Music on Work: A Mixed-Methods Diary Study Investigating How the Presence of Music Relates to Focused State, and Examining Media Multitasking

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ABSTRACT
Simultaneous use of multiple media, also known as media multitasking, becomes increasingly common as ubiquitous computing gets popular. Among media multitasking activities, the concurrent use of music appears to a far greater extent than others. Previous studies identified the negative impacts of music on working productivity from diverse facets, whereas overlooked its benefits. From a reversed perspective, this study uses an AMMI questionnaire and a 1-day diary along with follow-up interviews to explore people's media multitasking behaviour and how the focused state relates to the presence of music. It is found that people are fond of listening to music, and different types of tasks affect their choices of music. They generally do not listen to music when they are focused as it is distracting, but if they do, they prefer peaceful music, regardless of their music preferences. Despite the frequent use of music in everyday life, people still significantly underestimate their actual music usage. However, no correlation is found between the AMMI score and the actual media multitasking level here due to some limitations. These findings can help better utilise music for improving working productivity.

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Author Keywords
Music; media multitasking; focus; working productivity; media multitasking index (MMI); diary; focused state

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Empirical

INTRODUCTION
As ubiquitous computing gets popular, the availability and accessibility of various media and technologies have made media multitasking a common lifestyle. Media multitasking is a behaviour that "*multiple media consumed simultaneously, including multiple windows open on a single platform*" [11, 33], such as listening to music on the phone whilst writing the dissertation on the computer. Given the speedy growth of the number and age group of media multitaskers, related research has become mushrooming. These studies, mainly from the perspective of cognition and behaviour change, have already explored the harmful effects media multitasking brings, for instance, increased anxiety [7, 60] and poor academic performance [32,33,65], as well as the strategies used to regulate this behaviour. A review Lang and Chrzan [31] gave systematically summarises various theoretical and experimental approaches of previous studies and reflects on their conclusions, providing a structured reference for subsequent research.

Of all the media multitasking activities, the concurrent use of music is excessively frequent. Music ties closely with work activities long before the invention of machine and computer, as it can satisfy universal needs in different fields [64]. Nowadays, music becomes more omnipresent, on the commute, during exercise [49], and at work and study [54]. It is believed to inspire human arousal, which subsequently affects people's mood [57, 58]. However, being regarded as a kind of irrelevant background sound in the working place, the detrimental impacts of music has also been identified in a bunch of studies, including resumption lag, longer task completion time, higher error rate, and increased potential cognitive loads [4, 17, 52], which are all culprits of low working productivity.

In order to mitigate the bad effects from frequent low productive media multitasking and the detrimental impacts that music brings into the workplace, strategies are provided by numerous studies. For example, digital self-control tools are widely consumed for the sake of self-regulation of the use of digital devices [38]. Task management tools are developed to help people get things done faster and more efficiently [16]. Notification tools (e.g., the splendid *Oasis* [24] and the new-emerged *TimeToFocus* [9]) are used to weaken the harmful self-interruption behaviour, which is also to blame for low working productivity. Nevertheless, existing studies seldom redirect the view of research to the reversed perspective, considering the potential benefits that these so-called interruptions

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might have on prompting people to be in a more focused state and how to make good use of them.

To better understand how the focused state is related to the presence of music, as well as people's understanding of their media usage and multitasking behaviours, this study is designed to explore two main research questions refined from reviewing previous work. As a combination of qualitative and quantitative research, after using a questionnaire to identify the implicit tendency of media multitasking, a 1-day diary study and its follow-up interview are conducted for recording as many real-life scenarios as possible and then getting more detailed information on top of that. Using a descriptive summary of diary entries as background, a thematic analysis of interviews will also be provided to present a better understanding of the relationship between the use of music and being focused on work. A quantitative analysis will be used to analyse participants' media usage and multitasking behaviours. New topics for future research on music and work efficiency might be obtained from this study, as well as some innovative ideas for the design and theory of forthcoming technology.

This dissertation is structured as follows. First, previous work is presented to provide theoretical and practical foundations, thus identifying existing research gaps and determining research questions. Second, the methodology of this research is precisely described. Third, the results of the qualitative analysis are presented as a descriptive summary and themes categorised for research questions, followed by the quantitative data about media usage and multitasking. Fourth, some interesting or particular points are discussed, along with the limitations and future directions of this study. Finally, the conclusion section serves as a summary of the whole dissertation.

RELATED WORK

Basic Psychological Concepts

For the sake of providing a comprehensive view to understand this study, some relevant psychological concepts are explained here first, including executive function, cognitive load, and arousal and mood.

In general, executive function (EF) represents a bunch of multidimensional cognitive processes that are goal-directed, i.e. a set of mental skills required to guide behaviours. It mainly consists of working memory (WM), cognitive flexibility (also called shifting), and inhibition (including self-control and interference control) three areas [5, 8, 36]. WM is a brain system that is responsible for simultaneous information storage and processing for complex cognitive activities, such as language comprehension and reasoning [3]. Cognitive flexibility represents people's ability to switch among different tasks goals, and inhibition is self-monitoring and regulation. As for music, Loui and Guetta [36] provided an overview of relevant EF research. At first, scholars were interested in whether and how EFs are strengthened by the use of music and musical training. As more studies emerged afterwards, the main research focus shifted to the prolonged effects of musical training that relate to two transferring skills, namely near transfer and far transfer. The former occurs within one modality (e.g., music and speech), whereas the latter occurs between two less related domains (e.g., music and IQ). The importance of a deeper understanding of the intersection between music and EFs was emphasised in the end because how to flexibly organise mental information is indispensable to higher working productivity.

Cognitive load is another fundamental concept related to this study. According to [48], it represents the load on the cognitive system brought about by conducting a specific task. Research on cognitive load has focused on the instructional area, for example, digging into the relationship between cognitive load and multimedia learning, which represents a learning pattern with both the auditory and visual channel, i.e. processing words and pictures concurrently [35, 45]. Mayer and Moreno [42] examined the concept of cognitive overload under the context of multimedia learning and enumerated five scenarios with detailed descriptions. In addition, the impacts of media multitasking on increasing students' cognitive load have also been studied a lot [32, 33, 65]. In terms of music, Jeong et al. [26] conducted laboratory experiments to examine the change of cognitive load when performing different melodic contour identification tasks. Their results indicated that, whilst listening to music, appropriate melodies can reduce the perceived cognitive load. However, there is little research on the relationship between music and cognitive load.

A large amount of previous work also studies the increased arousal and mood change caused by the presence of music. Referring to *APA Dictionary of Psychology*, the word "*arousal*" have two definitions, one is defined in physiological terms and the other in psychological terms. Empirical experiments were conducted [12, 57] and the results revealed the higher ratings of pleasure caused by music associates with physiological arousal. From the psychological aspect, arousal is always linked to mood, which is defined as a short-lived emotional state. The *Mozart Effect*, saying that people perform better on tests of spatial abilities when listening to Mozart's music during preparation [43], was almost the oldest one being comprehensively studied [62, 63]. Husain et al. [22] listed a collection of well-established studies on the arousal-mood hypothesis. Other research also concluded that one possible reason why music influences performance on simple serial recall tasks is the subsequent arousal change [18, 28, 52]. The method used to collect participants' ratings on arousal is called the experience sampling method (ESM) [15], which is also used here for capturing self-reported emotional states.

Media Multitasking

With the advent of the era of ubiquitous computing, the availability and accessibility of various media and technologies have made media multitasking a natural way of life for many people. As the name implies, media multitasking is a special form of multitasking that multiple media are consumed concurrently (including multiple windows on a single media platform) [11, 33], for instance, you are listening to music when writing your dissertation on the computer. Given the rapidly increased number and the gradually expanding user age range of media multitaskers, research in this area becomes mushrooming. These studies, mainly from a cognitive and behavioural perspective, have analysed the effects media multitasking brings and the strategies to regulate this

behaviour [7, 14, 60], while the causes of it are still being explored. Lang and Chrzan [31] reviewed previous studies focusing on media multitasking, systematically summarising various theoretical and experimental approaches of media multitasking research and reflecting on different published results.

The media multitasking behaviour is believed to have adverse impacts, especially on young people, supported by a growing amount of experimental evidence. Lee et al. [33] used a between-subjects experiment to determine how much information college students obtain in three different levels of media multitasking conditions, finding that a high-interactivity media multitasking during learning interferes more with knowledge acquisition. Another study [65] investigated the relationship between media multitasking and educational learning outcomes, and their results showed that different levels of the cognitive load caused by media multitasking habits alter how much information will be retained by students. Same conclusions were also drawn from other similar studies, claiming that more media multitasking also ties closely to delayed mental development [11, 66] and poor mental health [7], reduced self-control ability [69], and attentional failures [53]. This behaviour, however, does not necessarily cause a deficit in all types of tasks. It was found that media multitasking is positively associated with multisensory integration [37] and emotional negative stimuli prevention [60].

