Digital Games vs Mindfulness Apps: Which is More Effective for Post-Work Recovery?

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ABSTRACT
In an age of constant connectivity, it is becoming more difficult for people to make the division between work and leisure time. However, post-work recovery is essential for overall wellbeing, thus identifying activities which promote recovery is important. With the proliferation of smartphones, there are opportunities for easy access to recovery promoting activities. Two activities that have been identified as encouraging recovery are digital games and mindfulness apps. This research explores whether either activity is more effective at promoting post-work recovery through two studies. The first study was a lab experiment where need for recovery was induced and participants undertook one of three break tasks: a digital game, a mindfulness app or the non-media control with a fidget widget. The break tasks were successful in promoting a reduction in tense arousal but no significant difference was identified between the three conditions in terms of recovery experience. However, a positive correlation between enjoyment and overall recovery was identified. Following this, an in-the-wild study with working professionals was carried out to establish if the results were replicated in a natural setting and to identify other influencing factors on recovery. The results differed from the lab experiment, with evidence that the mindfulness app was more successful at reducing tense arousal. However, the digital game significantly reduced psychological detachment over the mindfulness app. Again, a positive correlation between recovery and enjoyment was identified. Qualitative data suggested that personal preference impacted enjoyment and that fluctuating needs for recovery mean that one break type is not always universally successful at providing the recovery experience required. This suggests that individuals can more effectively recover if they enjoy an activity and if the activity addresses their specific needs for recovery.

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1. INTRODUCTION

The world is becoming increasingly connected and, perhaps more importantly, constantly connected. This is changing the way that people approach different facets of their lives, particularly in terms of work. Historically, jobs encompassed a work and rest cycle where people work their assigned hours and rest in their leisure time without the two crossing over [55]. However, constant connectivity is resulting in these different facets becoming increasingly intermingled. Although this can provide flexibility for some workers, interrupting a rest period with work-related demands can prevent people from fully recovering and recharging from work. There are several theories behind the exact mechanisms for how post-work recovery occurs [7,21,42], but prior research unanimously agrees that continuing with work tasks and taxing work-related resources without a period of uninterrupted rest will prevent successful post-work recovery. A lack of recovery has been linked with a plethora of consequences for health and wellbeing [21,45]. Additionally, individuals who recover in leisure time report positive productivity benefits when they return to work [40]. In an ideal world, it would be recommended that individuals keep work and leisure separate and take steps to ensure they do not engage in work-related activities outside of work. However, this is not always possible or practical, particularly as the ability to work at any time or place has resulted in expectations from both individuals and organisations to be constantly available [20]. For this reason, it is important to endeavour to learn more about recovery and what activities, or aspects of these activities, promote successful recovery.

The constant connectivity of modern technology can be problematic, but there is also potential for it to offer a solution, as it can provide easy access to activities that could promote recovery. There has been substantial research into various forms of media and their impact on recovery [32,34,35], and although recovery has been shown to be promoted by media there is conflicting evidence on which aspects of recovery certain types of media promotes. It therefore makes sense to investigate different alternative

avenues. Digital games are perhaps not something the public would associate with recovery, but they have been shown to promote it in prior research [4,28,29,32] although there are contradictions on what elements of recovery games encourage.

Separately, a growing and topical wellness movement is mindfulness, with apps that deliver mindfulness and meditation activities also growing in popularity over recent years. The health benefits of mindfulness have been captured in academic literature [3,16] and in the popular press. Mindfulness activities have also been found to promote certain aspects of recovery [8,22] but, like digital games, there is a lack of consensus as to exactly what elements of recovery they encourage or what aspects result in recovery. As both activities have shown evidence of benefits and are available on a smartphone, investigating whether digital games or mindfulness apps are more effective at promoting post-work recovery could provide valuable insights into recovery and the mechanisms behind recovery that result in people feeling recharged for the next working period.

