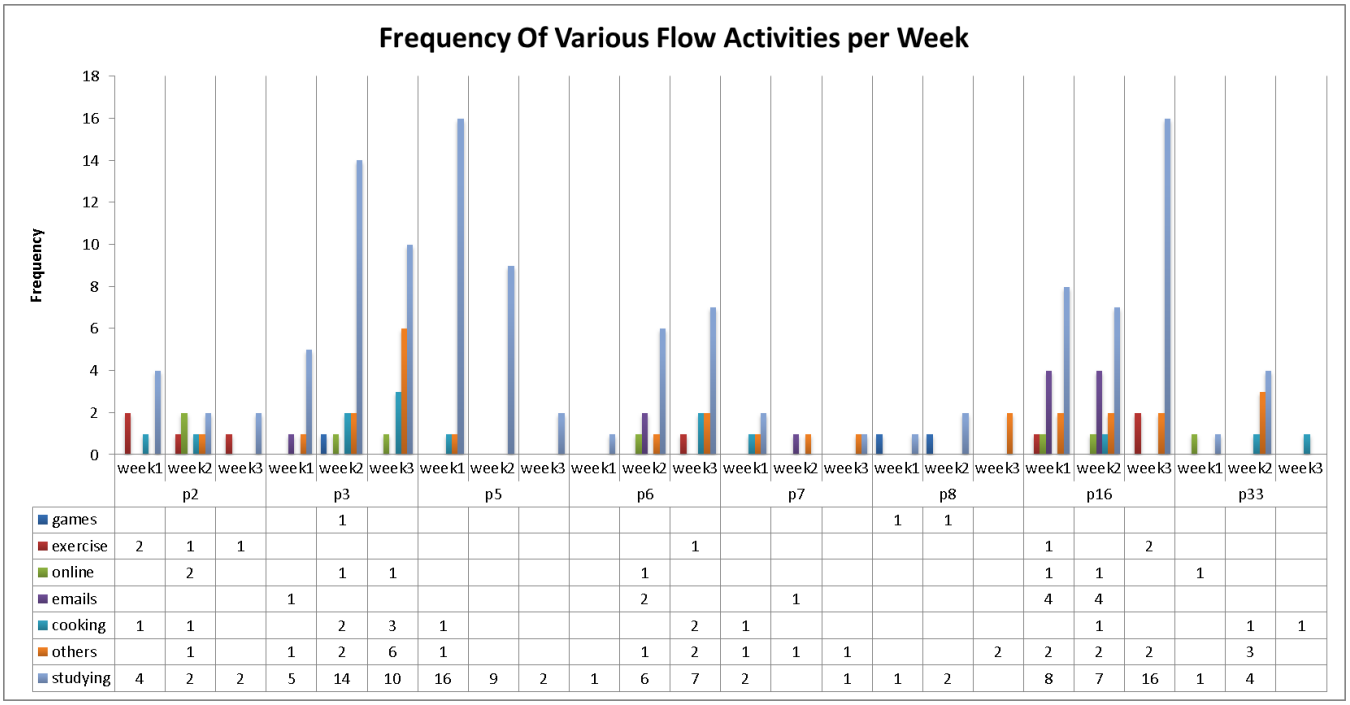
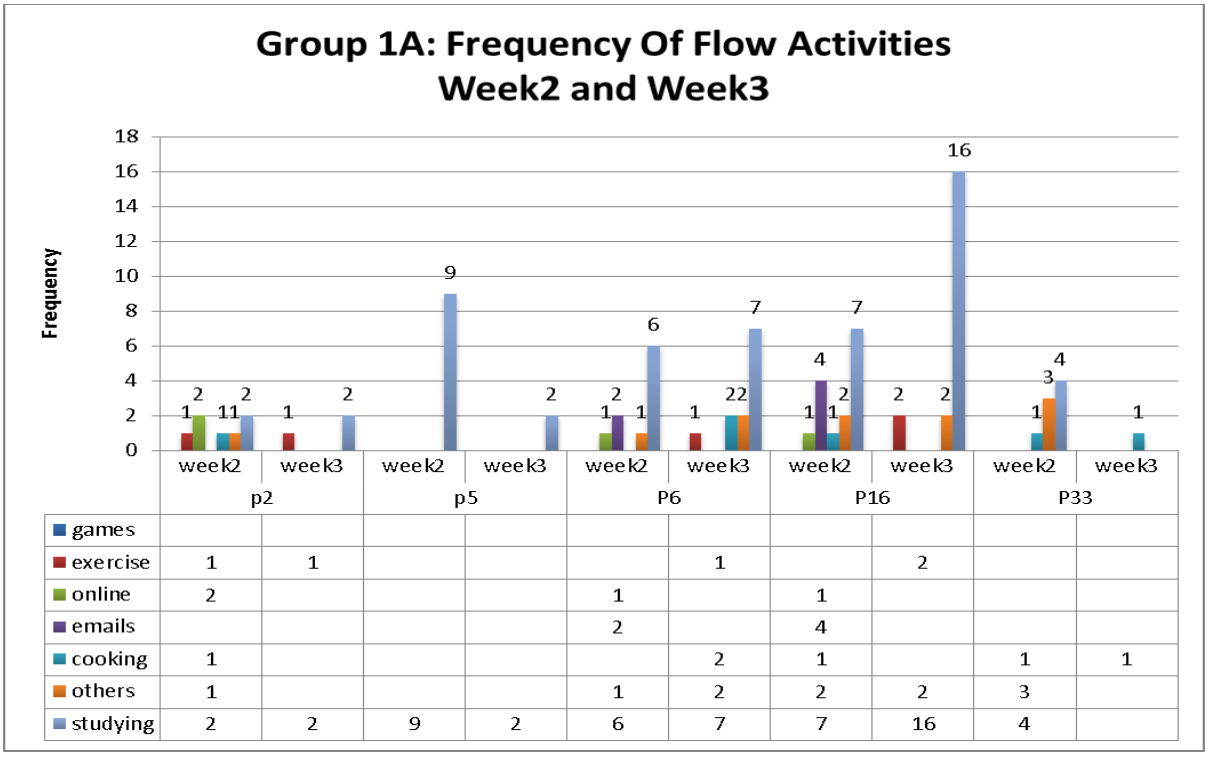


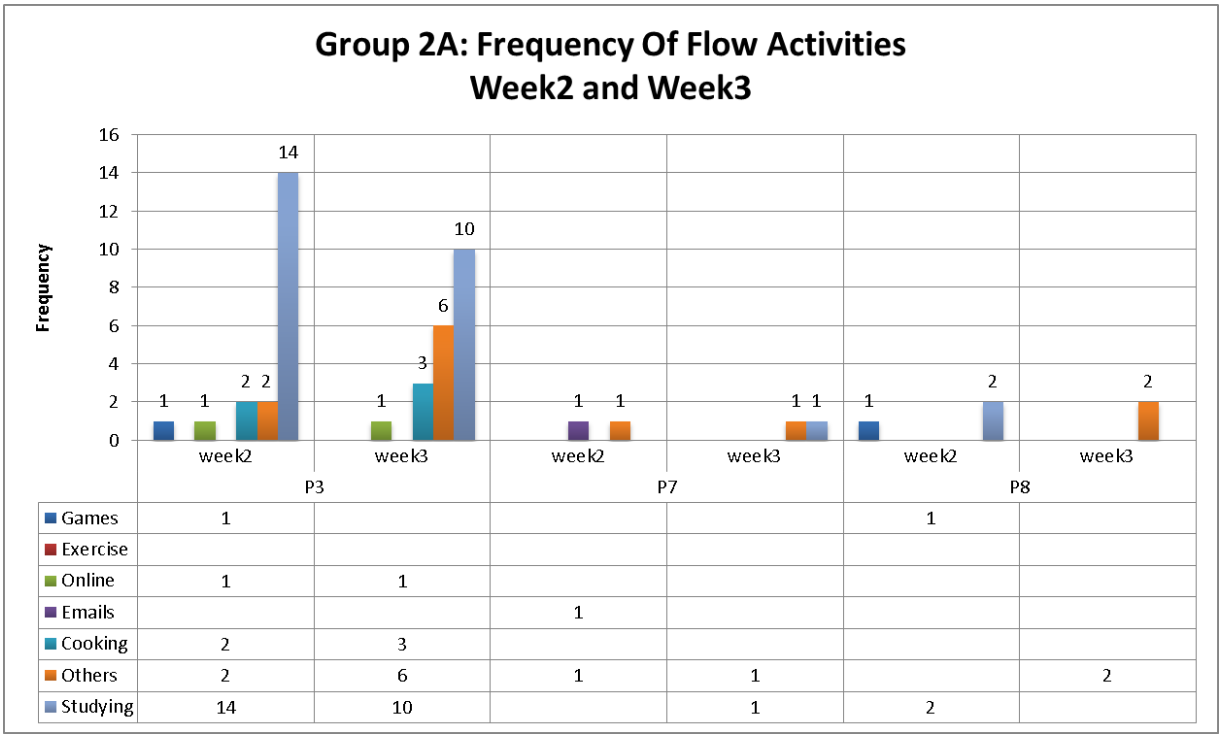
FIGURE 5.14: COMPARISON OF THE FREQUENCY OF DIFFERENT FLOW ACTIVITIES PER WEEK GROUPED BY PARTICIPANT ID

From FIGURE 5.16, for participant P3 in Week2, we find that activities such as 'Studying', 'Others' and 'Cooking' produce suitable flow conditions. During Week3 the frequency of 'Others' and 'Cooking' activity increased making it more likely for P3 to be in flow, despite the notifications being active. Thus we believe that the reverse behaviour as found in Group 2 where the percentage-of-time in flow during Week3 is greater than the percentage-of-time in flow during Week2 (see FIGURE 5.8) can be attributed to the increase in the frequency of flow-inducing activities during Week3.



	p2		p5		P6		P16		P33	
	week2	week3	week2	week3	week2	week3	week2	week3	week2	week3
games										
exercise	1	1				1		2		
online	2				1		1			
emails					2		4			
cooking	1					2	1		1	1
others	1				1	2	2	2	3	
studying	2	2	9	2	6	7	7	16	4	

FIGURE 5.15: COMPARISON OF THE FREQUENCY OF DIFFERENT FLOW ACTIVITIES FOR WEEK2 AND WEEK3, GROUPED BY PARTICIPANT ID TAKEN FROM GROUP 1 OF FIGURE 5.8



	P3		P7		P8	
	week2	week3	week2	week3	week2	week3
Games	1				1	
Exercise						
Online	1	1				
Emails			1			
Cooking	2	3				
Others	2	6	1	1		2
Studying	14	10		1	2	

FIGURE 5.16: COMPARISON OF THE FREQUENCY OF DIFFERENT FLOW ACTIVITIES FOR WEEK2 AND WEEK3, GROUPED BY PARTICIPANT ID TAKEN FROM GROUP2 OF FIGURE 5.8

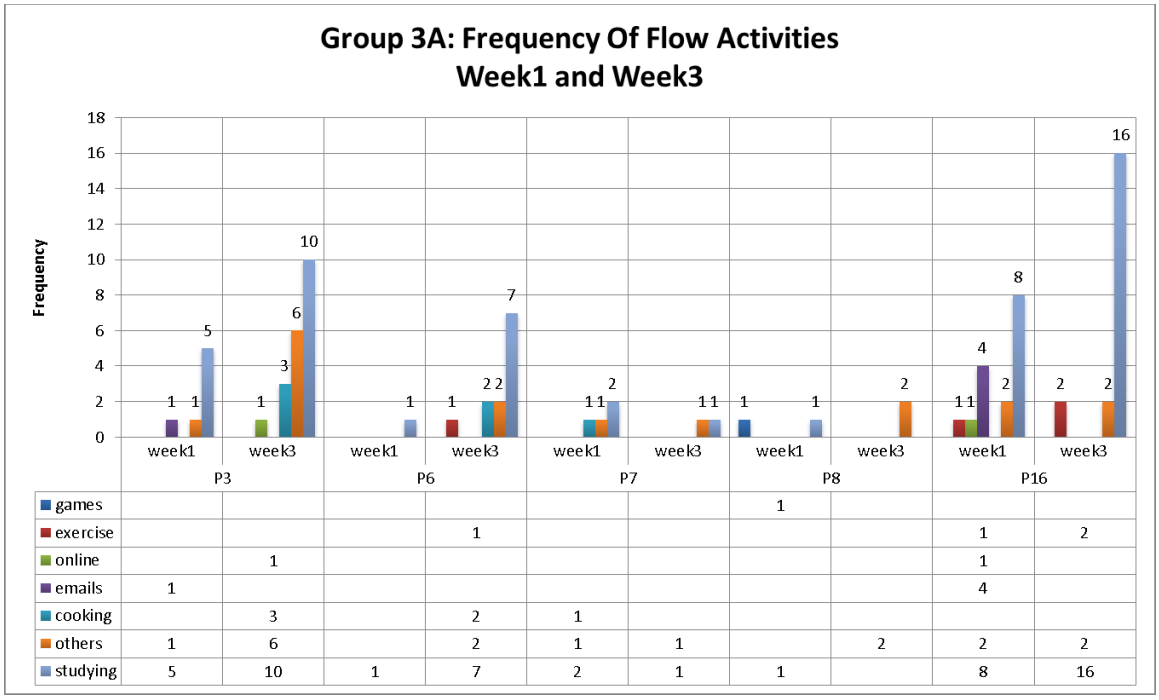


FIGURE 5.17: COMPARISON OF THE FREQUENCY OF DIFFERENT FLOW ACTIVITIES FOR WEEK1 AND WEEK3, GROUPED BY PARTICIPANT ID TAKEN FROM GROUP 3 OF FIGURE 5.9

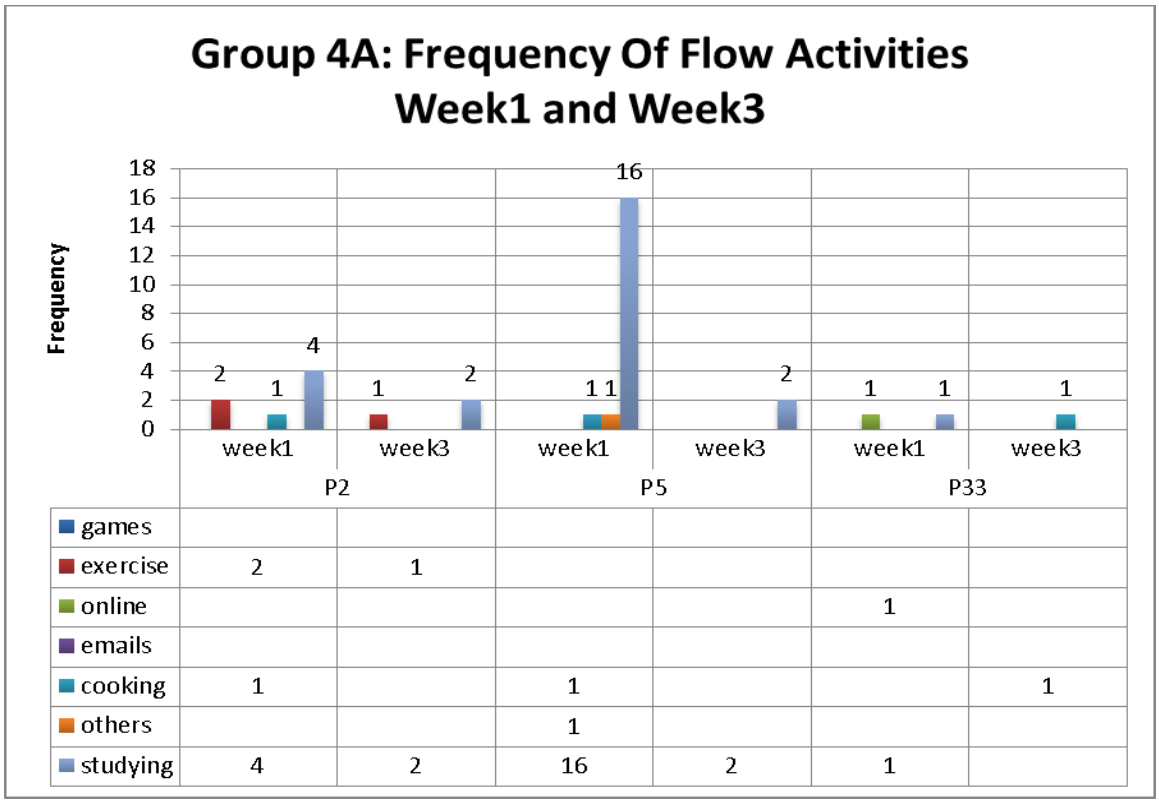


FIGURE 5.18: COMPARISON OF THE FREQUENCY OF DIFFERENT FLOW ACTIVITIES FOR WEEK1 AND WEEK3, GROUPED BY PARTICIPANT ID TAKEN FROM FROUP4 OF FIGURE 5.9

FIGURE 5.18 shows that for the participants P2, P5 and P33, there are not enough flow-inducing activities during Week3 when compared to Week1. P2 engaged less in the 'Exercise' and 'Studying' activity during Week3 as compared to Week1. Similarly, P5 who had spent a lot of time 'Studying' during Week1 spent very less time 'Studying' during Week3. Both of the participants reported during the end of Week3 interview that they had completed their thesis work and were rarely engaged in any flow related activities during Week3. This major change in their lifestyle caused their percentage-of-time in flow to reduce during Week3.