Considering that the behaviours of media multitaskers are influenced not only by the external environment [30] but also their intrinsic preferences, a questionnaire-based index was introduced to identify the extent of individual media multitasking preference [47] via 12 media forms. Respondents need to record the total time spent using each media weekly and to rate how frequently they use other media in conjunction with the primary one, from "Never", "A little of the time", "Some of the time", to "Most of the time", with assigned numeric values 0, 0.33, 0.66 and 1 in turn. This media multitasking index (MMI) is created via the following formula:

$$MMI = \sum_{i=1}^{11} \frac{m_i \times h_i}{h_{total}} \tag{1}$$

where m_i represents the number of media used (i.e. the sum of frequencies) while using primary media i, h is the self-reported number of hours per week spent on primary media, and h_{total} is the total number of hours per week spent with all media. Heavy media multitaskers (HMMs) and light media multitaskers (LMMs) can be identified therewith, with the index value one standard deviation or more above the mean and one standard deviation or more below the mean, respectively.

The MMI questionnaire was tested by Ophir et al. [47] on 262 participants, finding that HMMs are more vulnerable to irrelevant interference. Other studies applying MMI mainly focused on analysing the impact of individual differences in the behaviour change of media multitaskers [55, 59]. The launch of MMI provides a new idea for comprehensively investigating on what drives people to multitask with media.

Growing empirical research evidence consistently reveals the lack of validity of MMI as an assessment from various aspects. For example, it may cause ambiguity because even if the values of MMI are equivalent, the real media multitasking scenarios can change if different media are used as the primary media, where MMI cannot distinguish [67, 68]. Besides, Baumgartner et al. [6] argued that there are 144 questions in this longish questionnaire, the vast majority of which are repetitive, making respondents feel arduous and then give low-quality answers, and there is another debate over how to interpret MMI depending on contexts. To solve the aforementioned problems, they significantly reduced the number of questions in MMI [6]. Edwards [19] believed that without the need to ask each media pair separately, the same information could also be captured using fewer questions, and therefore created an abbreviated MMI (AMMI) questionnaire, where one uncommon media is replaced by two other media. The AMMI is now in widespread use because of its proven equivalent validity and less completion difficulty. A questionnaire is created referring to the weighted version of AMMI to collect participants' estimated media multitasking behaviours in this study, for simplifying the study design with equal validity.

Sometimes people use multiple media because without any of them, they can not finish the task. This ability is known as "*dual-tasking*", which can be seen as a special case of multitasking. In general, multitasking represents coordinately completing several tasks to achieve an overall goal, while dual-tasking refers specifically to two tasks are performed in parallel [39]. The ability to dual-task can be used to assess people's cognitive flexibility of EF. There are essential differences between dual-tasking and multitasking behaviours. For instance, switching tasks when multitasking is self-initiated without a time limit while it is usually necessary and time-sensitive when dual-tasking [39]. Many studies have already investigated the relationship between dual-tasking and areas related to automatic control (e.g., autonomous driving [10, 25]), whereas little research has paid the attention to compare and summarise the differences between multitasking and dual-tasking when it comes to media consumption.

Working Productivity

The concept of productivity was first introduced by economists as a measure of the quality of being productive, usually expressed in terms of the rate of output per unit. Nowadays, the phrase "working productivity" becomes exceedingly popular in the current social environment of intense work. People have different measures of working productivity. One classification of the productivity measurements has three general categories, including physiological (arousal), objective (task performance) and subjective (perceptions of the level of load in a task) measurements [13]. Kim et al. [29] also summarised six themes (i.e. work product, time management, worker's state, attitude toward work, impact & benefit, and compound task) that describe the productivity assessment facets in more detail via a diary study with knowledge workers. In this study, a participant's attentional state (worker's state) is used as the measurement of working productivity.

High working productivity is always associated with a high level of concentration and the state of being focused. Mark et al. [40] used automatic digital activity log and experience

sampling probes to understand how attentional states change with context. They created a structure that divides the level of task involvement into four levels based on two criteria, engagement and challenge, as shown in Figure 1. Their results revealed an overall high level of focused attention during five working days, especially on Monday, with happiness doing rote work and stress doing focused work. Different working patterns were also identified at the beginning, middle and end of the day as well. People are most concentrated in work mid-afternoon when they frequently use productivity apps and check email. Another paper from Mark et al. [41] also observed that handling email is rated higher working productivity with longer email duration, where the self-interruption is reported more productive than relying on notifications. Considering that this study is specifically investigating different types of work, using quantitative criteria to measure working productivity may lead to biases as well as increase the design difficulty, so the four-quadrant structure is used here to classify different levels of working productivity, where the focused state represents the highest level.

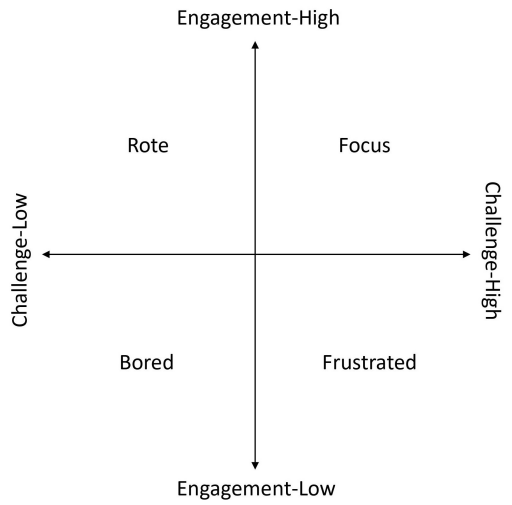

Figure 1: The theoretical framework representing four different attentional states from [40].

Nevertheless, previous work has reached a conclusion that there is a high possibility for people to interrupt themselves in a very short period, which is always deemed to be one of the biggest stumbling blocks to increased working productivity. According to Gillie and Broadbent's research [20], the similarity to the main task and the amount of required cognitive load seem to determine whether interruptions will be disruptive or not. Dabbish et al. [17] analysed many observed task switching behaviours and identified the essence of self-interruption to be the consequence of organisational environment, individual differences, and former experienced external interruptions, reflecting in abandoned ongoing tasks and self-initiated focus shifting. They also pointed out that individuals were significantly more likely to self-interrupt to complete a solitary task, as opposed to engaging in a communication event. Jin and Dabbish [27] identified seven categories of self-interruptions in computer-related activities via grounded theory, including adjustment, break, inquiry, recollection, routine, trigger and wait, and suggested more on utilising rather than eliminating self-interruptions for improving productivity.

There are many strategies for mitigating the harmful impacts of self-interruption. On the one hand, various software tools appear, for example, *GroupBar* [16], a project-related task manager that helps people classify different documents to reduce their time waste when switching tasks, and *TimeToFocus* [9], a notification tool showing people the interruption duration to increase time awareness. Digital self-control tools have also been implemented for self-regulation (for a review, see [38]). On the other hand, the concept of the working sphere was introduced to inherently characterise people's fragmented working style and identify people's working behaviour [21]. People tend to switch to another working sphere after a short period of staying in the original one (12 minute on average [21]), indicating less continuity among different working spheres. In that case, knowledge workers develop strategies to prevent unpredictable things and successfully arrange their time, such as creating a to-do list or ranking the importance of work to be completed, as well as making reasonable plans [1].

Music and Work

Our life and music are closely interrelated. A new form of music will develop as a result of human's changing minds and advances in technology, at the same time music is continuously satisfying people's universal needs in different fields as well. Scholars from psychology pioneered the systematical study of the role and influence of music on human cognition and behaviour, the most common one among which is investigating the relationship between music and arousal [34, 57, 58]. Schellenberg [58] reviewed previous research and found existing evidence supports that listening to music during the preparation enhances performance on various cognitive tests, but the effects are temporary and stem from the influence of music on mood and arousal. Afterwards, Salimpoor et al. [57] conducted an empirical experiment using human body signals (e.g., heart rate, blood volume pulse) as measurements, revealing a strong positive connection between ratings of pleasure caused by music and emotional arousal. Other studies also confirmed the effect of music on eliciting physiological arousal [12] and decreasing arousal due to stress [50].