This research considers whether a digital game or mindfulness application is more effective at encouraging post-work recovery and whether certain factors of each medium influence recovery in some way. This was investigated through two complementary studies. The first study was a lab experiment which involved invoking work strain on participants through a work task, followed by a break task. The break task was the independent between-subject variable, with three conditions of either a digital game, a mindfulness app or the non-media control. All conditions reduced the recovery outcome of tense arousal, although there was not one break task which was significantly more effective than the others. The results showed no significant difference in recovery experience overall between the three break tasks, although a positive correlation between recovery and enjoyment was identified. To investigate whether these results were replicated in a natural setting, the second phase was an in-the-wild study with working professionals. Participants used a digital game or mindfulness app for ten minutes over a five day period after work. The results suggested that the mindfulness app was more successful at reducing tense arousal. In terms of recovery experience, there was no significant difference overall, but the digital game was significantly more effective at promoting psychological detachment. Again, a positive correlation between recovery and enjoyment was identified. Post-study interviews indicated that enjoyment and personal preference influenced recovery, as well as identifying that participants had fluctuating needs for recovery which one activity could not always satisfy. Overall, this suggests that different people recover more effectively with different activities of their own personal preference and meet their current needs for recovery which continuously change.

2. RELATED WORK

This project draws from four different but related areas of literature. Firstly, the concept of recovery will be discussed, then the focus will narrow to media-induced recovery, followed by a review of digital games and mindfulness apps in relation to recovery.

Work Strain and Recovery

Many individuals can relate to feeling “drained” after a hard day’s work. Work puts demands on an individual’s personal resources, be it physical, psychological or emotional [55]. The body and mind need a mechanism to relieve this strain and refresh before future work. Recovery is a process that allows a person to replenish resources that have been depleted from stress and demands placed upon them, returning resources to pre-stressor levels [21,42,45]. Without recovery, negative strain and work load weighs on resources, which can result in poor wellbeing and over time can pose significant health risks [21,45]. It is vital for an individual to recharge for the next working period. As such, significant research has sought to understand what factors result in successful recovery.

There are numerous conceptual theories on recovery. Hobfoll put forward the Conservation of Resources Theory [7], suggesting that stress from activities such as work threatens an individual’s resources. Individuals try to protect their resources as the loss of resources causes stress. To recover, people need to either gain excess new resources in excess to offset the loss of others, or look to restore strained resources. The later and alternate Effort Recovery Model [21] postulates that the energy expended during work results in fatigue and mental load demands, which decreases performance. Once the individual is no longer working and putting demand on these resources, the process gradually reverses, with the reduction of mental load and restoration of mental faculties to a baseline. However, this model also notes that continued long-term work strain results in significant potential for negative impacts on an individual’s health and wellbeing.

Sonnentag and Fritz [42] combined both of these theories of recovery with additional literature on mood regulation and developed a model that identifies four underlying experiences which are key to successful recovery. The first is psychological detachment from work, where a person is mentally disengaged from work and their faculties are no longer occupied by work. The second is relaxation, where the elements that a person uses when working have no or low activation and an associated positive affect is felt. These two elements are important as they involve placing no demands on systems used at work. The latter two elements are related to building new internal resources and promoting feelings of self-efficacy. Mastery is the third underlying experience, which comprises of learning outside the work domain whilst feeling appropriately challenged. Control is the fourth experience, which focusses on the ability to decide which leisure activity to choose.

In a later paper, Sonnentag and Fritz [43] further theorised recovery in the Stressor Detachment Model, which focusses on the relationship between psychological detachment and job stressors. This model suggests that the effect of job stressors (including workload, time pressures or complex work) can lead to strain, which in turn can negatively impact wellbeing. The stressors and related negative activation can persist after the stressor's source has gone, for example when an individual leaves work but continues to ruminate over work-related issues. This sustained negative activation can be overcome through psychological detachment, which is why this is crucial for recovery. They suggested that psychological detachment acted as both a mediator and moderator in their model. As a mediator variable, psychological detachment explains why job stressors affect wellbeing, because job stressors impair psychological detachment and low levels of this lead to strain and poor wellbeing. Psychological detachment is also suggested as being a moderator variable, as it changes the strength and decreases the impact of job stressors on wellbeing. This illustrates the complexities of recovery and why further research in this area is needed.