Along with the various activities which induced flow, the different notification settings during Week1 as compared to Week3 also played a role in affecting the percentage-of-time in flow. FIGURE 5.19 shows the notification settings of the different applications used by the participants that generate notifications.

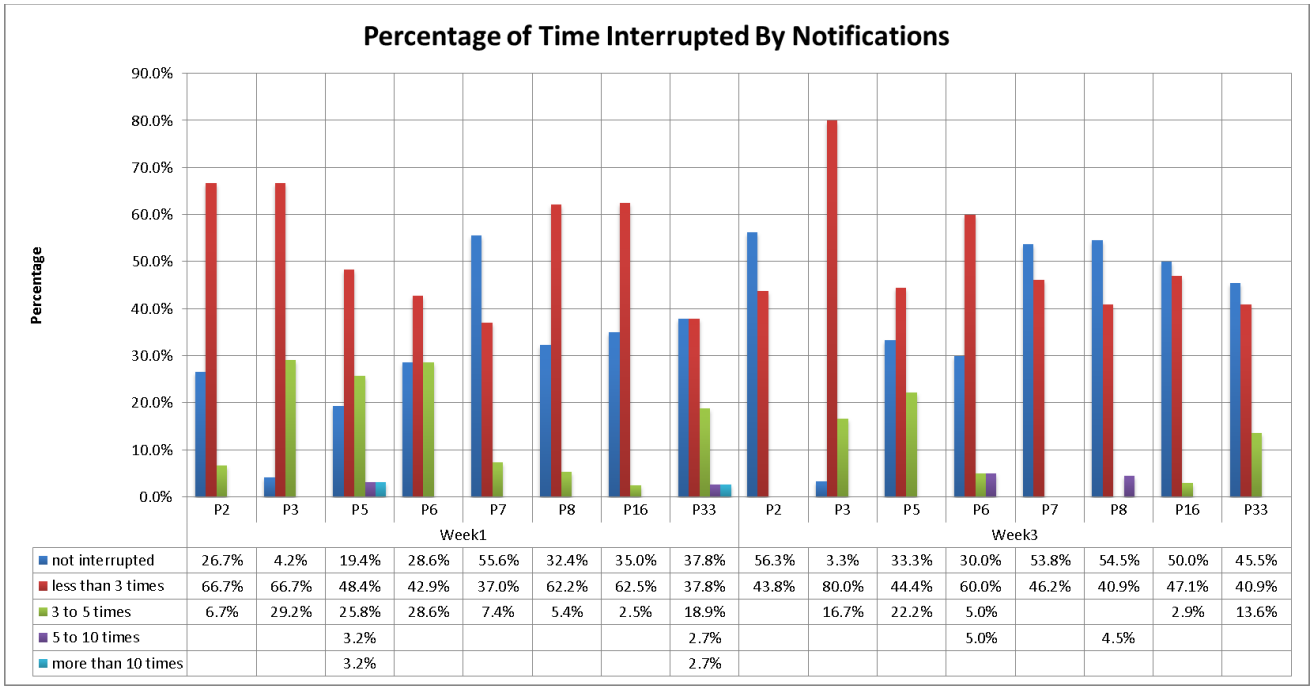
In the baseline condition of Week1 all the participants had their 'Email' notifications active. All participants except P3 used the 'Facebook' notifications and all participants except P7 used 'IM- Instant Messaging' notifications. Most of the participants had their 'Application Update', 'System Update' and 'Calendar' notifications active. During Week2 all the participants turned-off their notifications. Participants P16 and P33 kept their Calendar notifications active because they had multiple interview schedules planned for that week. In Week3 participants had the freedom to turn-on any notification. We suspected that 'Application' and 'System' update notifications and notifications from less frequently used applications would be kept turned-off by the participants. This hypothesis was partially correct as most of the participants chose to revert to their original notification setting configuration. P5 and P6 chose to turn-on all their application notifications. P5 and P33 kept the less frequently used application notification from 'Viber' turned-off. Few of the participants, P7, P8, and P16 kept their 'Facebook' notifications turned-off. P2 and P16 kept 'Application Update' and 'System Update' notifications turned-off, while P33 chose to turn-off only the 'Application Update' notification and turned-on the 'System Update' notification. Participants P5, P7, and P8, who used 'Calendar' notification during Week1, chose to turned-on the same in Week3.

	Week1								Week2								Week3							
Notifications from	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**
Facebook	✓		✓	✓	✓	✓	✓	✓	✗		✗	✗	✗	✗	✗	✗	✓		✓	✓	✗	✗	✗	✓
Twitter					✓								✗								✗			
Email	✓	✓	✓	✓	✓	✓	✓	✓	✗	✗	✗	✗	✗	✗	✗	✗	✓	✓	✓	✓	✓	✓	✓	✓
Instagram				✓								✗						✓		✓				
Microblog	✓	✓		✓		✓	✓	✓	✗	✗		✗		✗	✗	✗	✓	✗		✓		✓	✓	✓
Whatsapp/QQ/IM/WeChat	✓	✓	✓	✓		✓	✓	✓	✗	✗	✗	✗		✗	✗	✗	✓	✓	✓	✓		✓	✓	✓
Skype/Tango			✓								✗								✓					
Viber			✓				✓	✓			✗				✗	✗			✗					✗
Other SNS	✓			✓					✗			✗					✓	✗		✓			✓	✓
Application update	✓	✓	✓			✓	✓	✓	✗	✗	✗			✗	✗	✗	✗	✓	✓			✓	✗	✗
System update	✓		✓			✓	✓	✓	✗		✗			✗	✗	✗	✗		✓			✓	✗	✓
Spotify					✓								✗								✗			
Shopping Websites					✓								✗								✓			
Weather updates			✓								✗								✓					
Calendar			✓		✓	✓	✓	✓			✗		✗	✗	✓	✓			✓		✓	✓	✓	✓
	✓ = Notifications ON, ✗ = Notifications OFF																							

FIGURE 5.19: NOTIFICATION SETTINGS DURING WEEK1 (BASELINE), WEEK2 (NOT INTERRUPTED) AND WEEK3 (INTERRUPTED)

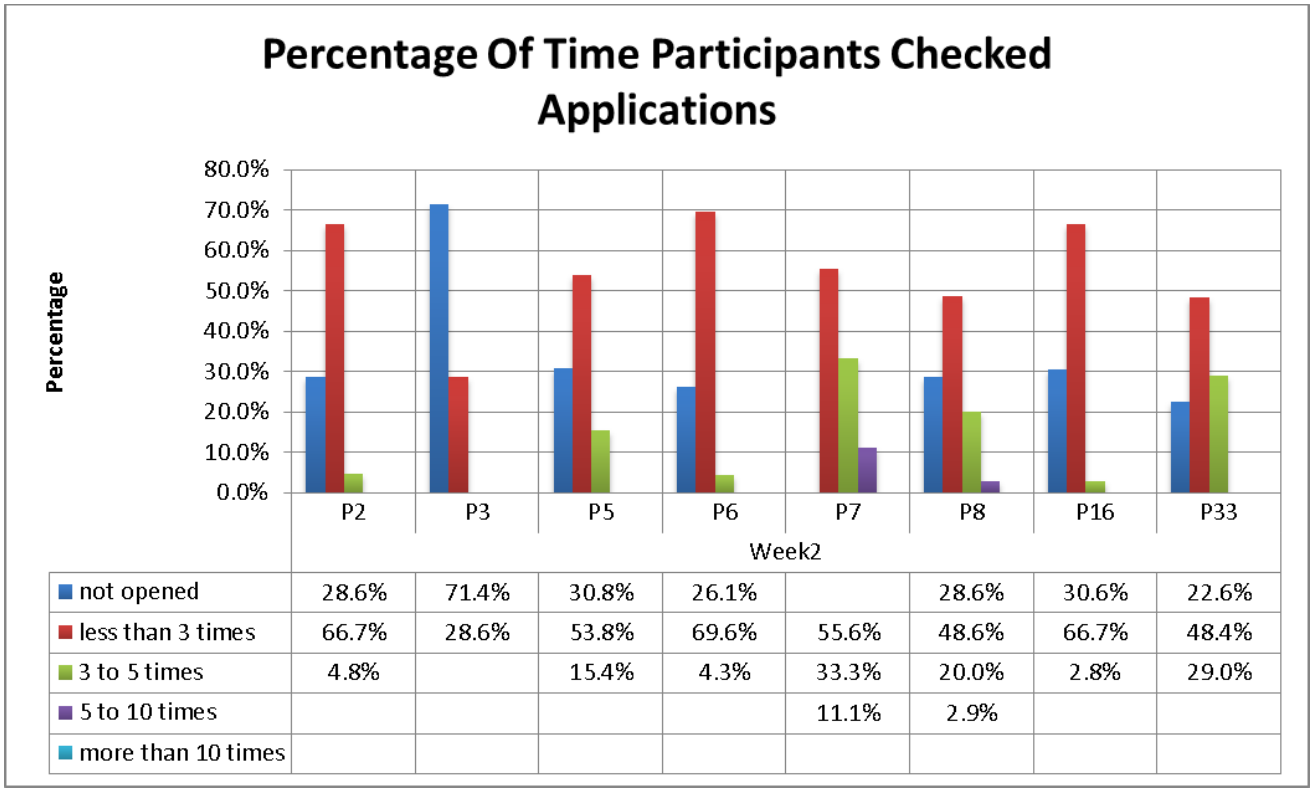
We further compared the percentage of time participants were interrupted by notifications during Week1 and Week3. We had asked participants to indicate on the ESF "How many times have you been interrupted by Notifications in the last 15 minutes?" using a 5-point Likert scale ("1= not interrupted", "2= less than 3 times", "3= 3 to 5 times", "4= 5 to 10 times", and "5= more than 10 times"). We did not use the frequency of occurrence of each scale as the number of responses varied between weeks. FIGURE 5.20 shows the percentage of time participants were interrupted by notifications during Week1 and Week3. A closer examination of the scale "less than 3 times" reveals that participants P2, P5, P8, and P16 were less interrupted during Week3 as compared to Week1. For the "not interrupted" scale, participants P2, P5, P6, P8, P16, and P33 were more "not interrupted" during Week3 as compared to Week1.

During Week2, as the notifications were turned-off we asked participants to indicate the number of times they had opened different applications in the last 30 minutes to check for updates. A 5-point Likert scale ("1= not opened", "2= less than 3 times", "3= 3 to 5 times", "4= 5 to 10 times", and "5= more than 10 times") was used to measure it. FIGURE 5.21 shows the percentage of the frequency of each scale. All participants except P3 spent more than 50% of their time checking applications for updates at least once every 30 minutes. Participant P7 and P8 spent 11.1% and 2.9% of their time checking applications for updates at least 5 times every 30 minutes respectively.



	P2	P3	P5	P6	P7	P8	P16	P33	P2	P3	P5	P6	P7	P8	P16	P33
	Week1								Week3							
not interrupted	26.7%	4.2%	19.4%	28.6%	55.6%	32.4%	35.0%	37.8%	56.3%	3.3%	33.3%	30.0%	53.8%	54.5%	50.0%	45.5%
less than 3 times	66.7%	66.7%	48.4%	42.9%	37.0%	62.2%	62.5%	37.8%	43.8%	80.0%	44.4%	60.0%	46.2%	40.9%	47.1%	40.9%
3 to 5 times	6.7%	29.2%	25.8%	28.6%	7.4%	5.4%	2.5%	18.9%		16.7%	22.2%	5.0%			2.9%	13.6%
5 to 10 times			3.2%					2.7%				5.0%		4.5%		
more than 10 times			3.2%					2.7%								

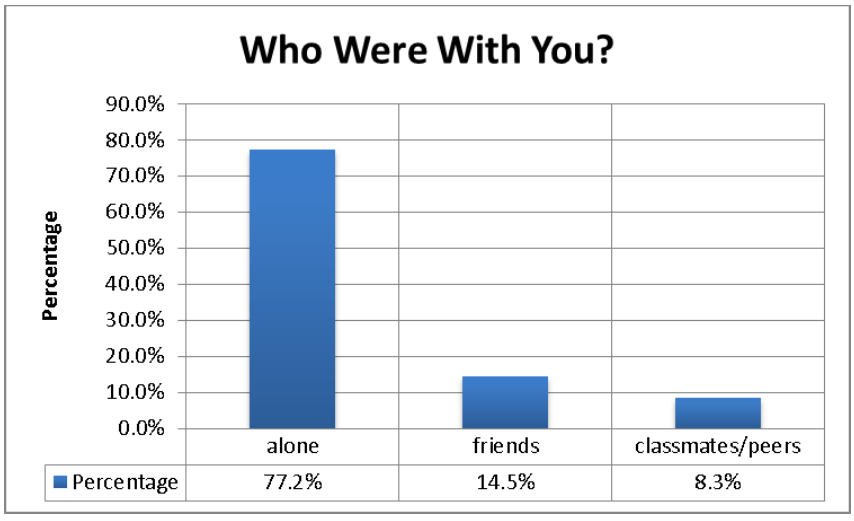
FIGURE 5.20: PERCENTAGE OF TIME PARTICIPANTS WERE INTERRUPTED BY NOTIFICATION DURING WEEK1 AND WEEK3.



	P2	P3	P5	P6	P7	P8	P16	P33
not opened	28.6%	71.4%	30.8%	26.1%		28.6%	30.6%	22.6%
less than 3 times	66.7%	28.6%	53.8%	69.6%	55.6%	48.6%	66.7%	48.4%
3 to 5 times	4.8%		15.4%	4.3%	33.3%	20.0%	2.8%	29.0%
5 to 10 times					11.1%	2.9%		
more than 10 times								

FIGURE 5.21: PERCENTAGE OF THE NUMBER OF TIMES PARTICIPANTS CHECKED APPLICATIONS FOR UPDATES DURING WEEK2

The ESF also asked the participants of their 'Companionship', "Who were with you, when you were signalled?". We collected their companionship entry corresponding to their flow states. Though we did not have any hypothesis for this category, it is interesting to find that nearly 80% of the time participants were alone when they experienced flow (FIGURE 5.22).

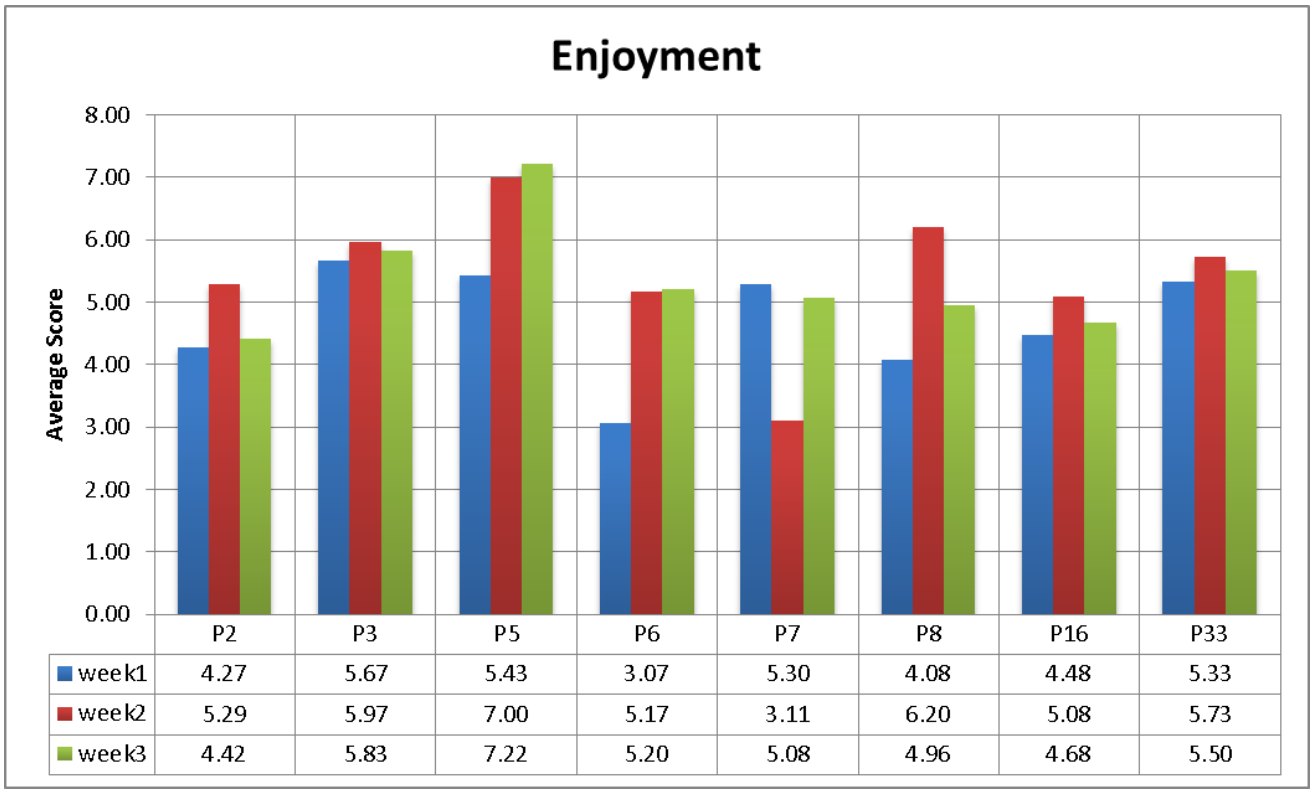


	alone	friends	classmates/peers
Percentage	77.2%	14.5%	8.3%

FIGURE 5.22: PERCENTAGE OF TIME PARTICPANTS SPENT IN COMPANIONSHIP

5.2.2 ENJOYMENT

'Enjoyment' is one of the many experiences attached with flow state. Participants indicated their level of enjoyment with the main activity using a 10-point Likert scale ("0= not at all", "3= somewhat", "6= quite", "9= very much"). We believed that participants would enjoy their activities more during Week2 as compared to Week1 and Week3 as there would be no interruptions by notifications. Our hypothesis was rejected as there was no significant effect of the absence or presence of notifications on enjoyment (Week1: M=4.70, SD=.88; Week2: M=5.44, SD=1.13; Week3: M=5.36, SD=.87), Wilks' Lambda = .601, F (2, 6) = 1.991, p = ns. FIGURE 5.23 shows the average 'Enjoyment' score for each of the participants during Week1, Week2, and Week3. Though the results were not significant, all participants except P7 had a higher 'Enjoyment' score during Week2 compared to Week1. The level of 'Enjoyment' decreased in Week3 (as compared to Week2) for participants P2, P3, P8, P16, and P33. A higher score for P5 during Week3 can be attributed to the fact that the participant had completed the post-graduation course in that week.