A more realistic scenario is, however, the majority of people would listen to music while they are doing something rather than before it starts, making the research on irrelevant sound effect (ISE) of considerable popularity [4, 18, 28, 46, 52]. According to [18], the ISE refers to the finding that background sound damages the performance of short-term serial recall tasks, which is the opposite of the conclusion reached above. Kantner [28] used controlled experiments to confirm the existence of ISE, and further explored the impacts of different genres of background sound, finding that vocal music impairs performance more than instrumental music does only when there is a chart in the task material. Neely and Lecompte [46] also found that the higher similarity of the background sound to the recall task negatively influences the task performance. Among various kinds of background sound, speech is often deemed as quite disruptive, and it is also confirmed by Dorsi

et al. [18] that a higher speech fidelity (speech likeness) contributes to the ISE.

The preference for music is another welcomed research field in ISE. Perham and Vizard [52] proposed a study that mainly tested five different music conditions, namely quiet, liked music, disliked music, changing-state speech and steady-state speech, to analyse the relationship between preference for concurrent music and the level of ISE via serial recall tasks. Using both lab-controlled experiments and a questionnaire, they found that the quiet condition was deemed to be more pleasant than other conditions, and the recall performance of quiet and steady-state speech conditions was observed significantly better compared with others. Another conclusion they drew was that the recall performance was contrasted with participants' views on different music conditions. Two music-occurrence conditions were demonstrated equally disruptive. Their results showed that the preference of music did not affect the recall performance, which means that both liked and disliked music are equally harmful to task performance. On top of this, Perham and Sykora [51] further discovered that unliked, unfamiliar music could elicit better performance than liked, familiar music owing to less acoustical variation, which is believed to be a key influencing factor of ISE.

Despite the breadth and depth of the aforementioned studies, they are still more or less inadequate. The deficiency mainly lies in the limited range of music genre choices as well as the simplicity of the serial recall task (only simple one-syllable consonants [51, 52] or basic mathematical problems [4]). In addition, most of them use controlled experiments that do not realistically simulate real-life scenarios, so the conclusions drawn might only cover a very limited scope of application. In that case, it is essential to explore the effects of music on human cognition and working productivity via *in-situ* study.

CURRENT STUDY

Many previous papers that paid their attention to investigate the detrimental impacts of music on people's working productivity [34, 64] and the strategies to prevent consequent interruptions to help people enter a deeper-focused state. However, there still lacks studies from the reversed perspective, considering the potential benefits that music might have on prompting people to be in a more focused state. Moreover, the application of MMI mainly focuses on identifying people's inherent tendency of media multitasking and then analysing the possible reasons for their behaviours referring to MMI score, rather than directly analysing people's real media usage.

Hence, this study aims to understand how the focused state is related to the presence of music, as well as how well people know about their media usage behaviours. Two main research questions are proposed as follows:

- *RQ1*: How does the present of music relate to people's focused state?
- *RQ2*: Do people have a clear perception of their media usage behaviours?

Taking different factors into consideration, *RQ1* and *RQ2* can be further broken down into the following six questions:

- *RQ1.1*: What are the reasons people listen to music?
- *RQ1.2*: How do the choice of music differ as to task types?
- *RQ1.3*: What are the music-relevant factors that may influence people's focused state?
- *RQ1.4*: Is there any relationship between music preference and people's focused state?
- *RQ2.1*: Can AMMI serve as a predictor of people's media multitasking behaviours?
- *RQ2.2*: Is there a difference between how long people estimate their media usage and how long they actually use?

After pinpointing the research questions, the researcher decides to use a time-based diary-interview study in order to not only get realistic records of participants' daily life, but also raise pertinent questions about the meaning and significance of some behaviours through the follow-up interview [70]. Considering the constraint of the pandemic and other factors, a fine-grained 1-day online diary is modified and used. An AMMI questionnaire is applied at the beginning as well for collecting estimated media usage data.

METHODOLOGY

Participants

Among the people who meet the inclusion criteria (health adults, not engaged in music-related occupation), 10 participants (8 females, 2 males) were recruited from UCL via social media advertising, including 1 part-time master student and 9 full-time master students. The mean age was 25.1 years ($SD = 1.8$), with a range from 23 to 27 years. Participants were paid a £40 ($\sim$\$53) Amazon voucher for their continuous participation in the online questionnaire, the 1-day diary, and the follow-up interview. During the deployment, one participant dropped out due to a personal issue.

Materials

The whole study is designed as a combination of qualitative and quantitative research. An AMMI questionnaire [19] along with three demographic questions distributed using Microsoft Forms is used as the first step, collecting the number of hours per week participants spend on each form of 13 different media, including print media, television, computer-based video, music, non-music audio, video games, voice calls, instant messaging, social media, email, web surfing, other computer-based applications and other mobile applications, as well as their self-rated concurrent usage of each media pair with "Never", "A little of the time", "Some of the time", or "Most of the time", which are coded as 0, 0.33, 0.66 and 1, respectively.

Afterwards, a 1-day diary is designed to allow users to record one of their weekdays at every 10-minute interval if possible. The diary template is created online via Microsoft Excel with the following 5 parts based on previous studies [15, 40, 54] (an example is shown in Figure 2):

- Part 1: Daily tasks. Participants record one main activity and the concurrent secondary activities if any.
- Part 2: Media usage. Participants write down every media they are using for the main and secondary activities. They

Please record your activities below

	Part 1-Daily tasks		Part 2-Media usage		Part 3-Music (Only fill in this part if you choose '4' in Part 2)			Part 4-Feelings about the main activity		Part 5-Levels of concentration				
Time Early Morning	What were you doing? Please write down one main activity.	If you did something else at the same time, what else did you do?	Which kinds of media you were using?	Others (not in the list)	Platform	Genre	Song name (optional)	Engaged	Challenged	How well were you concentrating? Not at all	Somewhat	Quite	Very	It is hard for you to concentrate on your main activity.
7am-7.10	*image labelling task on VS Code*	*listening to music*	*1,4,12*		*Spotify*		*Hello-Adele*	*X*				*X*		
7.10-7.20	*" "*	*chat with friends through message*	*1,8,12*	*home appliance*				*X*	*X*		*X*			*X*

Figure 2: A brief example of the diary spreadsheet.

can choose from the above 13 forms plus an extra one, namely video calls, which is set considering the pandemic.

- Part 3: Music usage (optional). Participants write down the platform, the music genres (14 genres, including blues, jazz, classical, folk, rock, alternative, heavy metal, country, soundtracks, religious, pop, rap/hip-pop, soul/funk, and electronical/dance) [54], and basic information about songs as much as possible. This part might be filled in only when participants report that they are listening to music.
- Part 4: Feelings about the main activity. Participants record their real-time feelings on the main activity, including feeling engaged and challenged [40].
- Part 5: Levels of concentration. Participants rate how well they are concentrating (5-point Likert scale, from not at all to very) and whether it is hard to stay concentrated based on the ESM [15].

A semi-structured follow-up online interview comes at the end for gaining a deeper understanding of participants' general music habits and some feedback questions about the whole study. This interview also focuses on some questions based on the participants' different diary entries. The guidance of the interview is created and modified based on [61].

Procedure

After being recruited, participants were be given an information sheet explaining all the details about this study and a consent form. After carefully reading the information sheet, participants signed the consent form if they were willing to and able to take part in this study on planned days. They were also welcomed to ask any questions they had before the study started. A brief introduction to the deployment of this study was sent via email right after the consent form was signed. To begin with, participants were asked to complete an online questionnaire before the official start of the diary study, which took about 20 minute. After that, every participant was given an individual link to an online diary template spreadsheet, consisting of one "To read" instruction sheet and one "To fill in" diary sheet. They were told to carefully read the instruction sheet first and then the contents at the front of the diary sheet before the start of the diary day. Since participants were at different time zones, the diary study was designed to start and end at their local time, aiming at getting the most realistic one day life. In the end, participants were interviewed online for around 30 minutes within 2 weeks after the diary study ended. The interview was only audio recorded.

Data Analysis

As this study has both quantitative and qualitative analysis, the method of data analysis is also divided into two parts. First, the diary data will be given a descriptive analysis on participants' behaviours [23] as background information. Given the design of the whole study, the interviews are used to supplement the diaries or to explore issues about music usage and preferences that the researcher wants to explore in-depth [70]. The researcher conducts a thematic analysis of the interviews. A deductive coding scheme is iterated first based on the research questions, where the diary entries will serve as the context. Afterwards, an inductive thematic analysis is adopted for more complex insights [1]. The results of both top-down and bottom-up thematic analysis will be worked out together for the final themes related to research questions.