As well as theoretical research, numerous empirical studies have exhibited the effects of recovery on working professionals and how a lack of recovery has negative consequences on wellbeing. The inability to mentally switch-off after work has been observed to negatively impact sleep quality [5]. Similarly, low levels of psychological detachment after work was shown to promote negative affect and fatigue the following morning [41]. Conversely, empirical studies have also demonstrated the positive effects on wellbeing when recovery was successful. Being psychologically detached from work during leisure time and engaged during working hours has been shown to result in positive affective states [44]. Experiencing mastery and relaxation has been shown to predict positive affect the following morning [41]. In Sonnentag's early empirical study [40], recovery after work was also shown to result in higher levels of work engagement, which resulted in proactive behaviour and the pursuit of learning goals.

Empirical studies have also made observations about the effect of recovery in relation to certain activities. A study comparing an active break (a walk) to a passive break (watching a video) observed that whilst rest was better than no rest, the benefits for both types of breaks were similar [46]. A separate study into workplace breaks found that whilst relaxation and social activities reduced work demands and negative affect, cognitive activities involving attention and effort resulted in increased negative affect from the influence of work demands [17]. The researchers suggested this may be because cognitive activities used the same resources used at work, thereby adding to workplace demands and preventing successful recovery, although they also postulate that it could be because some cognitive activities are perceived as routine as opposed to enjoyable. Trougakos et al [51] also observed that the nature of activity during workplace breaks influenced an individual's recovery and wellbeing. They distinguished between respites, where low effort or a preferred choice of activity was available, which promoted recovery, stopped resource depletion and resulted in higher levels of positive affect, versus chores, which drew from work resources, continued to deplete resources and resulted in negative emotions. In a later review it was noted that an activity one person might think of as a chore might be considered a respite by others, for example cooking [52], with Sonnentag and Zijlstra [45] making similar observations on how perceived pleasure of an activity influences an individual's overall need for recovery. Ragsdale et al [27] postulated that these perceptions of the quality of recovery could be due to the four underlying recovery experiences being present in an activity as opposed to this stemming from the activity itself. A study where employees were assigned different work breaks over four days found that whilst a break was better than no break, there were no significant differences in mood or cognitive performance between each break type, suggesting that there may not be one break activity that is suitable for all [37]. Therefore, the literature may suggest that individual preferences could result in whether people enjoy activities and recover from them. This has been highlighted in prior research [17] as something future investigation should address to gain insights into recovery and is addressed in the current research.

Media-induced Recovery

In the HCI field there has been significant investigation into activities which can facilitate recovery. Activities involving media consumption have been identified as successful to facilitating recovery.

Lab experiments into the effect of media on recovery have delivered contrasting results. One lab experiment found that media significantly increased psychological detachment and relaxation compared to the non-media control [34], whilst a separate experiment found that there were no significant differences between media and non-media except that the non-media control led to higher relaxation [32]. Contrastingly, the former experiment [34], which was investigating the effect of the valence of media content found that media with positive valence was associated with higher levels of relaxation than the non-media control, though this effect was not present for media with negative valence. This illustrates how media's content can potentially affect recovery. Another lab experiment compared hedonic entertainment, which is consumed for pleasure, relaxation and positive affect, to eudaimonic entertainment, which goes beyond simply pursuing positive affect and avoiding negative affect and instead focusses on self-determination, psychological growth and meaningfulness [35]. It found that whilst both hedonic entertainment and eudaimonic entertainment resulted in recovery and increased wellbeing, each type drove different recovery experiences, with hedonic media leading to higher psychological detachment and relaxation, whilst eudaimonic experiences was associated

with higher mastery. However, the researchers did note that it was difficult to fully separate hedonic and eudaimonic experiences, as media consumption could result in both experiences to varying extents.