	P2	P3	P5	P6	P7	P8	P16	P33
week1	4.27	5.67	5.43	3.07	5.30	4.08	4.48	5.33
week2	5.29	5.97	7.00	5.17	3.11	6.20	5.08	5.73
week3	4.42	5.83	7.22	5.20	5.08	4.96	4.68	5.50

FIGURE 5.23: PARTICIPANTS' AVERAGE ENJOYMENT SCORE DURING WEEK1, WEEK2, AND WEEK3

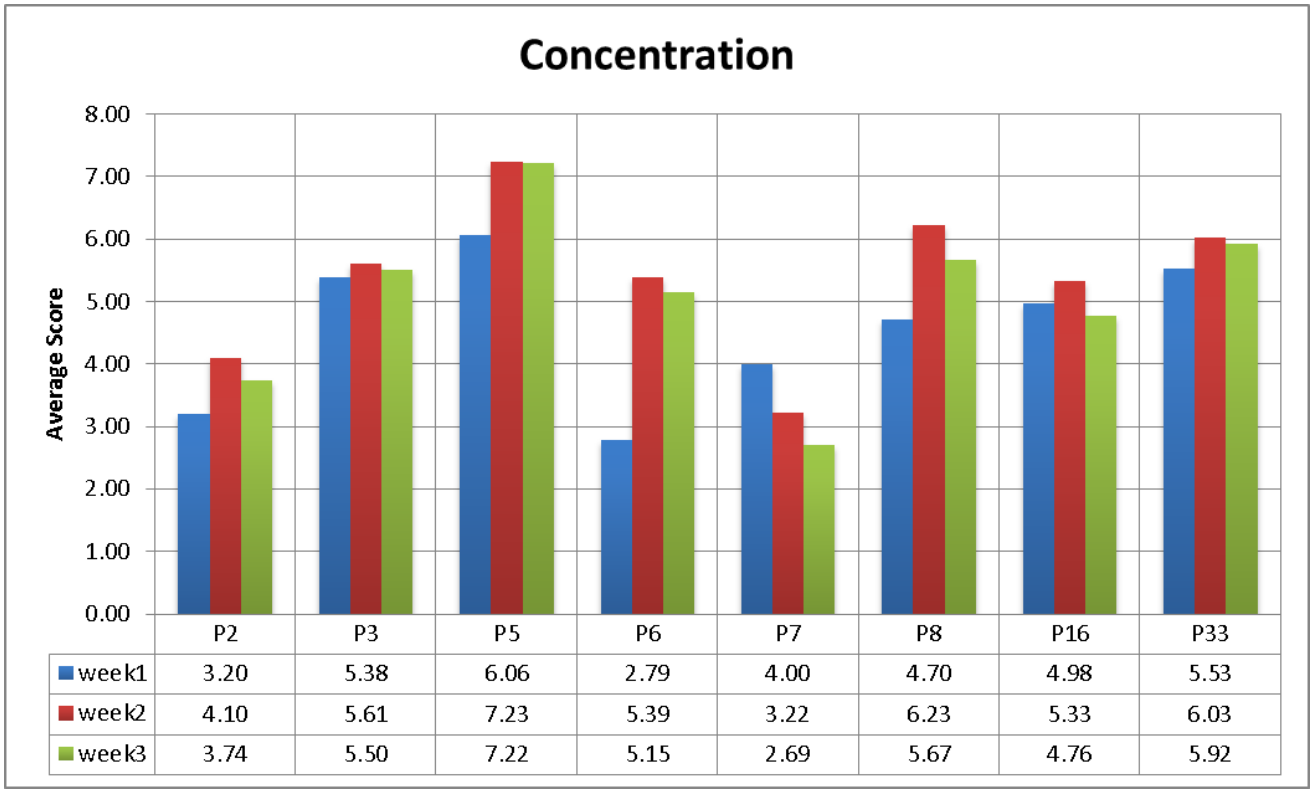
5.2.3 CONCENTRATION

We believed that the participants will be able to concentrate more during Week2 as compared to Week1 and Week3 as they would be less interrupted by notifications during Week2. We asked participants how well they were concentrating on the main activity and captured their response using a 10-point Likert scale ("0= not at all", "3= somewhat", "6= quite", "9= very much"). There was a significant effect of the absence of notifications on the level of concentration, Wilks' Lambda = .215, F (2, 6) = 10.94, p = .01. Three paired samples t-tests were used to make post hoc comparisons between conditions.

The first paired samples t-test indicated that there was no significant difference in the level of concentration for baseline (Week1) (M=4.58, SD=1.15) and not interrupted (Week2) (M=5.39, SD=1.25) conditions; t(7) = -2.29, p = ns. The second paired samples t-test also indicated that there was no significant difference in the level of concentration for baseline (Week1) (M=4.58, SD=1.15) and interrupted (Week3) (M=5.08, SD=1.38) conditions; t(7) = -1.32, p = ns. But, the third paired samples t-test showed that there was a significant difference in the level of concentration for not interrupted (Week2) (M=5.39, SD=1.25) and interrupted (Week3) (M=5.08, SD=1.38) conditions; t(7) = 3.90, p = .006.

The above results show that the absence of notifications during Week2 resulted in a significantly higher level of concentration among the participants compared to Week3 when the notifications were active. However, there was no significant difference between Week1 and Week2 or Week1 and Week3.

FIGURE 5.24 shows the average 'Concentration' score of the participants during Week1, Week2, and Week3. Though the results for Week1 and Week2 were not significant, we can see that the 'Concentration' score for all the participants except P7 is higher during Week2. Again the 'Concentration' score drops during Week3 for all the participants. When comparing Week1 with Week3, we do not find any discernible trend to exploit.



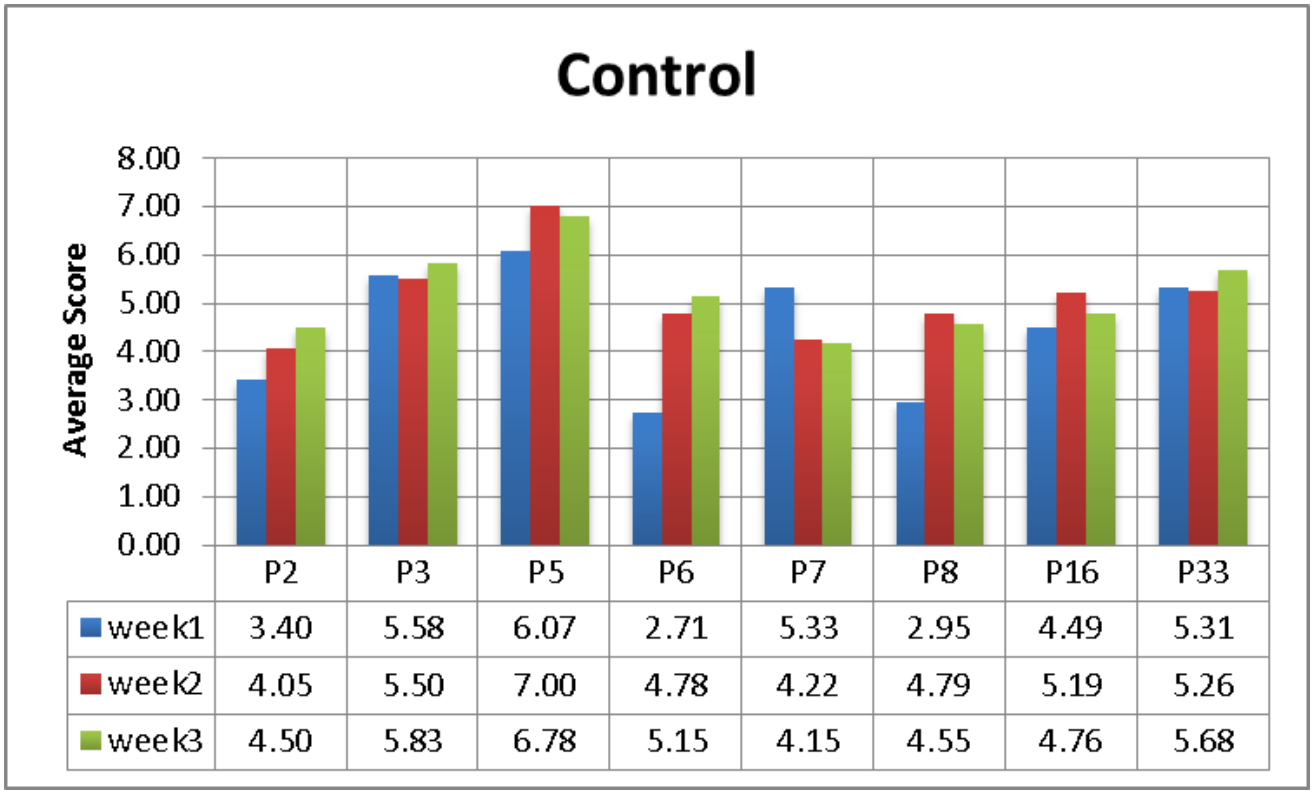
	P2	P3	P5	P6	P7	P8	P16	P33
week1	3.20	5.38	6.06	2.79	4.00	4.70	4.98	5.53
week2	4.10	5.61	7.23	5.39	3.22	6.23	5.33	6.03
week3	3.74	5.50	7.22	5.15	2.69	5.67	4.76	5.92

FIGURE 5.24: PARTICIPANTS' AVERAGE CONCENTRATION SCORE DURING WEEK1, WEEK2, AND WEEK3

5.2.4 CONTROL

We asked participants if they were in control of the situation and captured their response using a 10-point Likert scale ("0= not at all", "3= somewhat", "6= quite", "9= very much"). We did not have *a priori* hypothesis for this variable. FIGURE 5.25 shows the average 'Control' score of the participants during

Week1 (M= 4.48, SD= 1.29), Week2 (M= 5.09, SD= .91), and Week3 (M= 5.17, SD= .87). Participants P3, P5, P16, and P33 have scores above the variable's mean of 4.5, and also show a consistent control across the three weeks. There was no significant effect of presence or absence of notifications on Control; Wilks' Lambda = .673, F (2, 6) = 1.457, p = ns.



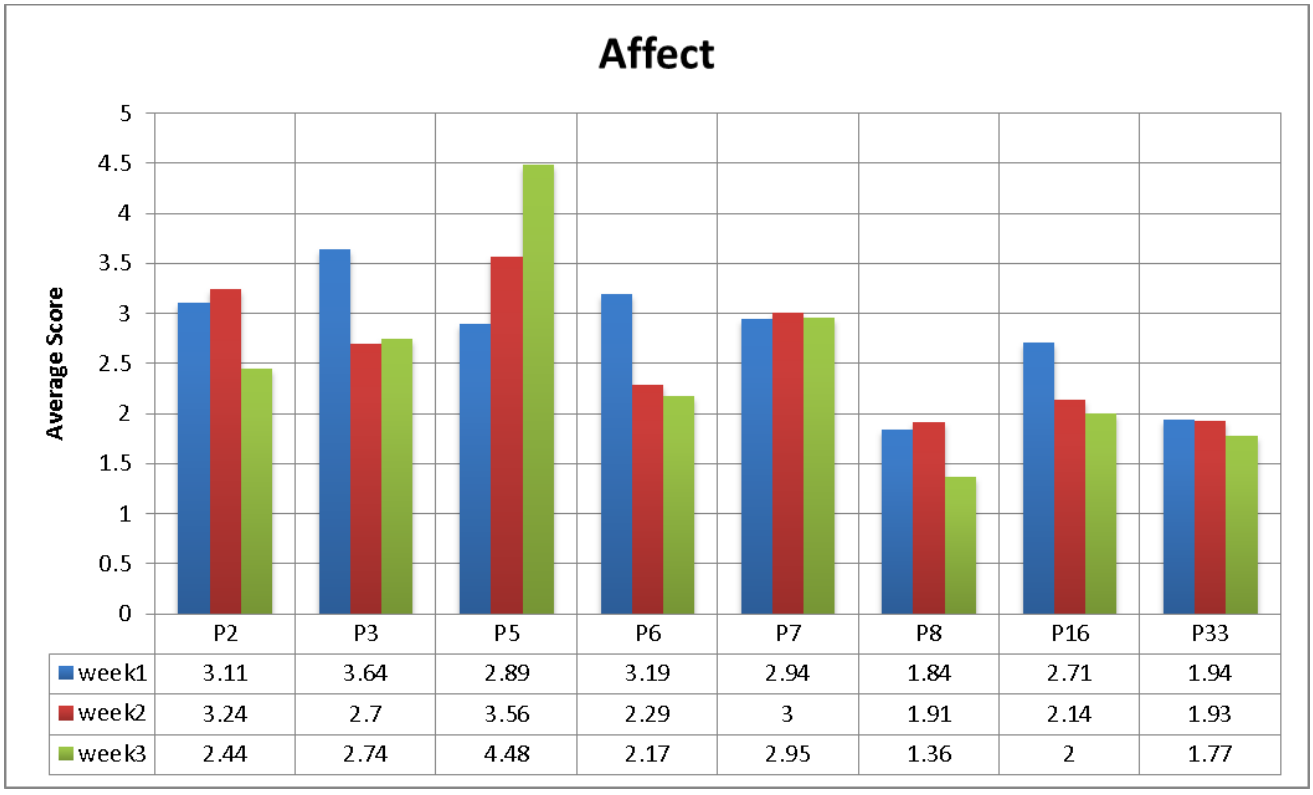
	P2	P3	P5	P6	P7	P8	P16	P33
week1	3.40	5.58	6.07	2.71	5.33	2.95	4.49	5.31
week2	4.05	5.50	7.00	4.78	4.22	4.79	5.19	5.26
week3	4.50	5.83	6.78	5.15	4.15	4.55	4.76	5.68

FIGURE 5.25: PARTICIPANTS' AVERAGE CONTROL SCORE DURING WEEK1, WEEK2, AND WEEK3

5.2.5 AFFECT AND POTENCY

Affect:

In general, flow state is associated with positive affect. We used an aggregation of 3 variable, 'Happy', 'Sociable', and reverse of 'Irritated' on a 7-point Likert scale ("0= not at all", "2= a little", "4= somewhat", "6= very much") to measure the 'Affect' of each of the participants. Our hypothesis stated that participants would indicate more positive affect during Week2 as compared to Week1 and Week3. Our hypothesis was rejected as there was no significant effect of presence or absence of notifications on affect (Week1: M=2.78, SD=.61; Week2: M=2.59, SD=.62; Week3: M=2.49, SD=.95), Wilks' Lambda = .871, F (2, 6) = .444, p = ns. FIGURE 5.26 shows the 'Affect' scores for the participants during Week1, Week2, and Week3. A closer examination reveals that most of the 'Affect' score values are lower than the average score of 3. We have reasons to believe that this was due to a design flaw in the ESF which led to a floor effect in the data set. Hence no further analysis was performed on the 'Affect' data set.