The data from the questionnaire will be used to calculate the weighted AMMI score via the following formula [19]:

$$wAMMI = 12 \times \sum_{i=1}^{13} \frac{am_i \times h_i}{h_{total}} \tag{2}$$

where am_i is the frequency rating the participant gave for each primary media, i represents each primary media, h_i is the number of hours per week spent using the primary media, and h_{total} is the total number of hours per week spent using all media forms. The weighted AMMI score is compared to the actual media multitasking levels to identify its validity. In addition, whether the actual usage time of media matched the estimated time of media using is analysed to see how well people perceive themselves in terms of media consumption and multitasking [55].

RESULTS

Results are presented in three sections. A descriptive summary of the diary entries is presented first to give insights about people's focused state, including scenarios and interruptions, as well as the presence of music. General media multitasking conditions are also showed in this section. Next, a qualitative analysis of the follow-up interview is presented, focusing on the benefits of music, how music influences participants' focused state, and the relationship between music preference and the focused state. Finally, a quantitative analysis of the questionnaire is shown for the verification of AMMI's validity and the comparison between the actual and estimated time of media usage. The first section gives an overview of participants' media usage behaviours, and the following two sections address *RQ1* and *RQ2* successively.

Descriptive Summary of Diary Entries

Excluding sleeping time, a total of 833 valid 10-minute diary entries are obtained from 9 participants. This section is divided into three parts, including the general summary of being focused, people's use of music and their media multitasking behaviours, for the sake of providing an overview of participants' real behaviours for subsequent analysis.

Being focused

The first thing the researcher considers is participants' focused state. According to Figure 1, in this study, being focused is defined as people feel both engaged and challenged in their activity. There are 96 diary entries where participants report they are focused on the main activity on hand, making up 11.5% of the total. Participants enter their focused state at different periods on the diary day, and the amount of time being focused varies among them as well. Three of the participants (*P*1, *P*5, *P*6) do not report any time that they are focused that day. Table 1 provides an overview of the time on the diary day that the participant is focused. Here, only time periods where the number of focused participants is equal to or greater than 3 are listed in the table. Among the remaining 6 participants, the commonly focused periods reported are concentrated in the late morning from 10 am to 11.30 am. The average focused time on that day is approximately 1 hr 46 minute. Participants can stay focused for approximately 35 minute at a time, but the longest focused period can be up to 1 hr 30 minute (*P*4, during an online meeting).

Time	Exact Focused Period	N
Late Morning	10 am - 10.40 am	4
	10.50 am - 11 am	3
	11.20 am - 11.30 am	3
Late Afternoon	5 pm - 5.10 pm	3

Table 1: The focused time periods reported by participants. Here, N = number of participants.

Table 2 summarises two main types of activity in which people are usually able to stay focused. The tasks that participants agree most are related to studying and working, for example, working on the dissertation or attending online meetings. Under this circumstance, participants always manipulate multiple media, such as computer-based applications, mobile applications and social media. Meanwhile, they listen to a wide range of music, from classical to electronical/dance. Leisure activities like exercising and playing Sudoku also enable participants to become focused. Contrary to studying and working, participants do not consume multiple media when they are focused in this case. Only one participant (*P*7) reports the use of pop music when exercising.

The fourth and fifth parts of the diary are designed to collect participants' real-time self-reported concentration levels on their ongoing main activity. For most of the focused activity identified in Table 2, participants rate a relatively high level of concentration (93% of the time), i.e quite or very concentrated. However, sometimes they find it difficult to keep concentrated on their main activity when they are already in a focused state, which is mainly to blame their secondary activities. For instance, *P*7 reports that when searching information for the dissertation while using social media to chat with friends, it is difficult to concentrate. *P*9 also writes that the pop-up advertisements and recommendations are disturbing to some extent whilst learning how to use one software on YouTube. Reported common interrupting secondary activities include listening to music, eating and drinking, in-person chat, and using social media and instant messaging.

Use of music

In addition to basic information about how people focus, the researcher also wants to understand how participants use music especially when they are in a focused state. In the 236 reported 10-minute diary entries with music (28.3% of total diary entries), only 23 diary entries record that participants are in a focused state whilst listening to music (9.7% of 236 music-recorded diary entries). It indicates that participants listen to music for about a third of the time on the diary day, whereas they seldom consume music when doing focus work.

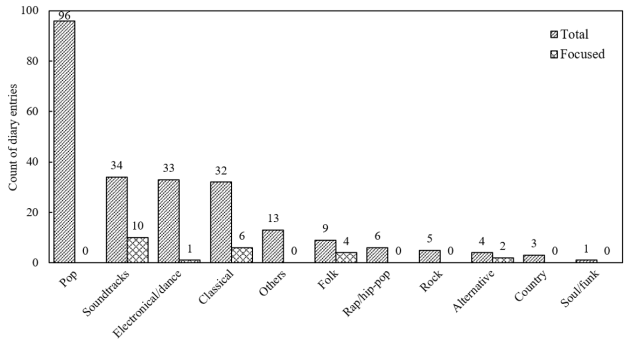

Figure 3: Count of diary entries of different music genres occur in all activities and focus activities.

As this study also investigates the influence of music preference on the focused state, the researcher is also interested in participants' music choices when they are focused. Figure 3 compares the total time spent using different music genres with the time these genres are used in the focused state. Four music genres (blues, jazz, heavy metal, and religious) are removed from this figure because they own zero records in the diary. It is clear that pop music is the most popular in general (96 diary entries), followed by soundtracks and electronical/dance. However, in the focused state, soundtrack (10 diary entries) and classical music (6 diary entries) make up the majority of these few hours of music listening.

Media multitasking behaviour

Not only does music appear very frequently in participants' daily life, but they always use it with other media at the same time, i.e. media multitasking. In order to explore the relationship between music and media multitasking, the first step is to understand the participant's real media multitasking behaviours. Participants record their media multitasking behaviours in 226 diary entries, accounting for 27.1% of total diary entries. Figure 4 gives an overview of the frequency of being concurrently used with other media for each of the

Type	Main Activity	Media Multitasking	Music Used	Music Genres	N
Studying & Working	Working on dissertation	Yes	Yes	Classical, Soundtracks, Pop, Electronical/dance	6
	Attending online meetings	Yes	No	-	2
	Replying to emails	Yes	Yes	Pop, Folk	2
	Working for jobs	Yes	Yes	Soundtracks	1
Leisure	Exercising	No	Yes	Pop	2
	Playing Sudoku	No	No	-	1
	Cooking	No	No	-	1

Table 2: A summary of two types of activities where people are able to stay focused. Here, *N* = the number of participants, and - represents no values.

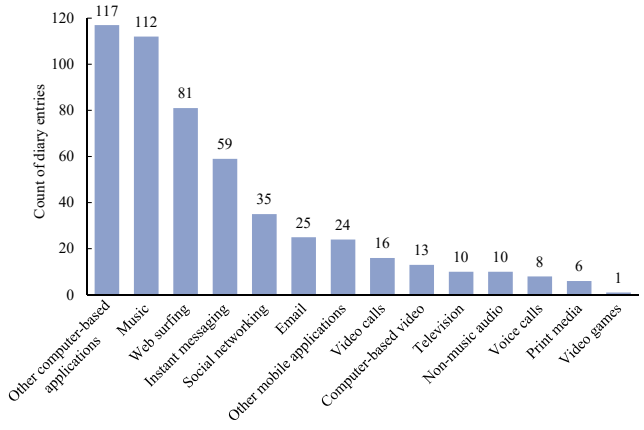

Figure 4: Count of diary entries in media multitasking conditions for each media.

14 media forms. It is obvious that the frequency of other computer-based applications and music are far higher than other media forms. The number of times music appears in the diary entries recording media multitasking behaviours is 112, which is a very high figure (49.6% of media multitasking diary entries), thus indicating that participants like to listen to music along with using other media. When participants are surfing the website or sending instant messages, they are also prone to use other media at the same time.

In these 226 records, the vast majority of media multitasking is with just two media forms, but there are times when three or four media are used concurrently. Table 3 presents the top seven popular two-media pairs. Among them, the pair {music, other computer-based applications} appears in 54 diary entries in total, followed by {instant messaging, social networking} and {music and web surfing} in turn. With regard to the combination of three media, {music, web surfing, other computer-based applications} becomes the most popular one with the count of 11 diary entries. It is worth noting that the only combination of four media, {non-music audio, web surfing, other computer-based applications, other mobile applications}, is from *P*6 with the count of 4 diary entries. It means that participants use music a lot in general and prefer to use it concurrently with other media.