An individual's enjoyment of different types of media also influences recovery levels. Reinecke et al [32] found a significant positive correlation between enjoyment and overall recovery, with enjoyment also being a mediator between recovery and feelings of energetic arousal. This illustrates that enjoyment is important to the success of media-aided recovery, with the authors [32] suggesting this is due to media's potential to satisfy hedonic needs, but also that enjoyment acts as a form of needs satisfaction for non-hedonic needs. This was illustrated by Tamborini et al [47,48], who evidenced the link between enjoyment and the satisfaction of intrinsic needs theorised through self-determination theory [36].

Although there is significant evidence that media consumption results in recovery, media use can also be attributed to negative wellbeing, particularly in terms of procrastination. There are assertions that how an individual perceives their personal media use can impact the extent to which media contributes to recovery. Reinecke et al [30] suggest that strenuous work results in ego depletion, where a person has reduced self-control after exhausting willpower on work tasks. If an individual's ego has depleted, the individual can perceive media use as procrastination, thereby feeling guilty, which is a stressor on resources and reduces the positive influence of media on recovery [30]. Reinecke et al [31] explored the relationship between media facilitating recovery, contributing to positive wellbeing, and media facilitating procrastination as a distraction from negative thoughts about an upcoming task. In this empirical study, they found that when people were using media to recover depleted resources they did not negatively evaluate this and were more likely to enjoy media, unlike when people used media to procrastinate where they negatively evaluated it. This suggests that people can recognise that media consumption may aid recovery but do not always do so and illustrates how personal perception alters recovery efficacy.

Observations on recovery in relation to specific devices which deliver media to users have also been made. For example, a lab experiment investigated whether using a smartphone in a waiting situation impacted recovery following a work task designed to fatigue participants [33]. In terms of the four recovery experiences, smartphone usage negatively affected relaxation, possibly due to the stimulating effect of the device, but resulted in higher feelings of control, possibly because the individual felt they could self-determine what they did within the break rather than this being specifically related to the smartphone. The numerous insights into the relationship between media and recovery illustrate the potential opportunities in these areas. To investigate more deeply the present study focusses on two types of media-based activities delivered on a smartphone: digital games and mindfulness applications.

Digital Games

Digital games have been identified in prior research as a specific type of media which can provide numerous psychological benefits. For example, digital games have been shown to inhibit mood repair, with games that provide an increased sense of control associated with repairing poor mood states, such as boredom or stress [1]. Different aspects of digital games have also been linked to different states of wellbeing; for example, when contrasting solitary games to social games [53], solitary players experienced greater wellbeing in terms of autonomy and presence, whilst social players experienced greater relatedness. There have been numerous studies into whether digital games can affect recovery, particularly in relation to Sonnentag and Fritz's [42] four experiences of recovery. Games have been identified as having potential to satisfy all four aspects; high interactivity and immersion allow for psychological detachment, games tend to be relaxing, players can control progress within games and games provide opportunities for mastery and accomplishments [28].

Survey-based studies have found empirical evidence of digital game use contributing to recovery, though other factors also contributed to use. Reineicke [28,29] used online surveys to understand the effect of games in leisure time and at work. In leisure time [28], people who associated games as contributing to recovery were more likely to play them after a stressful workplace situation, with people experiencing higher levels of work fatigue playing more games. In the workplace [29], there were similar findings with games usage resulting in recovery from work-related fatigue. In both studies people with less social support played games more frequently. Collins and Cox [4] also investigated whether digital games were a viable alternative to promote post-work recovery using an online questionnaire to compare gamers with non-gamers. They found that digital game players had an overall lower need for recovery compared to non-gamers and that games were particularly effective in terms of relaxation and psychological detachment from work. Thus, digital games can contribute to parts of recovery but not equally in all four experiences of recovery. Gamers also reported lower negative experiences of work interfering with home life than non-gamers. The study also identified that there was not a link between increased wellbeing and time spent playing games, suggesting that people could spend only a short time playing digital games to reap the benefits of recovery and that some genres promoted recovery in different aspects to others, suggesting that a game could be created that satisfies all four aspects of recovery.