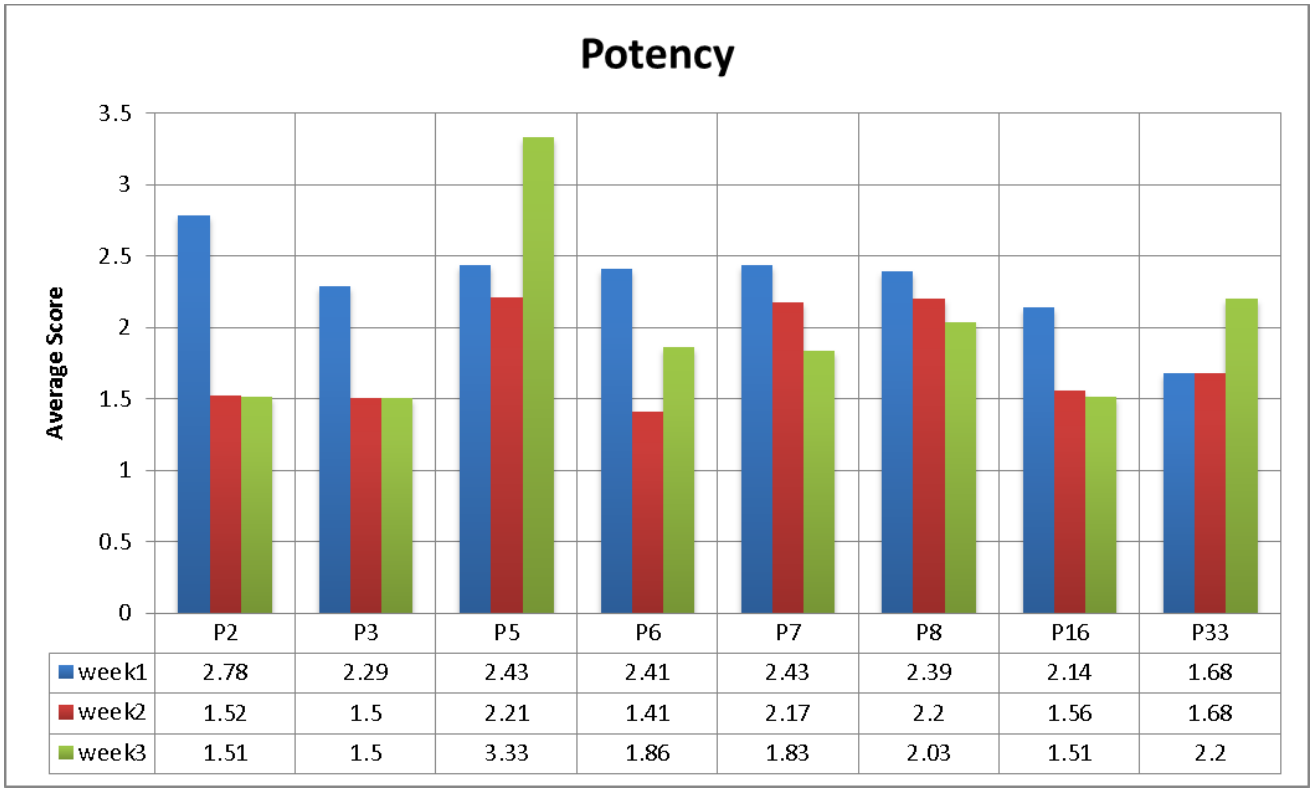


	P2	P3	P5	P6	P7	P8	P16	P33
week1	3.11	3.64	2.89	3.19	2.94	1.84	2.71	1.94
week2	3.24	2.7	3.56	2.29	3	1.91	2.14	1.93
week3	2.44	2.74	4.48	2.17	2.95	1.36	2	1.77

FIGURE 5.26: PARTICIPANTS' AVERAGE AFFECT SCORE DURING WEEK1, WEEK2, AND WEEK3. AFFECT IS A COMPOSITE TERM MADE UP OF 'HAPPPY', 'SOCIABLE', AND '(NOT) IRRITATED'

Potency:

'Potency' is the measure of the level of activation or alertness during the flow state. We measured 'Potency' with 4 variables, 'Alert', 'Strong', 'Excited', and 'Passive (reversed)' using a 7-point Likert scale ("0= not at all", "2= a little", "4= somewhat", "6= very much"). We hypothesized that the 'Potency' of an individual would reduce during Week2 because of fewer interruptions, more flow activity and deprivation from habitual behaviour (section 6.1.3). FIGURE 5.27 shows the average 'Potency' scores for the participants for Week1 (M=2.31, SD=.31), Week2 (M=1.78, SD=.35), and Week3 (M=1.97, SD=.61). Though there was a significant effect of notifications on potency, Wilks' Lambda = .320, F (2, 6) = 6.37, p = .033; we found that all the 'Potency' scores are lower than the average score of 3. This is again attributed to the design flaw in the ESF. Hence no further quantitative analysis was performed on the 'Potency' data set.



	P2	P3	P5	P6	P7	P8	P16	P33
week1	2.78	2.29	2.43	2.41	2.43	2.39	2.14	1.68
week2	1.52	1.5	2.21	1.41	2.17	2.2	1.56	1.68
week3	1.51	1.5	3.33	1.86	1.83	2.03	1.51	2.2

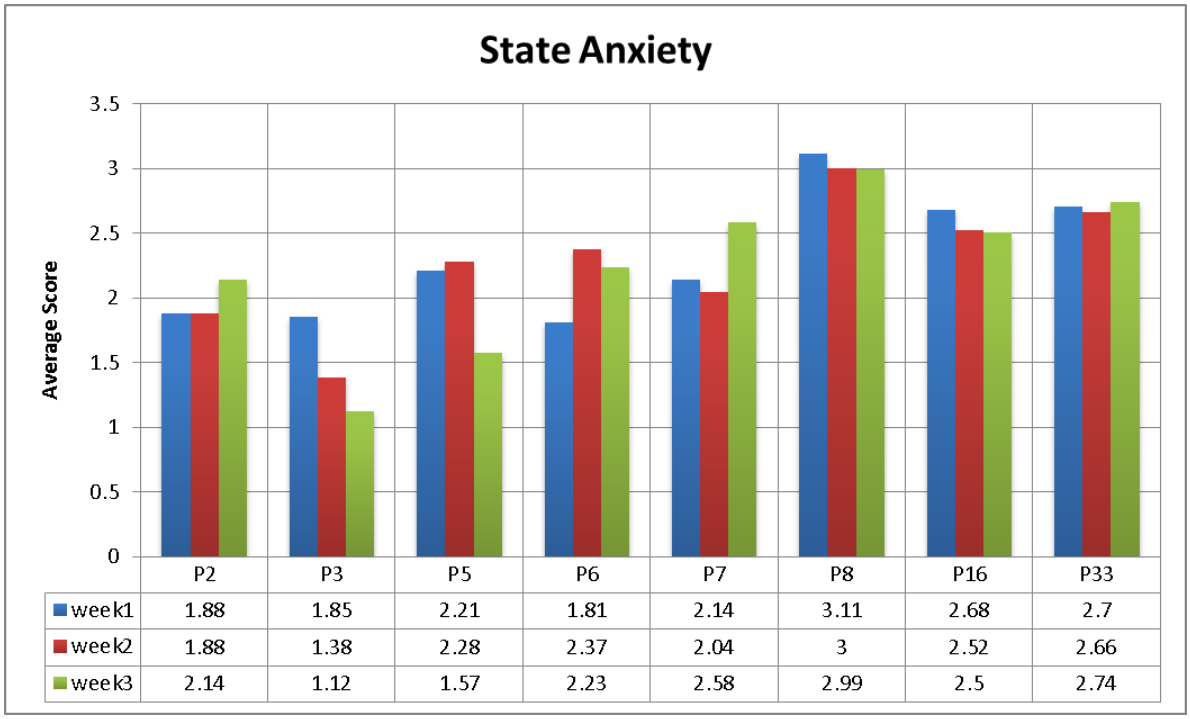
FIGURE 5.27: PARTICIPANTS' AVERAGE POTENCY SCORE DURING WEEK1, WEEK2, AND WEEK3. POTENCY IS A COMPOSITE TERM MADE UP OF 'ALERT', 'STRONG', 'EXCITED', AND '(NOT) PASSIVE'

5.2.6 STATE ANXIETY

The state-anxiety was measured using the STAI-6 questions. STAI-6 uses 6 variables on a 4-point Likert scale ("1= not at all", "2= somewhat", "3= moderately", and "4= very much") to obtain the average STAI-6 score. We hypothesized that the state anxiety would be lower during Week2 due to absence of notifications. The quantitative results proved otherwise; there was no significant effect of presence or absence of notifications on state anxiety (Week1: M=2.29, SD=.48; Week2: M=2.26, SD=.5; Week3: M=2.23, SD=.62), Wilks' Lambda = .978, F (2, 6) = .069, p = ns. This non significance can be attributed to the fact that state anxiety was associated with multiple factors. For instance, in some cases anxiety was used in the context with the main activity that the participants were then engaged in and were planning to accomplish. And at other times it was associated with the uncertainty of absence of information due to lack of notifications. For the latter case participants indicated that they spent time opening applications to check for updates as they had notifications turned-off. FIGURE 5.21 shows the percentage of the number of times participants opened applications to check for updates during week2. A qualitative analysis of state anxiety is provided later. FIGURE 5.28 shows the 'State Anxiety' scores for the participants during Week1, Week2, and Week3.

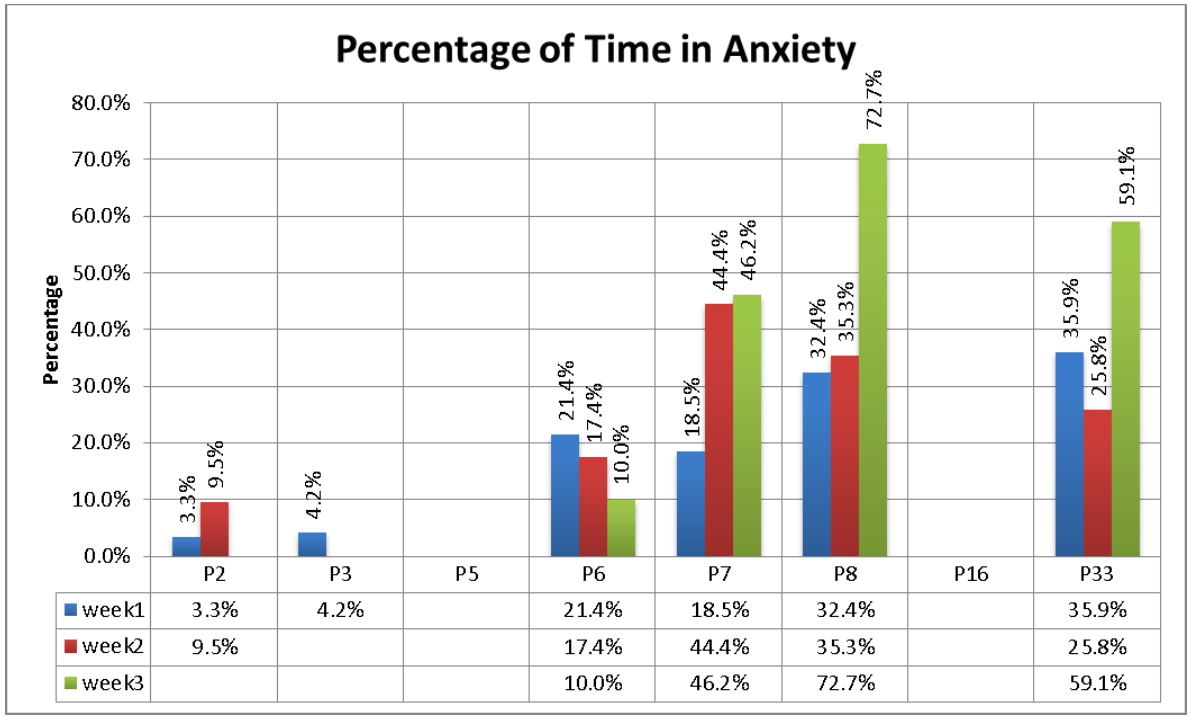
As the STAI-6 scale was unable to provide any conclusive results, we decide to calculate the percentage-of-time in anxiety using the procedure that was used to calculate the percentage-of-time in flow. FIGURE 5.29 shows the percentage of time spent in anxiety by the participants during Week1, Week2, and Week3. We performed repeated measures ANOVA to check for significance. There was no significant effect of presence or absence of notifications on the percentage-of-time in anxiety (Week1: M=14.47, SD=14.61;

Week2: M=16.55, SD=17.26; Week3: M=23.49, SD=30.69), Wilks' Lambda = .788, F (2, 6) = .806, p = ns. Again, we did not find any interesting trend except that participant P8 and P33 spent more than 50% of their time in anxiety during Week3.



	P2	P3	P5	P6	P7	P8	P16	P33
week1	1.88	1.85	2.21	1.81	2.14	3.11	2.68	2.7
week2	1.88	1.38	2.28	2.37	2.04	3	2.52	2.66
week3	2.14	1.12	1.57	2.23	2.58	2.99	2.5	2.74

FIGURE 5.28: PARTICIPANTS' AVERAGE STATE ANXIETY SCORE DURING WEEK1, WEEK2, AND WEEK3



	P2	P3	P5	P6	P7	P8	P16	P33
week1	3.3%	4.2%		21.4%	18.5%	32.4%		35.9%
week2	9.5%			17.4%	44.4%	35.3%		25.8%
week3				10.0%	46.2%	72.7%		59.1%

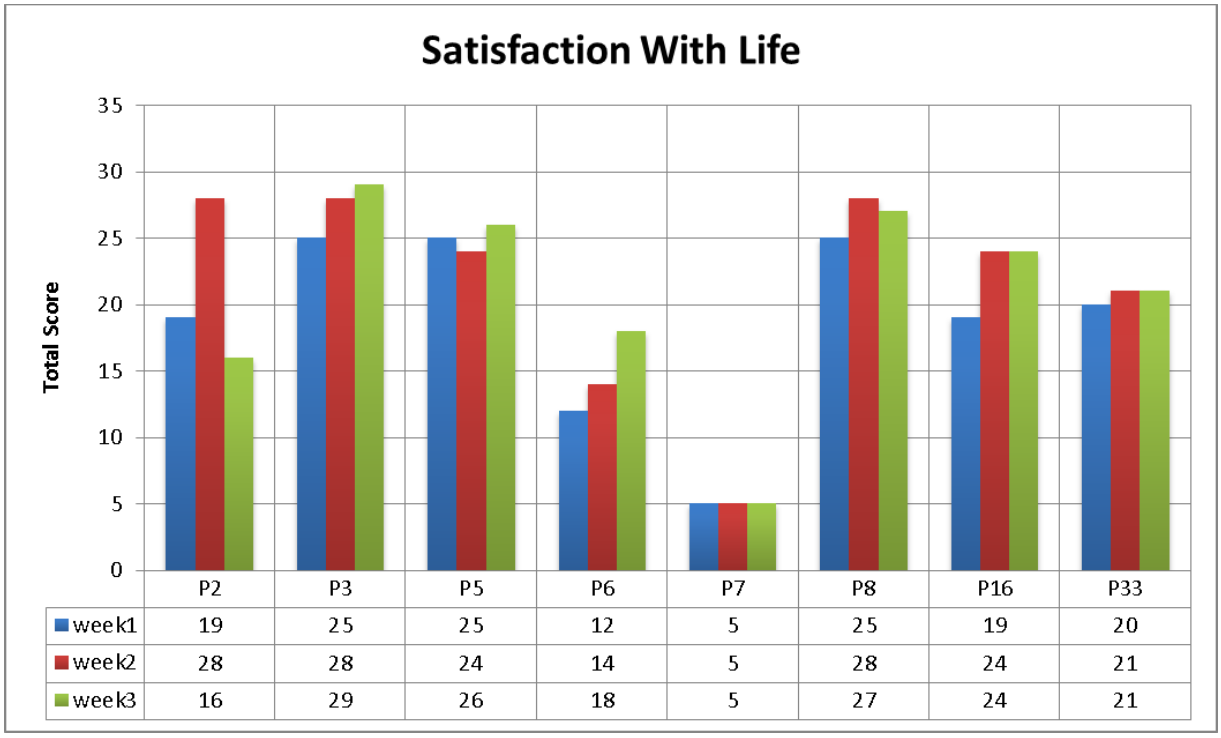
FIGURE 5.29: PERCENTAGE-OF-TIME IN ANXIETY DURING WEEK1, WEEK2, AND WEEK3, GROUPED BY PARTICIPANT ID

5.2.7 SATISFACTION WITH LIFE

Satisfaction with life was measured using the SWLS. We used the sum of the absolute score of 5 variables on a 7-point Likert scale ("1= strongly disagree" to "7= strongly agree") to obtain the SWLS score. As SWLS was administered at the end of each week, we hypothesized that the absence of notifications during Week2 would lead to a significantly higher SWLS score for the participants for Week2 when compared to Week1 and Week3. Though there was a significant effect of notifications on satisfaction with life, Wilks' Lambda = .350, F (2, 6) = 5.56, p = .043; the results of the post hoc comparisons using paired samples t-tests were not significant.

The first paired samples t-test between the baseline (Week1: M=18.75, SD=7.11) and not interrupted (Week2: M=21.50, SD=8.17) conditions were not significant; t(7) = -2.47, p = ns. The second paired samples t-test between the baseline (Week1: M=18.75, SD=7.11) and interrupted (Week3: M=20.75, SD=7.77) conditions was also not significant; t(7) = -1.93, p = ns. The third paired samples t-test between not interrupted (Week2: M=21.50, SD=8.17) and interrupted (Week3: M=20.75, SD=7.77) conditions was also not significant; t(7) = .442, p = ns.

FIGURE 5.30 shows the SWLS scores for the participants for end of Week1, Week2, and Week3. Except for participant P2, all other participants have approximately same SWLS scores for the 3 weeks. We find that participants P2, P3, P8, P16, and P33 have a higher SWLS score for Week2 when compared with Week1. There is no single trend to exploit for comparing Week1 with Week3, and Week2 with Week3.



	P2	P3	P5	P6	P7	P8	P16	P33
week1	19	25	25	12	5	25	19	20
week2	28	28	24	14	5	28	24	21
week3	16	29	26	18	5	27	24	21

FIGURE 5.30: PARTICIPANTS' SATISFACTION WITH LIFE SCORE AT THE END OF WEEK1, WEEK2, AND WEEK3

TABLE 5.2 summarizes the quantitative analysis results.