Media pair	Count
Music, Other computer-based applications	54
Instant messaging, Social networking	22
Music, Web surfing	21
Web surfing, Other computer-based applications	19
Other computer-based applications, Video calls	16
Music, Email	10

Table 3: The number of occurrences of the top seven media pairs in the diary study. Here, *Count* = number of diary entries.

RQ1 Thematic Analysis of Follow-up Interviews

In addition to understanding the participants' daily routines, the researcher also wants to look more closely at the reasons for some of the behaviours recorded in the diary and at some basic questions related to music and focus so as to gain more comprehensive answers to the research questions. Based on the analysis of diary entries, the follow-up interview data is analysed through the combination of top-down and bottom-up thematic analysis. Initial codes are generated based on *RQ1*, and some new codes are added during the coding process. Afterwards, codes are iteratively deleted, merged and classified. The results are summarised into three parts corresponding to the four detailed research questions of *RQ1*.

RQ1.1 Reasons for listening to music

The first thing is to have a general understanding of why people listen to music. Based on the results of the thematic analysis on the interview, five themes are generated, describing the reasons for people to choose to listen to music, namely *music helps concentration*, *music helps adjust*, *music helps get rid of distractions*, *music prompts sleep*, and *personal choice*. These reasons are explained in more detail in the following parts.

Music helps concentration. All 9 participants think listening to music, especially when they are doing some computer activities that acquire a certain level of concentration, can help them enter a focused state quicker.

> *P2: And also, usually when I was studying or working, I sometimes get used to listening to some music to help myself focus on my work.*

P7: When I really can't focus on studying, I always try to listen to some smooth and light music to help me focus.

Sometimes people have already entered the focused state. At this point, music plays a vital role in helping them stay focused, prolonging their working hours.

P8: It can keep me trying to do my work, I mean last for a very long time. If I didn't listen to music, I may work on my tasks for one hour, but with music, I can work for three or four hours.

P9: But then when I start concentrating, the music helps me stay concentrated [...]

Music helps adjust. Apart from increasing focus, participants also describe various functions music has in their life, one of which is to help them adjust. Music can energise people, making people become less sleepy and continuing their tasks, which may also be said to be the same as a motivator.

P4: I would definitely listen to music to motivate me.

P6: When I know I'm sleepy, I usually listen to some pop songs to energise me, making me become more excited.

Sometimes it can also be used to calm people down from a very stressed status and give them a break.

P3: But if the task, the activity, makes me feel very stressed and I want to relax, I will listen to it.

P5: I'm just listening to the music so it kind of calms my mind.

When bad things come out, music can help people get rid of the depressed state and become happier.

P2: [...] I may feel angry or depressed. So maybe I'm gonna listen to some music to help me get over this kind of emotion.

Some participants also say that they think music can create a sense of enjoyment when they are doing something boring, or enhance their feelings when they are having fun.

P2: I listen to some music when I was doing some chores, it helped me enjoy the moment.

P4: [...] when I'm just at a party or something, or I'm having a good time or I'm doing something fun, I do listen to happy music that makes me excited.

Music helps get rid of distractions. Besides helping adjustment, music can also serve as a kind of background sound, helping people escape from the noise when they are doing something important or prevent them from being disturbed.

P2: [...] I remembered I was studying in [place], and [place] usually has noise made by someone else, so I need to listen to music to get rid of the noise.

P9: I think it does help because it prevents me from getting distracted.

Music prompts sleep. Some special kinds of music can help people fall asleep quicker as well.

P5: [...] I think I just use it to try and distract myself [...] and sometimes I find that sleep music stops me from thinking about other things because I'm just listening to the music so it kind of calms my mind.

P8: I may listen to music when I try to fall asleep [...]

Personal choice. There are times when people listen to music for no particular reason. They simply want to listen to music, so they choose to do so.

P6: It still depends on whether I want to listen to it or not at the time.

P8: Sometimes just listen to music because I want to listen to them.

RQ1.2 Music choices in different work

In addition to the diversity of reasons for listening to music, there is also a very wide variation in the choice of music that participants make in different activities. In this study, all daily activities, including computer activities, are divided into four categories referring to people's attentional states [40], consisting of *boredom work* (neither challenging nor engaging), *frustrating work* (challenging but not engaging), *rote work* (engaging but not challenging) and *focus work* (both engaging and challenging). For each category, participants' music choices will be summarised and explained.

Boredom work. Participants generally regard chores as boredom work, for instance, doing dishes and laundry, sweeping the floor, and cooking. In that case, they all show that they will definitely listen to music to make them feel less bored and increase their sense of enjoyment.

P3: I listen to music when I'm doing something boring, like cooking or washing clothes, or doing housework, because it makes me feel less bored, that is, when I'm doing something quite mechanical.

P9: [...] my favourite time to listen to music is when I'm doing chores because chores are so boring and like washing my dishes. And like you know, doing my laundry and like cooking and like cleaning the house and stuff. It's so boring that I need music to entertain myself.

One participant also shows a specific preference for upbeat music, such as pop music, when doing boredom work.

P5: [...] again, just like my favourite music (pop), quite upbeat.

Frustrating work. When a boring activity becomes a little bit challenging, it becomes frustrating. At this time, participants behave variously. Most of them choose no music to prevent distractions from the melody and lyrics.

P5: I tend to say no, just because when I would say a task is difficult, I just need to concentrate more, and when I need to concentrate a lot, I don't listen to music. Even if my interest is very low at this, I wouldn't.

P9: [...] maybe no music because if I have no interest in working on it, if I start listening to music, I'll just get really distracted and not work on the problem.

However, others say that they will choose to listen to some peaceful music in this situation, helping them relax.

P3: I listen to music that relaxes me, the kind that is lighter, quieter, not too loud.

Rote work. Considering that participants are all university students, rote computer work does make up a large part of their life, for example, replying to emails, making slides, or just organising files and notes. When participants are doing this kind of work, they sometimes use fast and upbeat music to prevent them from falling asleep.

P4: Probably not classical music, for example, I would listen to like other genres that like a kind of motivating, in some ways like pop [...]

P8: Positive one, positive and has a lot of changes in the lyrics, makes me feel very happy, absorbed and awake.

Some other mindless activities like getting ready in the morning and making coffee are also mentioned by one participant as rote work, with the use of upbeat music.

P9: Like for example like cleaning my room, I'm listening to really upbeat music. But in like makeup is like not so hard to, so I'm also listening to upbeat music. Making coffee is not so hard, so I'm listening to upbeat music.

Focus work. Participants tend to classify activities that are closely linked to study and job as focus work since they require a high level of engagement and often a certain relevant knowledge. Generally, participants report that they rarely listen to music whilst they are in a focused state.

P4: When I'm focused, I can't listen to music that has where someone singing or, you know, and it like anyone speaking or something like that.

However, they do need some soft music when they want to relax or prevent external interruptions.

P3: Generally, I don't listen to it, but if the task makes me feel very stressed and I want to relax, I will listen.

Except using the four-quadrant framework [40], another way of classification is utilised as well. Activities are categorised according to people's daily life, including exercising, computer activity, commuting, housework and relaxation. Apart from the previously mentioned housework and computer activities, in the remaining three situations, participants are very fond of listening to music, and they usually have no particular requirement for the genres of music.

P1: I always listen to music when cycling, [...] always when cycling, literally always, even if it's only for 5 or 10 minutes. And also when commuting, so also on the bus or on the tube or whatever, or when grocery shopping.

P4: When I'm just at a party or something, or I'm having a good time or I'm doing something fun, I do listen to happy music that makes me excited.

P7: Music is my best partner when I exercise.

RQ1.3 Music impacts the focused state

In the previous section, it is concluded that people rarely listen to music when they are focused, so this section is used to further analyse in detail what impacts people's music usage in this case. From both the diary and interview, most of the participants think that the focus work is those related to their study or job, for example, writing the dissertation and collecting data, preparing job interviews, and attending online meetings. These activities not only acquire participants' effort, but also are challenging to some extent. They report that they will listen to music when they are in a focused state. Four music-related factors that may impact the focused state are outlined as follows, consisting of *characteristics of music*, *loudness of music*, *familiarity with music*, and *cutting songs*.

Characteristics of music. The music itself is deemed as the biggest factor that influences people's focused state, including melodies and lyrics. Participants are more willing to choose soothing melodies, for example, piano soundtracks or classical music, when trying to enter or already in the focused state.