	Week1		Week2		Week3		Wilks' Lambda p*	Significance, p**		
Dependent Variables	**M**	**SD**	**M**	**SD**	**M**	**SD**		**Week1 - Week2**	**Week2 - Week3**	**Week1 - Week3**
Percentage-of-time in flow	23.21	19.56	39.98	21.09	32.07	25.72	.005*	.004**	.302	.401
Enjoyment	4.70	0.88	5.44	1.13	5.36	0.87	.217			
Concentration	4.58	1.15	5.39	1.25	5.08	1.38	.010*	.056	.006**	.228
Control	4.48	1.29	5.09	0.91	5.17	0.87	.305			
Affect	2.78	0.61	2.59	0.62	2.49	0.95	.661			
Potency	2.31	0.31	1.78	0.35	1.97	0.61	.033*	.011	.296	.209
State-anxiety	2.29	0.48	2.26	0.50	2.23	0.62	.978			
Satisfaction-with-life	18.75	7.11	21.50	8.17	20.75	7.77	.043*	.043	.672	.095

*= Significance level= .05; **= Significance level= 0.017

TABLE 5.2: SUMMARY OF DESCRIPTIVE AND INFERENTIAL STATISTICS OF DEPENDENT VARIABLES

5.3 QUALITATIVE ANALYSIS

Each participant was interviewed 3-times during the study period. One of the participants was unable to attend the end of Week3 interview due to personal reasons. We conducted 23 end-of-week interviews which generated over 180 minutes of recording (after editing[4]). All the interviews were transcribed and grouped under their respective week. We then used emergent and *a priori* coding schemes for coding and categorization of the transcripts. As per *a priori* coding, the categories were established prior to any analysis. These categories correspond to the themes (section 3.3) upon which the interview questions were based on. Emergent coding was then performed on the transcriptions. We report the results of the coding below.

5.3.1 FLOW ACTIVITIES

As a part of the *flow* study, we were interested in learning about the participants' everyday flow activities. This would solve two purposes, first, cross referencing of the end of the week interview data to the ESF data collected over that week to check for similar event occurrences, and second, to find out which of the everyday events contributes to flow experiences. Hence, during the interviews we directed a simple

[4] Editing of the audio involved removal of short and long pauses and filler words

question at the participant to share his/her most productive and engaging experience during that week. Considering the entire study period of three weeks, the most common everyday activity that induced *flow* was 'Studying' and its variants such as, reading, writing, editing, learning, data analysis, etc. It must be noted that these events were not random occurrences, but were directed to achieve a goal. For instance, we found that reading news events and social updates on the web were not interpreted as flow neither in the sampling data nor in the interviews. On the other hand, reading of a research paper that would contribute to achieving a goal for that week was considered to be a flow activity. This is supported by the below participants' comments.

> *"I was working on my dissertation and I was very involved. I was highly focussed." – P3 Week1*
>
> *"I was analysing data for the whole time." – P5 Week1*
> *"I was writing a dissertation obviously that week and I was concentrating only that." – P5 Week2*
>
> *"Last week I was doing some data analysis in statistics and I was quite focussed when I was working on it." – P7 Week1*
>
> *"I was writing something for hours uninterrupted." – P8 Week1*
> *"Last week I was writing my dissertation and was thoroughly focussed on it. ...Just very effectively. …Just stopped talking with my friends. I don't care about all other friends if they want to contact me. I was able to write a lot of words." – P8 Week2*
>
> *"I was preparing an experiment for my study." – P33 Week1*
>
> *"Yes I had such experience last week. I have my own research, so I was quite focussed on analysing my data in detail. I think that's the particular experience." – P16 Week2*

Some of the other activities that were considered to be engaging included playing games, learning a new language and performing yoga or exercise. Writing and editing of email was also reported to be a flow activity. We were able to confirm these claims with the ESF data as quantitative analysis found these activities to be ideal for flow condition (high challenge and high skills). Below are some of the other participants' comments that support the ESF data (Figure 5.14).

> *"I was involved when I was editing emails." – P16 Week1*
>
> *"That was when I tried to study Japanese language. Every day I spent 3-4 hours trying to study more about Japanese language. That's the experience when I was highly immersed." – P3 Week2*
>
> *"While I was playing games in the party..." – P33 Week2*

5.3.2 FLOW INTERRUPTED

For the Week1 and Week3 interviews, we slightly modified the straightforward flow activity question, and asked participants to describe a recent situation where they were focused on an activity and were interrupted by an incoming notification. This question was followed by questions on emotional response, actions towards notification, resumption lag, and if they were frustrated or felt at-ease on receiving the notification. The sole purpose of asking this question was to reconstruct the same scenario that the participants experienced during the week and to determine if they perceived notifications to be disruptive to their main activity when in *flow*-like state. Below are two transcripts from end-of-Week3 interviews.

"It was last Thursday, I was very focussed on writing of my dissertation and I received an email notification. …To be honest I did not feel so annoyed. …Just a bit curious as to who has sent the email. …I checked the notifications [immediately] and found it to be a spam. I ignored it. …I was neither frustrated nor at ease…No it did not affect my task [main activity]. It took a while but it was fine." – P3 Week3

"I was once studying in the library and received a notification. …I felt interrupted. No other feelings. …[I received notification from] WeChat (an Instant Messaging application). …I checked it immediately and replied to my friend. …I think I was at ease. …[I had it turned-on] Because if my friends want to contact me, I can immediate know the messages. …I felt happy and relaxed after I replied to my friend. At the same time I felt a little bit tensed about my work because I have to rethink where I was. Because it was from my friend so I wanted to reply [immediately]. …When I turned back to my main activity, I was a little bit worried. I wanted to accomplish my main activity as soon as possible but I was interrupted and so a little bit worried and tensed." – P16 Week3

Participants expressed mixed feelings when they were interrupted by notifications. They did not necessarily feel frustrated but used negative affective words and in some cases descriptive sentences to convey their emotions [1], [17]. Below are some of the comments from the participants comparing their experience of being interrupted during Week1 and Week3.

"I have a thought that someone is pinging, that's all. It might be important or might not be. So I'll check when I'm free, but not now. …I was at ease when I received it as I have got used to it." – P5 Week1
"As usual I just felt someone is pinging me. Just thought for a second." – P5 Week3

[on receiving an email notification] "I was annoyed because it wasn't a working day. But I was not frustrated." – P7 Week3

"I am busy with the writing and do not have a lot of time. But I do not feel happy or irritated. Just okay that I got a notification." – P8 Week1
[on receiving an IM communication] "Well, it's annoying. I was focused but my friend wanted to find me. Actually I feel really annoying and frustrating." – P8 Week3

"I was a little afraid that I will miss something." – P33 Week1
[while in a Yoga class] "I ignored it a little. It interrupted others in the class. …May be a little frustrated. I was a little confused about who sent me the message." – P33 Week3

Interestingly we find that participant P8 who had a neutral feeling towards notifications during Week1 developed a negative stance during Week3. Similarly, participant P33 had a somewhat descriptive tone to the interruption experience during Week1 but experienced a little frustration during Week3. Participant P5 had a stable reaction during both the weeks. In this context, we find that the average 'Control' score for P5 is quite high and remains above average during all the three weeks (FIGURE 5.25).

5.3.3 Flow Experience

Every flow activity is accompanied by its typical *flow* experience. While describing their flow activities, participants also shared their flow experiences. In general, participants claimed to be effective, immersed, focused, productive, unconscious of their surroundings, and unaware of how fast the time was passing.

We were also able to capture these flow constructs using the ESF. Below are a few comments from the participants describing their flow experiences. These comments can be read independently as well as in conjunction with the flow activity comments in section 5.3.1

[Lost track of time] "…a little bit." – P2 Week1

"I was really immersed. I was also unconscious of the time passing, and I did not know that it is already three or four hours." – P3 Week2

"I am not aware of whatever is happening." – P5 Week1
"I was a bit tensed. Okay. I was quite productive and was not aware of the surroundings." – P5 Week2

"I was quite focussed when I was working on that." – P7 Week1

"It is a feeling that I don't get any interruptions, I am focussed, and it is effective. I can finish my work quickly." –P8 Week2

"I was involved when I [was] editing emails." – P16 Week1
"When I was really concentrating… I won't check the time, and maybe cannot track how long I have been analysing [data]." – P16 Week2

"It was very interesting. I lost track of time." – P33 Week2

5.3.4 NOTIFICATION-HANDLING STRATEGIES

Self-regulation strategies (SRS) are typical to goal-directed activities (section 2.2). We were interested in the extension of participants' SRS to handle their everyday notifications, which we refer to as notification-handling strategies. But, as strategies are closely associated with goals, we first asked our participants to reiterate their goals for that week. All participants had clear and achievable goals for themselves for each week. Below are few of the goals that were shared with the interviewer during the end of week interviews.

"…preparing documents for VISA." – P2 Week1

"I should finish 5000 words for my thesis and every day I should workout for 2 hours." – P3 Week1
"I must say, I am having two Japanese language books. So my goal was to go through every single page of one of the books." – P3 Week2
"…to complete my dissertation." – P3 Week3

"I just had a deadline that I have to finish my analysis of data within a week. I had a timeline for finishing my introduction and methods and then analysis part." – P5 Week1
"Yes. I had to submit my dissertation rough draft before 30th. So I was planning to finish one day before the deadline." – P5 Week2
"Yes, as I said I just want to finish my thesis work, I had to clear all the feedbacks from my supervisors and get my thesis bind." – P5 Week3

"Not a specific goal. Just working on my thesis and I was designing an experiment, but did not have any deadline." – P7 Week1

"Last week I decided to write some 2000 words for my dissertation." – P8 Week1
"I was expecting to write many words for my dissertation" – P8 Week2
"To write my dissertation, interview (participants) and evaluate (results)." – P8 Week3

"…to contact all my participants for my study." – P16 Week1
"I set a goal for myself last week that I should finish the literature review and methodology part of my dissertation." – P16 Week2
"I have to finish data coding." – P16 Week3

"Before Friday, I had to submit my literature review. By Monday, I need to run my experiment." – P33 Week1
"My main goal was to complete my experiment." – P33 Week2
"Yes. Data analysis" – P33 Week3

Having set a goal, participants used multiple strategies to achieve them. Their strategies included keeping a timetable, setting up reminders, etc. But, we were interested only in their notification handling strategies. Thus, coding of the transcripts generated five strategies that were common across participants. They were momentary delaying of attention to notification, self-initiated technology breaks, '*glancing',* silent mode, and ignoring notifications. *'Glancing'* was defined as a peeking behaviour where the user checks the notification to determine some of the key aspects of that notification, such as which application generated the notification. In '*glancing*', users did not attend to the notification by opening the corresponding application. Ignoring notifications was defined as a conscious denial of attention to incoming notifications after the notifications made their presence known with audio or visual or haptic stimuli. Ignoring notifications did not include '*glancing*'. Below are few comments taken from the end-of-week interviews of Week1 and Week3, which indicate the notification handling strategies used by the participants.

Momentary delaying of attention to notifications:

While I am writing, I will ignore and first complete the sentence. [After completing the sentence or a paragraph] I will check the message and reply to it." –P3 Week1

Self-initiated technology breaks:

"In between [my work] I'll take a break so that during that break I'll check my mobile [for] whatever notifications. …[Also] before going to bed I'll check it." – P5 Week1
"As I mentioned earlier, I used to check my notifications only after completing my tasks. I just need to finish my task that I started and then move to check my notifications. Till then I will not open it." – P5 Week3

"I don't want to turn-off the applications [notifications]. …every morning I'll check my (something like) twitter. Then I don't check it throughout the day." – P16 Week1

Glancing:

"I just glance at it…" – P2 Week1

"What I did was that I usually just have a look at the messages. …If it is an advertisement [ad emails/messages] I'll just ignore it. " – P3 Week1

"I usually if I notice the flashing light I will check it. I may not read it, I just see the notification from which application it is from." –P7 Week3

Silent mode:

"My phone is always in silent." – P2 Week1

"Well, I will not turn them off. But if sometimes I have too many notifications I will put my phone in silent" – P3 Week1
"Actually sometimes I kept in silent and sometimes I turn-off notifications which I feel are of no use or not urgent" – P3 Week3

"I have strategies. … I turn my phone over if I don't want to be interrupted." – P7 Week1

"Actually I always miss the sound of the notification [in silent mode]." – P33 Week1

Ignoring notifications:

"…I just leave it there [ignored it]." – P2 Week1

"Well, not a whole strategy. But when I am focussed on working, I might just turn it off or simply ignore it. I usually have it in vibrate mode." – P8 Week3

"Yes. Normally I'll turn my mobile phone to vibrate. So if I was expecting something, I'll check it or else just ignore it." – P16 Week3

"[If not in silent] I ignore then. I'll check it later." – P33 Week1
"If I am analysing the data, I cannot stop and I ignore it. I reply to the notification after I finish a part of the work." – P33 Week3

While Week1 and Week3 had similar settings (all/some notifications turned-on), Week2 created an entirely different situation. With all the notifications turned-off participants usually found themselves at the mercy of their '*will*' and '*need*' to check the applications for updates. We categorized the responses into two primary contexts; first, when participants were anticipating an event to occur, such as arrival of a new email, and second, in general (i.e. not anticipating) to meet their social information and awareness need. Below are the comments from the participants that indicate their strategies for the above contexts.

Anticipating an event to occur:

"I was expecting a feedback email from my supervisor. [But as notifications were turned-off] I had to open my email every other hour." – P3 Week2

"I was expecting my project-mate to email me as well to ping me on Facebook. …So what I did was whenever I got a break, in-between my work, I just opened the application whichever I want and just check it." – P5 Week2

"I kept checking my emails. …like if I tweet someone or something, I keep coming into twitter to see if they replied." – P7 Week2

"Well, several times I was expecting email and QQ message (IM messages). So for QQ, I will login and last for one hour. I'll wait if they will contact me. And for emails, if I'm expecting something, I'll check it many times a day. Frequently." – P8 Week2

"Because I know every 3 or 4 days my supervisor will send me my research data. So when the day approaches, I expect email. I will check email very frequently. Once or twice in the morning, and also in the afternoon." – P16 Week2

"[Expecting email from participants] I opened the email tab in Google Chrome and so I keep checking see the email tab if any new emails" – P33 Week2

In general

"[Social notifications] With the notifications off, I had to open my laptop or turn on the application on my cell phone to get updated. …Well… only the main applications I use for social networking. …After dinner, after I finish everyday job, I open the main applications to talk to my friends. [Email] I have to admit… I opened my email for one or two days." – P3 Week2

"[Social notifications and Emails] Like as I said …I'll finish it off [main activity]and will then have a break… Then I'll browse and do anything over that period of time. During the break only, be it social network, or emails or something browsing." – P5 Week2

"Well… When I had a few minutes and wasn't doing very much. ..,I was looking whenever I was free." – P7 Week2

"Just login to QQ [IM], Email, [and other social networking sites] and check if there are any updates. If I'm working, I am focused, I might forget. [Social notifications] Facebook 4 or 5 times a day, QQ[IM] a little more often. [Email] five times a day." – P8 Week2

"[Social notifications] When I could not go on with my main activity, then I check my social networking messages. I don't have fixed time. [Email] I'll check emails more frequently than the social messages." –P16 Week2

"I checked QQ [IM] frequently." – P33 Week2

Except participant P5, who was consistent with her notification-handling strategy across the three weeks, all other participants used a combination of one of more notification handling strategy. FIGURE 5.31 summarizes the notification-handling strategies used by the participants during Week1 and Week3.

	Week1								Week2								Week3							
Notification-Handling Strategy	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**	**P2**	**P3**	**P5**	**P6**	**P7**	**P8**	**P16**	**P33**
Momentary delaying of attention to notifications		✓		✓																✓				
Self-initiated technology breaks			✓				✓		✓	✓	✓	✓	✓	✓	✓	✓			✓					
Glancing	✓	✓																			✓			
Silent mode	✓	✓	✓		✓			✓									✓	✓						
Ignoring Notifications	✓							✓														✓	✓	✓
	✓ = Yes																							

FIGURE 5.31: DIFFERENT NOTIFICATION HANDLING STRATEGIES USED BY PARTICIPANTS DURING WEEK1, WEEK2, AND WEEK3

With three rounds of interviews we were able to capture the context when these strategies are preferred over others. To the best of our knowledge, no previous research has taken this into consideration at a similar granular level. It was evident from the interviews that participants had mixed feelings regarding notifications and there was no clear majority either in favour or against turning-off notifications. But during a special case where participants were *anticipating* an event they felt strongly that they 'must have notifications turned on', and under these circumstances, they found themselves being more anxious than

usual. A participant said, "I kept checking my email application every few minutes as I was expecting a feedback from my supervisor. I was a bit tensed". One of the common strategies used by the participants was turning their mobile phones to 'Silent mode'. The 'Silent mode' was preferred when participants were engaged in a formal or semi-formal conversation that required their full attention and during periods of intense cognitive work such as studying or writing. One participant said, "When I am in a meeting with my supervisor or I'm interviewing *[participants]*, I keep my mobile phone in silent." Participants also showed respect for their immediate environment and in quiet places such as libraries or communal study rooms they turned their mobile phones to 'Silent' mode. In one occasion when a participant forgot to turn the phone to 'Silent' mode, she said, "*[In the study room]* I was so embarrassed when my phone beeped multiple times because a friend messaged me on QQ *[IM]*". Another favourite mode available in mobile phones is the 'Vibrate' mode. Participants reported using this mode when they were alone and did not want the notification 'beeps' to distract them. There was no majority on the preference of one mode over the other.

5.3.5 RESUMPTION LAG

Resumption lag is the time needed to re-collect and re-focus one's thoughts on the main activity after attending to the interrupting notification (section 2.1.2). All participants who attended to the notifications agreed that they could not immediate resume their main activity and took some time to re-focus on their respective main tasks. Below are a few comments from the participants who attended to their notification immediate after its arrival.