P3: [...] then I will listen to some quieter music, classical kind of piano music, which would let me calm down, and I think can help me better to focus my main task.

P9: So I would either listen to classical music, which usually helps me study because I think I've trained my brain into thinking that, when I listen to classical music, I need to be studying.

Lyrics are also considered to be a very intrusive part of the music, as they may take people's thoughts elsewhere. A majority of participants find the lyrics to be distracting, so they go for music without lyrics when they are focused.

P5: Because if I listen to something, a song I really like, all that has a lot of words, then I start thinking about the song instead.

P9: I would find myself paying attention to the lyrics and singing along to the lyrics, which was very distracting when I was trying to write emails, you know, read and write emails, because my brain would be distracted by the words in the song.

Nevertheless, some of the participants choose to listen to upbeat music sometimes, such as pop or electronical/dance music, because it can energise them and motivate them to continue their tasks.

P1: [...] especially back in the days when I was coding, like programming, I also like to listen to very fast paced music just because I kind of thought that it would motivate me to stay focused on the task.

P8: [...] but when I am working I prefer to listen to rock music and pop music, more active and more positive.

Loudness of music. One participant also reports that the loudness of music will affect the concentration level.

P9: It also depends on how loud the music is. Like if I'm using earbuds, it's really distracting, but you know, if it's like music playing in a café, it's more OK.

Familiarity with music. People's familiarity with the music they are listening to also influences the level of concentration to some extent. If participants are quite familiar with the song, they might start to think about or even sing along with it.

> *P2: As I mentioned, I think it depends on the song. If the song is I get so familiar with, maybe I will get distracted by it, and then maybe I'm going to sing the song, following when the song was playing.*

> *P6: Because if you can understand the lyrics, then you will listen to them carefully, and then you're not focused on the problem you need to solve.*

Cutting songs. When one song finishes and another song starts, or when two songs played in succession are very different in style, participants will notice that and tend to find what exactly happens, which will move their concentration to elsewhere.

> *P3: I occasionally think about it a little bit, like when the song cuts to the next song, I might be aware of it and I might not be so focused, just not completely focused on my main task.*

In addition to the aforementioned four music-related factors, people's familiarity with their task on hand also comes into play. Although participants have entered the focused state, their proficiency at the task will influence their choice of music, sometimes even influencing the focused state.

> *P1: It depends, like when I'm writing and I know what I want to write about and it's I'm just in this flow of just hammering the keyboard and just writing all everything, I can listen to music. But if I have to do a lot of research like desk research, read papers and summarise those, then I usually don't listen to music.*

Give an example, one participant ($P2$) records music use behaviour change in the diary. For the same task, no music was used for the first time, while the second time $P2$ chooses to listen to some music because of the increased familiarity with the ongoing task.

> *P2: [...] 'cause in the afternoon it was the very first time I was [task]. But at the night time, I'm kind of like getting familiar with [task] so I don't think it is challenging. I just think it becomes an easier task for me at that time.*

One interesting finding is that, over half of the participants notice when they are already absorbed in the activity, i.e. in a focused state, they tend to unconsciously ignore the music they are listening to and treat it as a natural ambient sound.

> *P4: I actually sometimes forget that the music is playing if I'm very, very focused, but it actually it's like background noise, kind of and it kind of helps me. So, I think it kind of helps me focus, but I don't realise the music is there when I'm really focused.*

> *P6: I would feel that the music becomes a kind of background, just becomes a part of the environment.*

RQ1.4 Music preference: little impact when focused

Apart from the aforementioned music-related reasons, a number of people-related reasons can also influence the choice of music, one of which is people's preference for music genres. In this study, whether music preference has an impact on people's focused state is also considered. Participants report different music preferences in the interview, for example, $P1$ only likes electronical/dance music, which can be found in the diary and confirmed by the interview. The remaining participants almost prioritise pop music as the most favourite one when asked what is their favourite music.

> *P1: I listen to a lot of drum & bass, and jungle, you could say it's a subtype or it's related to drum & bass. And but I also from time to time, I like to listen to electro swing.*

> *P2: In general, I like pop music, and most of the time I listen to pop music.*

> *P3: I quite like popular music, pop music.*

However, regardless of their own preferences for music, participants like to listen to music with similar characteristics when they are focused. They tend to choose music pieces that have peaceful and soft melody without lyrics, which are in contrast to the pop and electronical/dance genres. Music with only instrumental sounds is also popular when people are focused. These kinds of music are believed to be somewhat helpful to calm people down and adjust emotional states, and finally, enter the focused state.

> *P3: Then I found classical music to listen to, to calm myself down a little bit [...]*

> *P4: When I'm really focused, I can only listen to classical music without any singers or anything like instruments.*

> *P9: I listen to classical music, so I won't listen to really poppy music. I think when I'm studying, for example, that's challenging, so I listen to classical music.*

RQ2 Accuracy of Time Estimation in Media Usage and Media Multitasking Level

Besides the relationship between music and the focused state, this study also aims at participants' media usage and multitasking behaviours. In this section, the relationship between actual and estimated media usage time, and between the weighted AMMI score and actual media multitasking level (as a percentage of time participants spend on more than one media simultaneously on the diary day) are discussed through quantitative analysis, corresponding to *RQ2*.

RQ2.1 Actual media multitasking behaviour and AMMI score

This section investigates the relationship between the weighted AMMI score and actual media multitasking level (as a percentage of time participants spend on more than one media simultaneously on the diary day). The weighted AMMI scores of participants are calculated first, ranging from 3.76 to 9.67 ($M = 6.52$, $SD = 1.88$). Figure 5 is a scatterplot showing the linear relationship between the weighted AMMI score and actual media multitasking level. It can be seen in this figure that there is little correlation between the weighted AMMI

Media	**Differences of the Means** *(Actual - Estimated)*	**95% CI**	***t*-value**
Print media	-12 min	-40 min, 15 min	-1.03
Television	38 min	-14 min, 1 hr 31 min	1.68
Computer	5 min	-1 hr 21 min, 1 hr 31 min	0.14
Music	2 hrs 50 min	-1 hr 41 min, 3 hrs 59 min	5.69**
Non-music audio	1 min	-31 min, 33 min	0.09
Video games	15 min	-24 min, 56 min	0.89
Voice calls	-22 min	-44 min, 0 min	-2.41*
Instant messaging	0 min	-49 min, 48 min	-0.02
Social networking	-5 min	-1 hr 8 min, 57 min	0.22
Email	-11 min	-1 hr 10 min, 47 min	-0.45
Web surfing	3 min	-1 hr 36 min, 1 hr 43 min	0.09
Other computer-based applications	1 hr 39 min	-13 min, 3 hrs 32 min	2.02
Other mobile applications	14 min	-32 min, 1 hr 2 min	0.71

Table 4: Difference between actual and estimated media usage time for each media. Here, df = 8, * p <.05, ** p < .001.

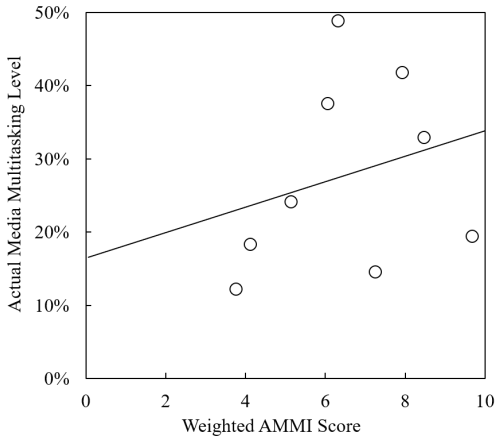

Figure 5: A scatterplot of actual media multitasking level against weighted AMMI score.

score and actual media multitasking level (r^2 = .081), i.e. participants who have a higher weighted AMMI score do not have a tendency to media multitask more than those with a lower weighted AMMI score. Statistical analysis also leads to the same conclusion, where it is not possible to tell from the weighted AMMI scores the media multitasking level of people, $F(1,7)$ = .618, p = .458. In other words, AMMI is not a good predictor of participants' real media multitasking behaviours in this study.

RQ2.2 Difference between reality and prediction

Next, the researcher analyses how well participants know about themselves in terms of media usage. Table 4 provides an overview of the differences between participants' estimated media usage time per day and their actual media usage behaviours on the diary day. The estimated usage time per day for each media is obtained by dividing the weekly usage time derived from the AMMI questionnaire by 7. Here, a paired sample t-test is used for statistical analysis, and the significant level is set to 0.05 for effect judgement.