> *It may take some time to re-focus on my dissertation, but I think it is still more efficient than I wait to attend to it." – P3 Week1*
> *"No it did not affect my task. It takes a while, but it is fine." – P3 Week3*
>
> *"I did not find it difficult to get back to my work. If it might have been a week day evening I might have felt a bit. And I do not respond immediately, that's my policy." – P7 Week3*
>
> *"It will take me some minutes to go back to focus on my study. It is quick, maybe 2 or 3 minutes." – P8 Week1*
> *"I need some time to refocus on my work again." – P8 Week3*
>
> *"…I have to rethink where I was." – P16 Week3*

After attending to the notifications, participants experienced mixed feelings. While they felt relaxed that they had replied to the messages, they were also worried and tensed about their main activity.

> *"Well, it interrupted me in my work. But it was important for my friend as we had decided to go out together." – P8 Week3*
>
> *"I felt happy and relaxed after I replied to my friend. At the same time I felt a little bit tensed about my work because I have to rethink where I was. …When I turned back to my main activity, I was a little bit worried. I wanted to accomplish my main activity as soon as possible but I was interrupted and so a little bit worried and tensed." – P16 Week3*

Some other participants who ignored the notifications said that they usually 'thought' for a while. After reflecting, if they were unable to resist the urge to ignore the notification, they usually ended up attending to the notification.

"…I think, if I ignore them and I go on writing my dissertation, and in the end go and check them, I do not think I can focus on writing, after I know that I have a notification." – P3 Week1

"Sometimes it may happen. If I think it is affecting my work or disturbing me [after ignoring notifications], I will check it." – P5 Week1
"I was disturbed when I received my notifications [though I did not attend to it]." – P5 Week3

"I was thinking who sent the message …" – P33 Week3

After a closer look at participant P3's comments, it seems that they are contradictory to the strategy that she used (momentary delaying of attention to notification) (FIGURE 5.31).

The resumption lag also depended on the content of the notification.

"It depends on the messages which I get. It depends on thing on which I get notification. If something is very important, and it is going to affect my mind, it is difficult to resume my work." – P5 Week1

We also asked participants to comments on their resumption lag during Week2. Note that in Week2 participants checked their applications for updates mostly during self-initiated technology breaks (section 5.3.4, FIGURE 5.31). Participants P3, P8, and P16 shared their concern of having notifications turned-off in terms of increased resumption lag. Below are a few comments from their transcripts.

"When I was studying Japanese language, sometimes it occurred to me that I should open the application to check if there is something new for me. I must say it is very interrupting." – P3 Week2

"…when I was writing and focused on it, suddenly I remember that I was expecting an email. So I'll check the email. And if there are no emails, I'll get back to my studies. I'll need some time to move back to my work." – P8 Week2

"I takes me a very long time to focus on the main activity. For example when I was writing dissertation and at some moment I feel tired, so I will open my Facebook [and other social applications] and check new events or new messages. When I finish and come back to write my dissertation …it make me a long time to reorganize my thoughts." – P16 Week2

In contrast to the above, participants P5 and P7 felt that it was fine with them to resume their main activity after their technology break.

"There won't be any much difference. …I won't think about it after closing the application." – P5 Week2

"I think I normally checked during break between activities so I was not going back to the same thing. I didn't feel interrupted [when I got back] because I interrupted myself …it felt like I was taking a break rather than feeling interrupted." – P7 Week2

The above interpretation captures the disruptive effect of notification on the main activity. But we were also interested in the participants' feeling after they respond to the notification. This aspect of notifications viz. *'urge to check'* has not been widely studied. Previous research has shown that for IM messages the recipient feels obligated to reply as the sender is aware of the presence of the recipient [8], [31]. But we found this *'urge'* among participants irrespective of the type of application that generated the

notification. We believe that this behaviour is similar to Berlyne's *curiosity-drive* [53] and *optimal arousal* (as reported in [54]) theory and Litman and Jimerson's interest/deprivation theory of curiosity [54].

5.3.6 PERCEIVED SENSE OF ACCOMPLISHMENT, ANXIETY, AND AWARENESS

We asked participants to express and compare their sense of accomplishment, level of anxiety and social awareness during Week2 with Week3. There was no clear indication of any increase in the sense of accomplishment during Week2. While comparing anxiety levels, some participants felt anxious about missing notifications during Week2, while others felt that there was not much difference (FIGURE 5.28, FIGURE 5.29). Social awareness increased for some of the participants, but 2 of the participants, P7 and P16, had their social notifications turned-off, hence they did not find any difference (FIGURE 5.19).

Accomplishment:

> *"I think… less accomplished in week3. I think I achieved more in week2 and was more focussed." – P3 Week3*
>
> *"I felt that I was getting more accomplished [in week3] because [during week3] I just hear the notification so that I had a thought that I am getting something but I don't want to open it and check it now. But during the week2 though the notifications were turned off, there was something keeping on reminding me that I have to check the applications to see what has happened. So there might be a slight disturbance while doing my work inweek2." – P5 Week3*
>
> *"Not much difference actually." – P8 Week3*
>
> *"I think there were no big differences." – P16 Week3*

Anxiety:

> *"Definitely more anxious in week2. I am a very sociable person and like to stay connected with my friends. But during week2 I was unable to receive notifications in time. So when I checked them it was 3-4 hours late and made me more anxious." – P3 Week3*
>
> *"I was anxious in week2. I definitely was checking the emails in week2. I guess every 1 or 2 hours, when I remembered. It often dependent on if I had sent an email or I was anticipating." – P7 Week3*
>
> *"I am more anxious in week3 because I got messages during work and it makes me feel annoying and upset and again I get more anxious." – P8 Week3*
>
> *"I did not feel any big difference. I was not anxious about getting the work accomplished. But, in week2 as all my notifications were turned off …I get worried about missing some important messages because I have to check messages all the time." – P16 Week3*

Social awareness:

> *"In week3 I was able to connect to my friends. During week2 I was less aware and missed contacting my friends." – P3 Week3*
>
> *"During the week3 I felt more aware of all the happenings of the things." – P5 Week3*
>
> *"No not really [cannot make a difference in social awareness]." – P7 Week3*

"During the week3 I turned all the notifications on. So I am more aware of what is happening with my friends and family." – P8 Week3

"It was not a big difference. I turned off the notifications from social networking applications. So I open individual application when I want to check about my friends." – P16 Week3

5.4 SUMMARY

In this section we performed quantitative analysis on participants' scaled ESM data, and qualitative analysis on their categorical ESM data and interviews. Results showed that (i) percentage-of-time in flow was significantly higher during the not-interrupted condition of Week2 compared to baseline condition of Week1; and (ii) level of Concentration was significantly higher during Week2 compared to Week3. Other measurements such as Enjoyment, State-anxiety, and Satisfaction-with-life showed non-significant results. Similarly, quantitative and qualitative analysis both showed that 'Studying' was the primary activity that induced flow among the participants. Qualitative analysis of interview data found 5 key notification-handling strategies; (i) momentary delaying of attention to notifications, (ii) self-initiated technology breaks, (iii) glancing, (iii) silent mode, and (v) ignoring notifications. In the next section we discuss by interpreting and justifying the above findings in detail.

6 DISCUSSION

Our findings build on previous *flow* studies and provide evidence of the existence of *flow* in everyday activities. While we were also able to defend our hypothesis that the percentage-of-time in flow would increase significantly during the non-interrupted condition of Week2; few of the other hypotheses were rejected. The following section provides a detailed discussion of each of the research questions and their corresponding hypothesis.

6.1 RQ1: IS THE DAILY FLOW EXPERIENCE BEING AFFECTED BY THE PRESENCE OF NOTIFICATION?

6.1.1 FLOW CONDITION AND EXPERIENCE

One of the many definitions of *flow* is based on the merging of action and awareness. When awareness is split by perceiving activities from outside, flow is interrupted. Interruptions as subtle as questions that flash through a person's mind, such as, 'Am I doing well?', 'Should I be doing this?' can cause a breach in awareness in turn disrupting flow [5, pp. 38-39]. Another characteristic of *flow* is the. In other words, it is the narrowing of consciousness or the centring of attention on a limited stimulus field. Thus any intruding stimuli must be kept out of attention [5, pp. 40]. Therefore, flow is difficult to maintain at any length of time without at least momentary interruptions. In the light of our study, notifications are considered to be the source of interruption. The arrival of notification is usually indicated by auditory stimuli known as a 'beep', visual stimuli known as 'blink', or haptic stimuli known as 'vibrate'. In some of the notification configurations a combination of two or more stimuli can be set to indicate the arrival or presence of notification. Due to the presence of these stimuli, notifications are considered an interruption as they attract immediate attention causing an abrupt redirection of cognitive resources from the main activity it [7].

Based on the above theoretical concept of *flow* and the interruptive nature of notifications, our hypothesis stated that there would be a significant increase in the percentage-of-time in flow during Week2 as compared to Week1. We were able to defend our hypothesis as participants spent significantly more amount of time in *flow* during Week2 as compared to Week1 (FIGURE 5.7). Flow state is also associated with positive affect, i.e. feeling of being happy, sociable, and cheerful. Unfortunately, we were unable to use the 'Affect' dataset generated by the ESF and hence shall not be able to provide any comments on the affective state of the participants during the three weeks. Nevertheless, we had collected qualitative data from the participants during the end of week interviews.

Week2 imposed an extreme condition of turning-off all the notifications which is not a feasible scenario in real life. Hence, we had a third week, i.e. Week3, during which participants were allowed to turn-on the notifications which they deemed necessary. We believed that participants would realize the importance of the absence of notifications during Week2 and would turn-on minimum notifications. Hence our hypothesis stated that participants would experience more *flow* time in Week3 as compared to Week1. Though the results were not statistically significant, a close analysis of FIGURE 5.9 and FIGURE 5.19 shows that the participants who did not turn on some of the notifications in Week3 experienced more *flow* time during Week3 as compared to Week1. This further strengthens our hypothesis that the absence of notifications increases the percentage-of-time in flow.

6.1.2 FLOW ACTIVITIES IN EVERYDAY LIFE

Though we have discussed the effect of notifications on the percentage-of-time in *flow* and *flow* experiences, we cannot entirely deny the fact that *flow* experiences are dependent on the activity that one is engaged in. As our study was in-the-wild, we captured a variety of everyday activities which included idiosyncratic movements such as doing nothing and hanging around, imagining activities such as contemplating and planning a trip, kinaesthetic activities such as walking, jogging, swimming, and driving, social activities such as talking with friends, online chatting, browsing social networking sites, and attending activities such as watching movie or TV, listening to music, reading books or webpages, and studying. This pattern of classification is provide in [5, pp. 146, 147 Table 9]. But we did not proceed with this classification as it would not have helped in identifying individual flow activities, which is crucial for the purpose of this study. Therefore we preferred a logical grouping of the everyday activities (FIGURE 5.10, FIGURE 5.11, and FIGURE 5.12).

When the concept of *flow* was first introduced it was believed that the experience of *flow* was limited to structured activities such as games, artistic performances, etc. [5, pp. 140]. But, later the trivial and less complex everyday activities were referred as *micro-flow* activities, in contrast to goal-directed and intrinsically rewarding *deep-flow* activities such as playing chess, rock climbing, surgery, etc. [5]. Our study reveals that goal-directed activities such as 'Studying', contributes to more than 60% of the total flow activities (Figure 5.13). Other trivial activities such as listening to music and radio, talking with friends, contemplating, hanging around, and searching did not induce flow state.

It can be argued that the above trivial activities can be interpreted as flow activities if we use a different model for the interpretation of flow condition. As discussed earlier in section 0, the Three Channel Model suggests that flow exists on a continuum from extremely low to extremely high challenge-to-skill ratio. Therefore using this model, activities which were considered less challenging and required less skills would be mapped onto the flow channel. For instance, hanging around, doing nothing, and contemplating, which have been rated with very low challenge and very low skill scores will still be considered under flow, but will be marked as *micro-flow* activities. But as it has been indicated by several previous studies [44, pp. 94], we used the Quadrant model (section 0) which is more accurate and consistent with the Experience Sampling dataset. The Quadrant model maps the trivial activities with low challenges and low skills (*micro-flow* activities) onto the 'Apathy' quadrant. Our study reveals the same, as *micro-flow* activities are mapped onto the 'Apathy' quadrant of the Quadrant Model (FIGURE 5.3, FIGURE 5.4, and FIGURE 5.5). At the same time, the Quadrant Model is considered somewhat lenient as it treats flow as a relatively common experience accessible to all individuals [44, pp. 94]. The number of 'flow condition' activities can be restricted by considering a more restrictive z-score cut-off value (such as 0.5 instead of 0) for challenges and skills. But we still decided to proceed with a cut-off value of 0 instead of 0.5, as most of our flow activities (Figure 5.13) were goal-directed and can be considered as *deep-flow* activities. We also admit that the percentage-of-time in flow as calculated using the Quadrant Model in this study (TABLE 5.1) will change considerably if we use the Experience Fluctuation Model (section 2.3.3) as proposed by Massimini and colleagues [46].

In summary, the type of everyday activity (*micro-flow* or *deep-flow*) and the choice of *flow* model, play a crucial role in the calculation of the percentage-of-time in flow. This makes it difficult to assign any single

factor, such as the presence and absence of notifications (in our case), as the sole cause of change in the dependent variable, i.e. percentage-of-time in flow (in our case).

6.1.3 FLOW DEPRIVATION

In an attempt to determine the extreme case of complete *flow* deprivation, twenty participants were asked to refrain from 'play' and 'non-instrumental' *micro-flow* activities for 48-hour duration in a study by Csikszentmihalyi and his colleagues [5]. Eight dimensions of physical wellbeing (ability to concentrate, tiredness, hunger, sleepiness, relaxation, sensitivity, health, and headaches) were used for accounting the general effects of *flow* deprivation. Several of these indices showed significant deterioration after deprivation. Participants reported being more tired, sleepier, having more headaches, and feeling less healthy and relaxed after the deprivation period. However, the ability to concentrate and sensitivity to stimuli was not affected. It can be argued that the experimental conditions in the above study was extremely debilitating as participants were not allowed to lead their 'normal' lifestyle. Nonetheless, the results were clear; it appears that when people stop using the habitual forms of experience (*micro-flow* activities), they notice an increased sluggishness in their behaviour but their ability to concentrate remains unaffected [5, pp. 162-178].

The results from our study suggest that for 7 out of 8 participants the 'Concentration' increased during Week2 as compared to Week1 (FIGURE 5.24). This is an extension of the results from different studies which show the disruptive nature of interruption in terms of decreased efficiency and performance, and the presence of resumption lag [3], [10], [55]. To measure the concentration, we had asked participants "How well were you concentrating?" This question assumes that concentration is dependent on the individual and the activity at hand. It is the measure of the undivided attention that the individual enjoys when in *flow* state [5, pp. 38]. It must be noted that concentration is a necessary but not a sufficient condition to be in *flow*. Though our measurement of concentration is an indication of undivided attention, it fails to account for any direct contextual impacts such as presence or absence of notifications. Another variant of 'Concentration' which we did not measure is 'Was it hard to concentrate?' This question would make it possible to directly tap into the interruptive effects of notifications in a given context.

As discussed earlier in the *flow* deprivation study by Csikszentmihalyi [5, pp. 162-178], the absence of habitual forms of experience introduces a slugglish behavior in the participants. Interestingly, we find that the potency of our 8 participants decreased during Week2 as compared to Week1 (FIGURE 5.27), indicating a sluggish behaviour due to the absence of notifications. The interpretation of this observation is open to speculation, but the only logical explanation is that notifications have become a part of life – a '*habit*'. Participants in our study have referred to the presence of notifications as a continuous part of life which has made it increasingly less disruptive. In the conditions during Week2, participants in our experiment were not denied access to applications, infact we made it clear that participants are free to open any application at any time to check for updates. We were particulary interested in the removal of notification stimuli which is known to be disruptive (section 6.1.1). In this context, the role of the 'Silent' mode, available in most smartphones is worth discussing. Though we did not have any explicit conditions for capturing the effects of 'Silent' mode, the qualitative analysis of the interviews throws lights into the various uses and benefits of this mode. Our participants showed a strong likeness towards the 'Silent' mode in which the smartphone supresses all cues (auditory, visual, and/or haptic) to indicate the arrival of notifications. This was listed as one of the popular notification handling strategies during goal-directed

activities. The absence of notification stimuli helped maintain the 'continuity' of processing of the main task with undivided attention. Along with this, a more apparent benefit of the 'Silent' mode was the 'availability' of all the notifications when one accessed the smartphone during 'technology-breaks' or after completeing the main activity. The availability of a single repository for all notifications saved time as participants did not have to open individual applications to check for updates.

In summary, the presence of notifications does deprive individuals from enjoying positive benefits of being in *flow* and its absence increases the level of concentration. At the same time, we find that a complete absence of notifications reduces potency by introducing sluggishness in individuals.