The performance of participants varies considerably for different media forms. Comparing the AMMI questionnaire data with diary entries, all 9 participants underestimate the amount of time they spend on music. In reality, participants listen to music for an average of 4 hrs 10 min (SD = 2 hr 16 min), while they expect they only use it for 1 hr 20 min on average (SD = 1 hr 20 min). From Table 4, it can also be observed that participants significantly underestimate the time they spend on music (2 hrs 50 min), $t(8)$ = 5.96, p < .001, 95% CI = [-1 hr 41 min, 3 hrs 59 min].

In addition to the music, which is the primary object of this study, the researcher also finds that there is also a significant difference between participants' actual and estimated usage in terms of voice calls. A paired sample t-test found that participants actually significantly spend less time (-22 min) than their expected, $t(8)$ = -2.41, p = .043, 95% CI = [-44 min, 0 min]. In terms of the remaining 11 media forms, there is no significant difference between the actual and estimated usage time. One interesting point is that, participants spend around 3 hrs 24 min (SD = 2 hrs 14 min) on other computer-based applications in reality, which is far more than their expected (M = 1 hr 45 min, SD = 1 hr 14 min), whereas the results of statistical analysis find there to be no significant difference between these two conditions, $t(8)$ = 2.02, p = .078, 95% CI = [-13 min, 3 hrs 32 min].

DISCUSSION

While a large body of research on how music influences people's concentration has focused on the distractions it brings, this study provides a new perception of the relationship between the presence of music and the focused state from the opposite aspect. People think activities related to study and work make them more focused, and they are actively absorbed at certain times of the day. Staying focused, however, is not an easy task due to the various distractions. In terms of music, people are very fond of listening to music mainly because it can help them concentrate and adjust, and different types

of tasks affect people's choices of music. People generally do not listen to music when they are focused, but if they do, they prefer soft and peaceful music, regardless of their music preferences. As for media usage, this phenomenon is very common in life, where music occurs frequently as well. In this study, no correlation is found between the AMMI score and the actual media multitasking level, but people tend to significantly underestimate their actual music usage.

Music on Focused State

The main research target of this study is music. If asking people why they listen to music, one of the important reasons is that music helps them to focus more. In this study, participants believe listening to music, especially when they are doing some computer activities that acquire a certain level of concentration, can help them quickly enter or stay longer in a focused state. However, in practice, they rarely listen to music when they need to concentrate. If people listen to music in this context, they are surprisingly consistent in their choice of music. They prefer peaceful music, i.e. music with soothing melodies and no lyrics, such as classical music and instruments, as lyrics and melodies are considered to be distracting.

The lyrics are deemed as one of the main characteristics that influence people's state of focus. Consistent with the findings of previous studies [4,18] that a higher level of speech likeness is more disruptive, participants in this study also say when they are focused, if someone is singing or speaking around them or if they are listening to music that has too many words or sounds like a comprehensive sentence, it is very distracting. It is possible to explain the reason for the intrusive nature of lyrics in terms of cognitive psychology. When people are listening to sound with speech components, the brain will automatically receive phonological information from the sound, resulting in a conflict in organising task-related information for WM, where information is kept for the brain to make connections [4, 36]. The more similar the lyrics are to the task to be performed, the more intrusive the music is due to the increased complexity in separating information [20, 46]. Moreover, the presence of lyrics will increase the irrelevant cognitive load because of limited WM, thus reducing working productivity [18, 28, 52].

The melody, or rhythm of the music, is considered to be greatly distracting as well. In this study, participants report that an upbeat and fast melody is often disruptive and they are more willing to listen to peaceful music, for example, piano soundtracks or light music, when they are trying to concentrate or already concentrated. This is in line with one of the premises of ISE that Perham and Vizard concluded, where the music must have a high degree of acoustical changes over time [52]. Lab-controlled experiments also demonstrate this with statistical data on task performance [18, 28].

Surprisingly, participants say that when they are fully concentrated, they usually ignore the presence of background music and just treat it as a natural ambient sound. This phenomenon is similar to "*cocktail party effect*" – the ability to focus listening attention on a single sound source while suppressing sound from other locations [2, 44]. In this study, however, rather than consciously ignoring particular sounds, people only realise afterwards that they unconsciously ignore the music at that time. Few existing studies have examined the causes of this phenomenon, making it becomes a potential research direction. The researcher also notices familiarity with the task will also impact people's music choices and thus influence people's concentration level. Future research could focus on figuring out the specific mechanisms behind the interaction of task familiarity and the choices of music, as well as how they affect people's focused state, to help increase working productivity.

Does Music Preference Really Matter

The researcher also interests in whether the preference of music is related to the music they are listening to when people are focused. Apart from diary entries, in the interview participants are asked about their music preference and feelings when they are listening to music. The conclusion drawn from this study is that, although most of the participants indicate that they have different music preferences, for example, pop or electronical/dance music, when they need to become focused, they are more willing to listen to peaceful music with soothing melodies and no lyrics. It suggests that people's preferences have little to do with the music they choose when focused.

This conclusion is in line with the findings in [52], where both liked and disliked music were found to have almost the same level of impairment on the performance of serial recall tasks, that is, music preference would not influence the task performance. The dominant explanation for this is both liked and disliked music can trigger changes in arousal and mood [58]. They equally increase people's cognitive load due to the melody and lyrics that music brings. As participants also report they rarely listen to music in a focused state even if they think music is helpful, it suggests that there are limitations on the beneficial effects that music may have on the EFs.

One might argue that how to differentiate between the effects of liked and disliked music in this case. A follow-up study of [52] further found that, there is a difference between the effects of liked and disliked music, although both have harmful effects compared to the quiet condition [51]. Disliked music has more severe impacts on task performance in terms of recall accuracy. However, the presented study only concludes the music that is liked but not compares with disliked music for simplifying the study design.

Special Cases in Media Multitasking

To better understand how well people know about themselves in terms of media usage and whether AMMI can predict people's real media multitasking behaviours, a questionnaire is sent out to collect participants' estimated weekly usage time and multitasking frequency for each media form. The questionnaire data is also compared with dairy data for verification. Results show that there is no significant correlation between actual media multitasking level and the weighted AMMI scores, indicating that this score cannot predict participants' media multitasking behaviours in this study. By counting the diary entries, the popular media multitasking pairs are spotted, in which music and other computer-based are the top-2 welcomed media forms and their combination is the most popular media pair. It shows that music is commonly used in our daily life and it appears frequently in media multitasking conditions.

As for media usage, people are prone to underestimate their music usage, which means that they spend far more time on music than they expected.

As one of the most important measurements of the inherent tendency of media multitasking, the MMI and its variants have been cited by many authoritative papers [47,55,59], indicating their high validity. In the presented study, however, a very weak linear correlation is found among 9 participants between actual media multitasking level and the weighted AMMI score (r^2 = .081), which is not consistent with previous studies. One possible reason for this result is the duration of the diary (only 1 day), which is very short compared to previous studies (1 or 2 weeks [47,55]). This results in very unrepresentative media multitasking behaviours being captured. Another reason that affects the validity of AMMI here is the lack of diversity of the participants. In this study, participants are all university students from the same programme. As this study is deployed in the summer holiday, unlike the office staff, participants are free to schedule their time for one day. This has led to a greater variation in recorded media multitasking behaviours. In addition, there are two obvious outliers in this study (as the data recorded in the diary differed significantly from other participants), which also contributes to the biased results. After removing the outliers, the AMMI score successfully predicts the actual media multitasking level (r^2 = .53).

In terms of media usage, participants actually spend a lot more time on the music than estimated. Sometimes they listen to music unconsciously, as more than half of the participants report that, before this study, they do not even realise how much time exactly they spend on different media, especially on listening to music. An interesting point found in this study is that, the use of music always serves as a secondary activity rather than the main activity. Furthermore, if people are listening to music, they have a very high possibility of media multitasking. In order to improve working productivity, it is very important to understand the characteristics of the compound task [29]. However, the relationship between the main activity and the secondary activities are not separated. Whether people listen to music is a media multitasking or dual-tasking behaviour cannot be distinguished [39]. In this study, the media dual-tasking cannot be pointed out because the reasons for consuming multiple media are not recorded. For future studies, it is worth investigating how people's focused state interacts with dual-tasking behaviours related to music, prompting the development of the relevant industry.