6.2 Is there an increase in state-anxiety due to the presence of notifications?

Anxiety is a general tendency to respond fearfully to stressors. It is a complex measure as it is affected by multiple factors. Anxiety is measured under two different categories, state anxiety (how one feels at the moment), and trait anxiety (how one generally feels). We were interested in measuring only the state anxiety and used the STAI (STAI-6) developed by Marteau and Bekker [47]. As the STAI-6 produces scores similar to those obtained using the full 20-item STAI, we were convinced that it would generate desired results. Previous laboratory study by Bailey and Konstan [3] has shown that when peripheral tasks interrupt the execution of primary tasks, users not only require more time to complete the tasks, but also experience more annoyance and anxiety. We hypothesized that during Week2 in the absence of interrupting notifications, state anxiety would decrease. Our hypothesis was rejected as we were unable to obtain any significant results between the three conditions. Further analysis was done to determine the cause behind the rejection of the hypothesis. Analysis revealed that during the entire study participants associated anxiety with either the activity they were performing or the uncertainty of absence of information due to lack of notifications. Though most of the participants said that they were anxious about missing important notifications during Week2, their STAI ratings did not indicate the same (FIGURE 5.28, FIGURE 5.29). During the end of Week3 interview, we explicitly asked participants to compare and describe if they felt more or less anxious about getting work accomplished during Week1, Week2, or Week3. Most of the participants' responses indicated that they felt more anxious during Week2. Their frequency of checking applications for updates increased when they were anticipating an event to occur. Few other participants had mixed feelings and were unable to provide definitive explanations.

In summary, notifications are not that intrusive as we had expected them to be. In fact the absence of notifications induced unwanted anxiety and reduced frequency of social interaction. Further, the STAI-6 is not ideal for administering multiple times specifically in in-the-wild studies, as multiple factors can confound the ratings of the individual scales.

6.3 Does the prolonged use of notifications affect subjective well-being?

Subjective well-being refers to people's evaluations of their lives. It includes judgements and evaluations based on feelings. People associate it with life satisfaction, absence of negative emotions, optimism, and positive emotions. Overall, subjective well-being is a heterogeneous category that includes diverse phenomena ranging from optimism to low anger to work satisfaction. Sufficient evidence is available that indicates that subjective well-being causally influences both health and longevity [56].

We were interested in our participants' subjective well-being at the end of each week (Week1, Week2, and Week3). We had associated the presence of notifications with anxiety and had expected percentage-of-time in *flow* to increase (in turn increasing positive affect) in the absence of notifications. Thus our hypothesis stated that participants' subjective well-being would enhance during Week2. In other words, we expected participants to score higher in the SWLS scale during Week2 compared to Week1 and Week3. But the results were not significant.

There are a few reasons why the SWLS failed to capture what we had expected. First, the items in SWLS are global rather than specific in nature. This allows respondents to weigh multiple domains of their lives in terms of their own benchmarked values, before answering the items in the SWLS. Second, unlike affective reactions which are often responses to immediate factors, SWLS reflects on a long-term perspective. This makes it difficult for the respondents to confine their opinion to a short period of 7 days (1 week). Third, the SWLS shows moderate temporal stability with a 2-month test-retest stability coefficient of .82. Thus it is insensitive to short durational changes [57]. However, in a separate study researchers used the SWLS over a period of 2-weeks and found the results to be significant [58].

In summary, our non-significant result indicates that the absence of notifications may have caused a minor short durational change in lifestyle, but that change was not significant enough to be capture by the SWLS tool.

6.4 DO PEOPLE USE STRATEGIES TO HANDLE NOTIFICATIONS IN THEIR EVERYDAY LIFE?

Self-regulation strategies (SRS) guide individuals towards their goal-directed activities over time and context. Previous study has shown the presence of three key strategies, ignoring interrupting stimuli (e.g. incoming messages), denying access (e.g. changing IM availability options to busy, invisible, etc.), and digital or physical removal (logging off the application or staying physically away from computer system) [8]. But their results were limited to IM usage only. In comparison, our study considered all forms of notifications irrespective of its source. We were able to include a variety of applications which generate notifications (social and system generated) (FIGURE 5.19). Thus, we collected a broader and richer set of five strategies (section 5.3.4). Our result not only concurs with the findings in [8] but also extends them. We discuss each of the strategies below.

Momentary delaying of attention to notifications:

The first strategy of momentary delaying of attention to the notification (section 5.3.4) is based on the theory of interruption lag (section 2.1.2). This short time lag in attending to notifications is utilized by users to rehearse their primary activity. They strive to reach a task/sub-task boundary by completing an on-going activity at a sub-task level (section 5.3.4, P3 Week1), thus releasing their mental resources and momentarily reducing workload [3], [11]. Our study provides conclusive evidence of the existence of interruption lag in an interruptive naturalistic environment, with no *a priori* assumption of the type of the main activity. Other lab studies have shown the presence [18] and importance [10] of cues during interruption lag. Study also shows that users can be taught to react to an alert by searching for cues and associating it with the task that is being interrupted [18]. This behaviour facilitates resumption of the main activity. But, in our study we were unable to observe this behaviour within our participants. We believe that due to the unpredictable nature of notifications, users find themselves engaged in various activities when they receive notifications. They find it difficult to train themselves to search for cues

within such a varied task pool. Thus, to prevent excessive disruption caused by notifications to their main activity, users often exploit the task/subtask boundaries during the interruption lag.

A recent study on text-message induced task switching [59] has shown that students who delayed their responses to a text message during lecture performed substantially better than those who opted to provide an immediate reply. From our study, the notification-handling strategy of momentary delaying of attention to notifications shows that this behaviour of delayed response is not limited to classrooms and text-messages. Our participants displayed similar behaviour in handling notifications in their everyday life. This could reflect a metacognitive[5] learning strategy to wait until the on-going task is deemed to be of lesser importance and only then addressing the interruptive notification.

Ignoring notifications:

A temporal extension of momentary delaying of attention to notifications is 'ignoring notifications'. This was another strategy that was used by few of our participants (FIGURE 5.31). Interestingly, for most of our participants other strategies took precedence over 'ignoring'. But, during focused activities this strategy was most effective. Similar results were derived from a study [8] where students reported ignoring incoming messages if they were engaged in tasks that demanded their full attention. But for this strategy to be successful, users must have control over their situations. This observation is based on our quantitative evidence (FIGURE 5.25) and the conclusions drawn from [8]. We believe that this is one of the most difficult strategies among all other notification-handling strategies as it demands control to resist the desire to respond to external stimuli (notifications) despite strong cues from the system, social expectations to respond promptly [8], and urge to reduce 'uncertainty' [54].

Self-initiated technology breaks:

Participants took small 'technology breaks' to solely check their notifications. This behaviour was dominant during Week2 as all the notifications were turned off. In a recent study on multitasking [60], researchers were able to justify the importance of 'technology-breaks' in an educational setting, and suggested allowing students short "technology-breaks" to reduce distractions. While their study refers to the introduction of 'technology-breaks' as an external aid to assist students, our research shows that it is mostly a self-initiated activity. It was evident from our study that users obsess over missing updates from their virtual social sphere. Here 'technology-breaks' proved to be an effective strategy by providing intermittent opportunities to quench this need.

Knowing when to take a break and when to focus without distractions is a typical metacognitive strategy. We realized that the self-initiated technology-breaks were the outcome of our 'extreme' experimental condition of complete absence of all notifications in Week2 (FIGURE 5.31). Nevertheless, this strategy could have been an important factor in increasing the percentage-of-time in flow in Week2 (FIGURE 5.7). This implies that the strategy behind self-initiated technology breaks can be learned to effectively manage notifications and reduce distractions.

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[5] Metacognition is the knowledge of one's cognitive abilities and the ability to "consciously and deliberately monitor and regulate one's knowledge, processes and cognitive and affective states" [60].

Silent mode:

We accept that a lenient version of our experimental condition of Week2 is the use of 'Silent' mode. In fact many participants used 'Silent' mode in their everyday life in various contexts. As discussed earlier, the benefits of 'Silent' mode lie in the absence interrupting stimuli, and the availability of all notifications for later viewing. One of the pitfalls of this mode is the presence of visual stimuli, when one is engaged in an activity within the same system that generates the notifications. For instance, while reading a book on a handheld device, a visual cue is provided that a new email has arrived. Keeping aside this pitfall, the 'Silent' mode can be very effectively coupled with self-initiated technology-breaks. We saw an indication of this dual strategy being implemented by one of our participants (FIGURE 5.31). We strongly believe that these strategies can be easily learnt and its use in everyday life would then help in counteracting the interruptive nature of notifications.

Glancing:

Another strategy that was frequently reported was *'glancing'*. As notifications provide a condensed view of the actual message, a 'glance' at it was sufficient to decide the source, urgency, and importance of the message. Based on this, participants decided their next course of action, either to open the application, check it and/or respond to it, or to ignore it as 'not important'. This property of notifications has deep implications in the design of notifications. We find that current notification designs include the 'Content title', 'Icon', 'Content text', 'Content info', and 'Time that the notification was issued' (section 5.3.4).

At first we did not have strong theoretical evidence to explain this behaviour. Hence we speculated that 'glancing' is an immediate, 'involuntary', 'semi-conscious' response to any new stimuli. But after some initial investigation, we discovered that '*glancing*' might be based on a behaviour that is termed as *wanting* and *liking* which refer to neurobiological systems that control motivation and subsequent experiences of pleasure [54]. Wanting is theorised to motivate approach behaviour and to attribute incentive value to new stimuli. Liking, then handles the evaluation of stimuli in terms of immediate or anticipated hedonic impact and corresponding affective value. In our context of interruptions by notifications, users tend to check the notification immediately ('*wanting*') and then evaluate their immediate context to decide whether to attend or to ignore ('*liking'*). Thus the 'wanting' and 'liking' system forms the basis of the 'glancing' strategy.

As discussed earlier (section 5.3.4), our participants had specific goals for each week. But none of our participants showed any indication of preventive or recuperative approach towards notification handling. This is in contrast with the findings from [8]. We expected this because our participants had different goals for each week (although we do not completely deny that there may have been an overall larger goal), and our study period of three weeks is comparatively *very* short to the data collection period of 1 year in [8]. Developing preventive and recuperative approach requires self-assessment of ones goals over a longer period of time. This was difficult to achieve over a period of 3 weeks.

In summary, these notification-handling strategies as more of a '*habit*'- learned from experience over years of smartphone use, rather than 'planned or thought of'. They have shown positive results in counterbalancing the negative affect associated with interruptions, and have proven to be effective in

managing notifications. What makes them interesting is that they can be learnt over a period of time to exploit its benefits.

6.5 SUMMARY

The results of this study may baffle researchers. In the beginning of the study we associated notifications with most of the negative characteristics of interruptions such as the disruptive cost of resumption lag [10], negative affect in terms of annoyance and anxiety [3], [12], reduced efficiency and performance in the primary task and decision-making, and increased error rate [3]. Apart from its very nature to break the continuity of on-going though processes, thus affecting an individual's percentage-of-time in *flow* and *flow* experience, the other negative aspects were not proved significant. While unmanaged and copious amount of notifications can lead to *flow* deprivation, a structured and thoughtful strategic approach towards notification handling will neutralize its ill-effects. The bottom line is that users want to multitask or task-switch and notifications encourages them to do so. Trying to curb notifications use will be a fruitless effort as all this does is shift the external auditory, visual and haptic distractors (stimuli provided by notifications) to an internal, anxiety-laden need to frequently self-interrupt oneself to check in into their virtual world. Over a prolonged exposure to notifications, users have developed key notification-handling strategies which they successfully incorporate in their daily lives as a '*habit*'.

6.6 EVALUATION OF THE METHODOLOGY

This section provides a review of the ESM methodology used in the study, highlights caveats, and recommends measures for preventing them in similar future endeavours.

ESM studies suffer from what is referred to as the "Heisenberg-style" challenge: the process of observing may influence the observations [24]. As described in the experiment design, SMS texts were used to signal the participants to initiate the filling of ESF on a daily basis. SMS text in itself is a major source of interruptive notification and can interrupt the flow of daily events. We had instructed participants to have their SMS notifications turned-on throughout the entire study. Even during Week2, when all other notifications were turned-off, SMS notifications were active. Though we sent only 6 SMS texts per day, being an in-the-wild study, we had no control on the number of texts each participant might have received from other sources. Our measurements did not take this into account and thus, number of SMS texts received per day was not included in the study. The effects of SMS notifications may have been small, but in an ESM study where response-level data is considered for the calculation of participant's affective state, these small effects can add up and affect the person-level data file. Thus Week2 was not entirely a 'not-interrupted' week.

Maintaining a high signal response rate is a difficult goal to reach in an ESM study, especially when it spans weeks. ESM is considered to be intrusive and burdensome in nature [44, pp. 108] with a typical response rate ranging from 50-80% for 8 or more signals a day over a course of 1-2 weeks. The length of an ESF is another burdening factor that increases attrition and impacts response rates [44]. Given these statistics, our study not only had a very low attrition rate but also produced a quite decent response rate. It can be argued that the number of individual responses in a person-level analysis, like the one performed in our study, is of less significance. But it should be noted that it is only at the signal-response level that each question of an ESF represents the population of moments of lived experience. The response rate is dependent on the total number of items in an ESF and the frequency of signalling. Our

final ESF was quite extensive and contained 40 items (categorical, scaled, open ended). During a pilot study to calculate the time taken to complete our ESF on a smartphone, participants averaged 5 minutes. But with subsequent tries, the average dropped to 4 minutes and 30 seconds due to practice effect. Though it may not seem to be a lot of effort, but filling 6 ESFs per day can be burdensome.

We had used electronic ESFs for our study because of its various advantages (Section 3.1.1). But the design (layout) of the ESM form was not optimized for mobile interfaces. For instance, a 10-point Likert scale required horizontal scrolling, which was counter-intuitive for some of the participants. Unfortunately, this design flaw was not identified during the pilot study and was brought up late during Week2. We are optimistic that in spite of this flaw the participants used ratings appropriate to their affective states, but the notion of selecting the lower scales during busy schedules cannot be ruled out.

The ESM was administered in English language. As the participation was not limited to native English speakers, and no English language proficiency tests were conducted; we ensured that the participants understood the meaning of the affective words used to describe the feelings. We took care not to include any flamboyant words, but few complex words were inevitable. To minimize this language barrier, we provided the participant's native-language translation of the complex words during the Orientation meeting.

It was also a common observation during the interviews that participants found it difficult to come up with affective words to express their emotions for the various interview questions. It can be arranged for the participants to have an emotional word prompt list (EWPL) [61]to assist them in answering interview questions related to 'feeling' and 'emotion'.

Lastly, a small sample size (N= 8), and a relative similarity in the age, gender, background, level of education, and expertise with technology of the participants, somewhat limited the generalizability of our findings.

In spite of these limitations, the study successfully collected enough data that could be analysed to obtain useful information to answer our research questions with logical and comprehensive arguments.

7 FUTURE RESEARCH

Our study has helped answer a lot of impending questions related to the effects of notifications on our everyday life. But we are just starting to understand the prolonged effects of interruptions on our lives, the rationale behind our everyday interruption-handling strategies, and the state and trait behaviours of individuals who manage interruptions more effectively than the rest. In this section we discuss a few of the most pressing future research questions.

First, do these findings generalize? Our study focused on young adults because they represent a core social-media user demographic. These users fall into the generation Y cohort [62], who do not know a pre-Internet time. They use Internet technologies extensively and regard these technologies as integrative to their everyday social and communicative process. This makes them an ideal group to study. We also believe that generation Y has become quite immune to interruptions (notifications). But at the same time examining whether these findings generalize to additional age groups is important. Exploring the affective scales of adults and older adults under similar experimental conditions as that of our study will provide an insight into their interruption-handling strategies and behaviour.

For the measurement of anxiety, we had used the STAI-6 form [47]. But the quantitative data analysis did not support our participants' opinions. Participants repeatedly mentioned that they felt more anxious during Week2 as compared to Week1 and Week3, but the STAI-6 form was unable to capture these feelings. Even the Quadrant Model for *flow* measurement was unable to depict the perceived anxiety levels of the participants during Week2. Thus, there seems to be a gap between what is being measured by the measurement tool and people's perception of anxiety. As the STAI-6 is a standardized tool for anxiety measurement, we can say with some certainty that the feeling associated with '*missing important notifications*' during Week2 is not 'anxiety'. From our study, we can only speculate the feeling to be either '*stress*' – stress of not being able to stay connected, or '*fear*' – fear of missing important messages/emails. It could also be a compound emotional response. Only further research can throw light onto this emotional response. It will then be important to devise a measurement tool to be compatible with longitudinal studies such as ESM.

Task-driven and Interrupt-driven behaviour: Task-driven behaviour is a continuous-concentration operation, where an individual attends to one task and ignores other peripheral events; e.g. when people are deeply engrossed in reading a book. In contrast, interrupt-driven behaviour exhibits continuous-distraction, where an individual continuously changes activities to respond to new events in the environment [11]. Our study hints that due to the prevalence of notifications, people are now sensitive to extraneous events, and are easily distracted. These are typical of an interrupt-driven behaviour. But there is no evidence to show how people with interrupt-driven behaviour would function in an uninterrupted environment (similar to Week2 in our study). Are they as likely to attain *flow* as their counterparts with task-driven behaviour? We believe that future studies can profile people with similar behaviour and observe them in the wild to determine their percentage-of-time in flow and other affective variables.

Notifications are capable of introducing new and often irresistible thoughts on top of the on-going though process, often unexpectedly. As a result, conflict arises between the on-going activity and the attention-seeking notification. Based on the curiosity-drive theory [53][54], an individual is likely to choose the

newly presented information in the notifications to reduce the unpleasant experience of "uncertainty". But this will be at the expense of the on-going activity. During our study we encountered participants who gave in to their urge of accessing new information immediately (or after a momentary delay) after the delivery of the notification. But there were few other participants who comfortably resisted this. We believe this attitude of the latter group to be typical of people who feel in control of their situations. But we do not have sufficient information to support the claim. Moreover, there could be other neutralizing factors at play as well. Further studies are needed to determine this neutralizing factor especially in the context of high notification usage. It should be noted that the urge to access new information is not a negative trait by itself. But when coupled with the rise in notifications, it poses a threat to affective well-being. Finding a solution to this can help cultivate attitudes that can resist urge in general.