Implications

How to better apply music in work space

Previous studies revealed the inherent segmentation of the working behaviours with the development of ubiquitous computing [21,40]. Considering people's working behaviours are quite segmented and can only last for a short time, along with the findings of music from this study, a cabin for music can be placed in the open office environment. This cabin can be used to relax people and to motivate them a little if they tried to focus on their tasks on hand but failed. At different times in a working day, various genres of music will be played, based on the identified high working productivity periods [40]. For example, when approaching the possible focused time, the cabin can start to play some peaceful music, creating an immersive environment for office workers to quickly enter the focused state and therefore achieving higher working productivity. The immersive experience can be built with the help of various peripheral devices, such as noise-cancelling headphones or earbuds. When people want to take a rest, they can choose whatever music they like to calm them down. In this special cabin, office workers can utilise music as much as possible to help themselves enter a focused state.

Design ideas for music platforms

In the interview, participants report that they frequently use the recommendation system of their music platforms to discover new music they might like. People use the recommendation system for different purposes. Some of them think recommended music is quite to their tastes while others only want to save the time to create new playlists by themselves. Referring to the results of this study, automatically detecting the surrounding environment and considering it when recommending music to users might be a potential development direction for music providers. Based on the types of tasks people are doing, the recommendation system will play corresponding music. The recommendation system also needs to optimise the song cutting process and put two songs with similar characteristics together as much as possible to reduce interference. In addition, music platforms can be designed to automatically adjust the volume of music while monitoring the surrounding noise level and the devices people are wearing.

Limitations

This study has several limitations. First, the number of participants is small and lacks diversity. All 9 participants are students from the same master programme, resulting in the limitation on participants' background, occupation and corresponding task types. Future studies can recruit a larger number of diversified participants [1,40,55], covering a wider age range and various occupations for generalisable results.

Second, the duration of the diary data is very short. Only a 1-day diary is deployed during participants' summer vacation, making it impossible to capture comprehensive and representative media usage behaviours. This short period also leads to two outliers listed in the discussion section. If possible, it is more convincing to use a longer weekly-based period as previous work, for example, one or two weeks [47,55,56].

Third, this study mainly collects self-reported data, including activities, media consumption, feelings about activities, and concentration level. Qualitative data alone is not sufficient to analyse the exact gaps that exist without the support of statistical data. Therefore, future work can improve the design of this study by adding some quantitative analysis to specifically identify the gaps and then enhance the findings, for example, task completion time and accuracy [1,16,40].

Fourth, some participants consciously change their behaviours when taking part in this study, which may reduce the veracity of data. As the diary is divided into many 10-minute slots, participants subconsciously merged their activities to better

remember and record their activities afterwards, which makes them more productive on the diary day. In order to collect more realistic data, other methods like observation [55] and digital tools [1, 52] can be used as supplements.

Lastly, people tend to use more video calls for online meetings under the pandemic, while this study cannot differentiate them from other computer-based or mobile applications. It may lead to biased results, as people will not listen to music if they are in a video call whilst they can listen under other circumstances. In that case, future work can divide video calls into a separate media form to gather more specific data.

Future Work

Future work can be considered from two perspectives. On the one hand, in terms of theory development, the AMMI questionnaire can be refined considering the growth of different media forms and the influence of the pandemic, for creating a more comprehensive structure to capture people's realistic daily behaviours. Besides, the specific working mechanisms of how music influence people can be further investigated. On the other hand, from the perspective of design, future work can focus on exact design ideas and products concerning music, for people to better improve their working productivity not only in the office but also at home.

CONCLUSION

While a large body of research on how music influences people's concentration has focused on the distractions it brings, this study provides a new perception from the opposite aspect. Through the analysis of six detailed research questions, this study delves into the relationship between the presence of music and the focused state using a combination of qualitative and quantitative methods. People think activities related to study and work make them more focused, and they are actively absorbed at certain times of the day. They are very fond of listening to music mainly because it can help them concentrate and adjust, and different types of tasks will affect their choices of music. People generally do not listen to music when they are focused, but if they do, they prefer peaceful music, regardless of their music preferences. Despite the frequent use of music in everyday life, people still tend to significantly underestimate their actual music usage. However, no correlation is found between the AMMI score and the actual media multitasking level here due to some limitations.

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APPENDIX

MEDIA MULTITASKING QUESTIONNAIRE

Part 1: Demographical data

This part aims at collecting basic demographical data.

1. How old are you?

2. What is your gender?

3. What is your occupation?

Part 2: Media usage

For this part, you should report the estimated time per week you spend using the medium (using the format 'HH:MM') as well as while using this primary medium, how frequently you concurrently consume any other form of media. The following 13 different media will be asked in this part:

- print media (for example, newspapers, magazines, books)
- television
- computer-based video (such as YouTube videos or online television episodes)
- music
- non-music audio (such as audiobooks, radio dramas, famous speeches)
- video games
- voice calls
- instant messaging (such as Facebook Messenger or WeChat)
- social networking (e.g., Facebook, TikTok)
- email
- web surfing (for example, searching papers from Google Scholar or booing a hotel online)
- other computer-based applications (such as word processing, making slides, and using MS Excel)
- other mobile applications (e.g., Deliveroo, Amazon)

4. How long do you spend on 'print media' per week?

5. When you are using 'print media' as the primary medium, how frequently you concurrently consume any other form of media?

6. How long do you spend on 'television' per week?

7. When you are using 'television' as the primary medium, how frequently you concurrently consume any other form of media?

8. How long do you spend on 'computer-based video' per week?

9. When you are using 'computer-based video' as the primary medium, how frequently you concurrently consume any other form of media?

10. How long do you spend on 'music' per week?

11. When you are using 'music' as the primary medium, how frequently you concurrently consume any other form of media?

12. How long do you spend on 'non-music audio' per week?

13. When you are using 'non-music audio' as the primary medium, how frequently you concurrently consume any other form of media?

14. How long do you spend on 'video games' per week?

15. When you are using 'video games' as the primary medium, how frequently you concurrently consume any other form of media?

16. How long do you spend on 'voice calls' per week?

17. When you are using 'voice calls' as the primary medium, how frequently you concurrently consume any other form of media?

18. How long do you spend on 'instant messaging' per week?

19. When you are using 'instant messaging' as the primary medium, how frequently you concurrently consume any other form of media?

20. How long do you spend on 'social networking' per week?

21. When you are using 'social networking' as the primary medium, how frequently you concurrently consume any other form of media?

22. How long do you spend on 'email' per week?

23. When you are using 'email' as the primary medium, how frequently you concurrently consume any other form of media?

24. How long do you spend on 'web surfing' per week?

25. When you are using 'web surfing' as the primary medium, how frequently you concurrently consume any other form of media?

26. How long do you spend on 'other computer-based applications' per week?

27. When you are using 'other computer-based applications' as the primary medium, how frequently you concurrently consume any other form of media?

28. How long do you spend on 'other mobile applications' per week?

29. When you are using 'other mobile applications' as the primary medium, how frequently you concurrently consume any other form of media?

INTERVIEW OUTLINE

Opening

Hello, thank you for your participation in my study. This interview serves as a follow-up study of my diary study, aiming at getting an in-depth understanding of your general usage of music and some feedback questions about this study. This interview will only be audio-recorded and transcribed anonymously. After transcribing, the record will be permanently deleted. Let's start.

Part 1: General questions about the diary day

1. Tell me about the day you did the diary. What was the (music) experience like?

- Was this a typical day for you? If not, what different/special things you did on that day?
- Were you exposed to more/less music than usual?
- Were you more consciously aware of music than usual?

2. Looking back on that day, what stands out as most significant to you and your experience of the study? Have you discovered anything new about yourself or music in general?

- More aware of something that you did not notice before?
- Negative/positive feelings?
- Functions that music has in your life.

Part 2: Questions related to RQs

1. What kind(s) of music do you like?

- How do you acquire your music/ come across (through purchase, friend's recommendation, walking on the street and hearing some music)?
- Under what circumstances do you prefer to listen to music (if you can conclude)?
- Would you listen to music under the following context (sharing screen):

2. Looking back on that day, what stands out as most significant to you and your experience of the study? Have you learnt/discovered anything new about yourself or music in general?

- More aware of something that you did not notice before?
- Negative/positive feelings?
- Functions that music has in your life.

Part 3: Feedback questions

1. How easy was it to do the diary? Were there questions that were not clear, or were not easy to fill in?

2. Did you consciously change your music habits, or the way you think about music, as a direct result of having this diary study?

3. Were there major genres of music listening in your current life that just happened not to be written in the diary? If so, what are these genres?

4. Has doing the study made you more aware of music in your environment/everyday life?