Our study took into consideration all forms of notifications irrespective of its source type. Though this provided a generalizable result, we believe that a more granular study will be able to differentiate the user behaviour towards social and system generated notifications. Further, under social notifications different applications are used with different frequencies. From our study we were able to confirm that users associate emails with formal communication, while social-media updates are associated with casual communications. This has led them to access emails applications more often compared to other social-media applications. Further studies can be done to investigate this behaviour. Also, we did not differentiate between smartphone, tablet or laptop notifications. Our conditions were extensive and thus our results are generalized across all platforms. Future studies can be targeted on one interrupting source while users are engaged with another.

Finally, although the analytical approach used in our study considered person-level analysis, there is scope for use of multilevel models to study flow. Though potentially challenging to perform, their results can provide a novel understanding of how notifications affect the perception of challenge and skill at a response-level and predict momentary quality of experience [44, pp. 98-100].

8 CONCLUSIONS

Notifications are one of the many inconspicuous little things that we attend to during a normal day. These seemingly benign occurrences of random 'beeps' and 'blinks' are indeed very useful provided that they are manually configured to signal only urgent, relevant, important, and anticipated information. Presence of copious amount of notifications impairs normal functioning by depriving oneself from the positive physical feelings, cognitive functioning in terms of concentration, and the benefits of being in *flow*. At the same time, a complete dearth of notifications, even for a week, produces anxiety and relatively increases the unpleasant experiences of uncertainty.

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1 APPENDIX A

1.1 INFORMED CONSENT FORM

Following is the informed consent form that was used in the study. All the Informed Consent Forms were based on this format.

The purpose of this form is to tell you about the study and highlight features of your participation in the study.

Who is running this?

The study is being run by Pratyush Pandab who is a Post Graduate student in the department of Computer Science at the University of York.

What is the purpose of the study?

The aim of the study is to investigate the role of notifications in the daily lives of people. Notifications are a way for computer/smartphone applications to provide alerts and related information to keep the user informed about events; such as emails, new chat messages, calendar event, status updates, etc. It is meant to inform users of events that are generally unrelated to the current user activity, by various display options and auditory cues. For further information please ask the experimenter or refer to the notification documentation.

How long will the study last?

This study requires data that spans over a few weeks. For the purpose of this study you will be required to commit for a period of 3 weeks.

What will I have to do?

You have been selected to take part in this study based on your daily notification usage and online activity. As mentioned above, this study shall last for 3 weeks. Starting from today, for the next 3 weeks you will be required to follow a specific notification configuration and fill in an online questionnaire at random intervals of time.

Screening interview and Orientation: Before the start of the study, you will take part in a semi-formal interview session with the experimenter. During this session a 20 minute discussion will take place on the topic of notifications, where the experimenter shall try to understand your daily usage pattern and strategies. You will also be guided on how to fill in the questionnaire. At the end you will be asked to fill in a Demographics questionnaire. The entire session will last for approximately 35 minutes.

First week: During the first week you will continue using the notifications as usual, i.e. no changes are required from your end. You shall receive SMS and are expected to complete one questionnaire each time. At the end of the week, an interview session will be scheduled with the experimenter. It will be a structured interview and you will be asked some general questions regarding your experience during the week. The session will last for approximately 30 minutes and will be recorded (audio only) for analysis purpose. No personal information will be disclosed.

Second week: In the second week, you will be asked to practically turn off all your incoming notifications. This includes your smartphone, tablet, desktop and any other electronic media devices that you carry around and has the capability to generate

notifications/alerts. Turning off refers to deactivating the notifications from your respective Notification Center of your devices and not merely keeping it in silent mode. Your SMS services will remain active as usual. It is to be noted that you are not barred from using the applications. It is only the notifications that are being turned off. You will be at complete liberty to open any application at any time and check the status therein. As usual, throughout the week, on each day you shall receive SMS asking you to fill questionnaire at random intervals of time. At the end of the week, you shall attend another interview.

Third week: During this week, you will have an option to revert to your original notification configuration or to continue to keep it turned off. It will be entirely up to you to decide and the experimenter will have no say in this matter. Moreover, you need not include the experimenter in your decision until the end of the week. The questionnaire will be still administered throughout the week. A final interview will take place at the end of the week and is expected to last 30 minutes.

Who will see this data?

Pratyush Pandab and his supervisor Dr Christopher Power, who is a Lecturer in Human Computer Interaction Research Group in the department of Computer Science at the University of York, will see this data. Pratyush will be responsible for compiling your data. However, once it has been compiled, the responses will not be individually identifiable. The experiment will be included in a dissertation but the data will only be presented in summary form and you will not be directly identifiable in any manner.

Do I have to do this?

Your participation is completely voluntary. You can therefore withdraw from the study at any point by communicating the same to the experimenter and if requested your data can be destroyed.

Can I ask a question?

Please feel free to ask Pratyush (experimenter) any questions you may have about the procedure that you will be following for the coming 3 weeks. Email pp664@york.ac.uk. If you have any questions about the purpose or background of the experiment, please wait until the end of the experiment and you will have a debriefing where all the questions shall be answered.

Please sign below that you agree to take part in the study under the conditions laid out above. This will indicate that you have read and understood the above and that we will be obliged to treat your data as described.

Date:

Name:

Participant ID:

Signature:

---

2 APPENDIX B

2.1 SCREENING INTERVIEW FORM

Screening Interview

About Your Notifications

1. Are you aware of notifications? **Researcher provides document showing examples of notifications and walks them through it**

2. Do you use them?

3. Can you please show me how your notifications work in an application or on a device?

4. Can you please indicate if you have notifications turned on for the following?

Facebook, Twitter, Google+, Email, Pinterest, Instagram, Tumblr, LinkedIn, Others, if any

5. How many notifications have you received last hour?

6. Is it possible to turn-off notifications on your mobile phone? Can you turn it off yourself?

About Your Strategies

7. Do you rely on the different notification sounds/tones to figure out what type of notification (e.g. new email, FB update, text message, etc.) you have received?

8. Do you personalise the audio notifications (sounds/tones)?

9. How does notification help you in your day-to-day interactions with your device/application?

10. Please tell me a recent situation where you have?

Ignored notifications

Turned off notifications/device to check later

11. Please tell me a recent situation where you have changed your notification settings?

12. Please tell me a recent situations where you have changed the way you use notifications (e.g. you have been ignoring notifications for a long period of time)?

2.2 PARTICIPANT'S SLIP

Experience Sampling : Week 1	
Participant ID:	Experimenter Name: Pratyush Pandab
Name:	Email ID: pp664@york.ac.uk
Experience Sampling URL: http://tinyurl.com/esm-week1	Phone No. 07448304752
Informed Consent Form URL: http://tinyurl.com/esm-icf	Supervisor Name: Dr Christopher Power
Notification URL: http://tinyurl.com/notification-inv	Email ID: christopher.power@york.ac.uk

2.3 END OF WEEK1 INTERVIEW FORM

End of Week1

During the previous week you monitored your notification usage but led your usual lifestyle. Please answer the questions based on your previous week experiences.

1. Please tell me a recent situation in the last week during which you felt that you were working really well (e.g. losing track of time, being really productive, not aware of your surroundings). Were you interrupted?

If interruption is not system related - ask same question about technology interruptions specifically.

2. Can you please tell me how that experience made you feel?
3. Do you think it was worthwhile interrupting your main task?
4. Do you feel that you were able to get back to doing the task you were doing before being interrupted? Did you think you performed as well when you resumed the task?
5. In your opinion, how often does this type of experience happen?
6. Overall during last week did you find yourself frustrated or at ease when you were interrupted?
7. Can you please tell me about a time during the last week where you felt you were getting a lot of notifications?
8. Did you find yourself being more interrupted in what you were doing than usual?

If yes: Now that you have reflected on it, would you change something about how you manage notifications? (keep in Silent, etc.)

9. Now that you've done the first week of the study, can you think of any additional ways that you manage your notifications for … (specific personal technology profile)?
10. Have you changed any of these since we last spoke?

With main goal reported in first week from ESF

11. You mentioned that you did (main goal), can you tell me about any particular strategy that you used to complete that task/maintain focus/achieve high performance?
12. Do you feel satisfied that you achieved your goal? Do you think that the strategy contributed to achieving your goals?
13. Is your strategy with this goal the same or different to how you normally manage your notifications?

Different - how is it different?

14. Were you ever asked in the last week to turn off you notifications by anyone?

If yes: Can you tell me about it? When you turned them back on, how did you feel about the number of notifications? Or amount of information?

15. *(List of applications)* What is primary reason you use *(application)*? How do the notifications you receive support you in that?

2.4 END OF WEEK2 INTERVIEW FORM

End of Week2

During the previous week you turned-off all your notifications. Please answer the questions based on your previous week experiences.

1. Please tell me about a time in the last week that you felt that you were working really well (e.g. losing track of time, being really productive, not aware of your surroundings)
2. Did it ever occur to you that you have not been interrupted?
3. Can you please tell me how that experience made you feel?
4. In your opinion, how often does this type of experience contrast with your previous experience of immediate notification of updates/events?
5. Has there been any situation when you expected an email or update? With your notifications turned off, if you were anticipating/expecting an E-mail or update, how did you manage it?
6. To check the FB updates or the QQ [IM] messages, you opened their respective applications. Were you overwhelmed by the number of updates/notifications generated since the last time you checked?
7. Please tell me about a situation when you logged into the application and checked all the updates. Having checked the applications for updates/notifications, did you feel that you were able to get back to doing the task you were doing?
8. Can you tell me about a time during the last week where you felt you MUST have notifications turned back on?
9. You had a different experience last week. Can you think of any ways that you managed your notifications for … *(specific personal technology profile)* in the last week?
10. You mentioned that you did *(main goal)*, can you tell me about any particular strategy that you used to complete that task/maintain focus/achieve high performance?
11. Do you feel satisfied that you achieved your goal?
12. Were you ever asked in the last week to turn ON you notifications by anyone?

If yes: Can you tell me about it? When you turned them back on, how did you feel about it?

12. With notifications turned off, how did you cope up with your information and awareness need?

How did you manage social networking? Did you have any strategies in place?

13. Given the freedom for the next week, what will be your preferred notifications settings (turned-on or off) for the following *(specific personal technology profile)*?

2.5 END OF WEEK3 INTERVIEW FORM

End of Week3

During the previous week (Week 3) you were free to change the notification settings. Please answer the questions based on your previous week experiences.

1. Please fill the end of Week 3: notification setup form
2. Please tell me about a recent situation where you were focused on an activity and you received a notification.
   How did you feel when you were interrupted by the incoming notification?
   How did you respond to that notification? (actions that you took)
   Did you feel frustrated or at-ease when you received the notification?
   Which application generated the notification?
   Can you tell me why you had the notification settings turned on for this application?
   If:
   you ignored the notification, how did you feel? Why did you ignore?
   OR, you attended to the notification, how did you feel? Why did you attend to it?
3. Can you please tell me about a recent situation where you received a notification and it facilitated (helped) your main activity (it is obvious that you must have attended to it).
   How did you feel about it?
   Which application generated the notification?
   Can you tell me why you had the notification settings turned on for this application?
4. Can you tell me about a recent situation where you consciously turned your phone to Silent/Vibrate.
   Why did you do it?
   How did you feel after you changed the setting?
   How did you feel about accomplishing the task? (Accomplished more? or less?)
   Please compare Silent with Vibrate modes. Which do you prefer? Why?
   Any specific situation where you would prefer one over the other?
5. How many times have you been interrupted in the last 15 minutes?
6. How many times notifications were the source of the interruption?

Comparing how you felt during week-2 to week-3

7. Do you feel like you are getting more or less accomplished?
   In what way(s) are you accomplishing more or less?
9. Do you feel more or less anxious about getting work accomplished?
10. Do you find yourself more or less aware of your friends and what is happening in their lives?
11. During week-3 do you think you missed out on anything?

From the ESM data collected in the third week,

12. You mentioned that you did (main goal), can you tell me about any particular 'notification handling' strategy that you used to complete that task/ maintain focus/ achieve high performance?
13. Do you feel satisfied that you achieved the goal? Do you think that the above strategy contributed to achieving your goals?

14. Is the strategy with this (above) goal the same or different to how you normally manage notifications? How is it different?
15. Fill SWLS.

2.6 SATISFACTION-WITH-LIFE SCALE

	Strongly disagree	Disagree	Slightly disagree	Neither agree nor disagree	Slightly agree	Agree	Strongly agree
In most ways my life is close to ideal	○	○	○	○	○	○	○
The conditions of my life are excellent	○	○	○	○	○	○	○
I am satisfied with my life	○	○	○	○	○	○	○
So far I have got the important things in I want in life	○	○	○	○	○	○	○
If I could live my life over, I would change almost nothing	○	○	○	○	○	○	○

TABLE 2.1: SATISFACTION WITH LIFE SCALE

2.7 EXPERIENCE SAMPLING FORM

The questionnaire is meant to collect momentary situational information. Please try to be as accurate as possible. The word "beeped" refers to the moment you received the SMS text.

As you were beeped…

Where were you?

- ○ Home
- ○ Office/Work
- ○ Restaurant/Bar
- ○ Other:

What was the main activity you were doing?

Example: homework/study, household/chores, playing video games, etc.

Were you doing this activity because you…

Indicate all that apply, example had to and wanted to

- ☐ Had to
- ☐ Wanted to
- ☐ Had nothing else to do
- ☐ Other:

What else were you doing at the same time? (If any)

Example: listening to music, talking over phone with family, etc.

Who were with you?

- ☐ Alone
- ☐ Friend(s)
- ☐ Mother
- ☐ Father
- ☐ Sister(s)/Brother(s)
- ☐ Spouse
- ☐ Co-worker(s)
- ☐ Girl/Boyfriend
- ☐ Classmates/peers
- ☐ Teacher/Supervisor
- ☐ Others:

Based on the main activity you were doing, indicate how you felt.

	Not at all	1	2	Somewhat	4	5	Quite	7	8	Very
Were you enjoying yourself with the main activity?	O	O	O	O	O	O	O	O	O	O
How well were you concentrating?	O	O	O	O	O	O	O	O	O	O
How self-conscious were you?	O	O	O	O	O	O	O	O	O	O
Did you feel good about yourself?	O	O	O	O	O	O	O	O	O	O
Were you in control of the situation?	O	O	O	O	O	O	O	O	O	O
Were you living up to your own expectations?	O	O	O	O	O	O	O	O	O	O
Were you living up to the expectations of others?	O	O	O	O	O	O	O	O	O	O
Were you aware how fast the time was passing?	O	O	O	O	O	O	O	O	O	O

Indicate how you felt about the main activity which you were doing?

	Low	1	2	3	4	5	6	7	8	High
Challenges of the activity	O	O	O	O	O	O	O	O	O	O
Your skills in the activity	O	O	O	O	O	O	O	O	O	O

Indicate how you felt about the main activity which you were doing?

	Not at all	1	2	3	4	5	6	7	8	Very much
Was this activity important to you?	O	O	O	O	O	O	O	O	O	O
Was this activity important to others?	O	O	O	O	O	O	O	O	O	O
Were you succeeding at what you were doing?	O	O	O	O	O	O	O	O	O	O
Do you wish you had been doing	O	O	O	O	O	O	O	O	O	O

something else?										
Were you satisfied with how you were doing?	○	○	○	○	○	○	○	○	○	○
How important was this activity in relation to your overall goals?	○	○	○	○	○	○	○	○	○	○

As you were being beeped, were you feeling ...?

	Not at all	1	A little	3	Somewhat	5	Very much
Happy	○	○	○	○	○	○	○
Sociable	○	○	○	○	○	○	○
Irritated	○	○	○	○	○	○	○
Alert	○	○	○	○	○	○	○
Passive	○	○	○	○	○	○	○
Strong	○	○	○	○	○	○	○
Excited	○	○	○	○	○	○	○
Confused	○	○	○	○	○	○	○
Involved	○	○	○	○	○	○	○
Competitive	○	○	○	○	○	○	○

If you have felt a strong emotion since the last SMS, what did you feel and why did you feel that way?

Example: I felt happy and relaxed because I completed my assignment in time

Read each statement carefully and then select the option to indicate how you feel right now, at this moment.

	Not at all	Somewhat	Moderately	Very much
I feel calm	○	○	○	○
I am tense	○	○	○	○
I feel upset	○	○	○	○
I am relaxed	○	○	○	○
I feel content	○	○	○	○
I am worried	○	○	○	○

TABLE 2.2: EXPERIENCE SAMPLING FORM

2.8 GUIDE TO TURNING OFF NOTIFICATIONS

How to turn off iPhone Notifications

1. Navigate to the Settings menu and then tap "Notifications".
2. Select the app that you do not want any notifications from. If you tap that app, it takes you to its menu screen.
3. Within each app's menu, toggle Notification Center to Off.
4. Repeat the above procedure for all the apps that generate notifications.

How to turn off Android Notifications

1. Open the device's settings menu. Under the heading 'Device' tap 'Apps'.
2. Select the app that you do not want any notifications from. If you tap that app, it takes you to its App info screen.
3. Within each app info screen, uncheck the 'Show Notifications' option.
4. A warning pop-up will be shown. Tap 'OK'.
5. Verify that the 'Show Notifications' is unchecked.
6. Repeat the above procedure for all the apps that generate notifications.