There have also been lab experiments into the effect of digital games in relation to recovery. Reinecke et al [32] compared digital games as a form of interactive media to non-interactive media or no media. They found overall recovery experience was significantly higher with the digital

game over the other media conditions, so they concluded the level of interactivity was related to the level of involvement, which in turn positively correlated to enjoyment and recovery. When investigating the four aspects of recovery separately in comparing digital games with non-interactive media, the authors found that digital games resulted in significantly higher levels of mastery and control, although there was no significant result for psychological detachment or relaxation. When compared with Collins and Cox [4] as previously discussed, this illustrates the contrasting results of studies on digital games and recovery, but also the potential of the medium, highlighting why further investigation into this area could be valuable.

Mindfulness Apps

As previously discussed, different forms of media can elicit different aspects of recovery, but findings in this area are not always consistent. Investigating media which is not solely for entertainment could allow for observations about aspects of media that influence recovery. One form of media which could be argued to be eudaimonic [35] and is currently topical are mindfulness apps. Mindfulness is a concept related to consciousness and the non-judgmental awareness and acceptance of the present moment [3,16]. Multiple empirical studies have found that mindfulness promotes positive psychological effects and overall wellbeing [16], and in a similar vein, the relationship between mindfulness activities and recovery has been subject to prior research. Mindfulness has been described as a method to improve upon self-regulation of behavioural and psychological reactions [10]. Regarding recovery, self-regulation stems from an individual shifting their focus to the present moment (also described as decoupling the self from experiences [10]) and bringing awareness to visceral feelings in the body, such as awareness of breath (described as interoceptive awareness in [10]). For this reason, in some studies mindfulness activities have been postulated to encourage the psychological detachment element of recovery.

However, like research on previously discussed mediums, the results from prior literature varies. An in-the-wild study on work-life balance found that mindfulness was used as a segmentation strategy to establish boundaries and found that recovery in terms of psychological detachment specifically became better with the implementation of mindfulness activities [22]. A lab experiment suggested that meditation promoted higher levels of relaxation and mastery, which resulted in increased recovery, compared to the control of listening to the radio [8] although recovery was stronger if participants were motivated to undertake the study. In contrast in a field experiment, despite finding that mindfulness training improved sleep quality, Hülsheger et al found no effect on psychological detachment [10]. Again, this highlights the differing results found in recovery literature relating to specific activities.

There has been little research into how mindfulness in the format of an app specifically affects recovery, though there have been other observations about how mindfulness and meditation apps can deliver general wellbeing benefits or how aspects of these apps promote certain states over others. An in-the-wild study where participants undertook mindfulness activities on a smartphone for ten days found a significant increase in positive affect, but also found that people were more likely to experience these benefits if they enjoyed the task [9]. Regarding the digitally delivered technical features of mindfulness, a study of interactive meditation observed that the use of different human senses affected relaxation and different components of meditation in different ways (for example, audio helped if the participant was stressed, whereas if the participant was sleepy, vision and touch helped) [11].

Overall, existing literature on recovery thoroughly emphasises the importance of breaks and allowing individuals to recover, with several theoretical models around how recovery occurs. Although empirical studies agree on the benefits of recovery, there is conflicting evidence on whether some activities are more effective than others and what aspects of an activity result in successful recovery. To address this gap this study will investigate two recovery activities, digital games and mindfulness apps, to investigate their efficacy.

Research Questions

The current research investigates if digital games and mindfulness apps can promote recovery and whether one activity is more effective than the other at facilitating overall recovery or any of the four experiences of recovery (psychological detachment, relaxation, mastery and control) [42]. This involved two studies.

Study 1: Lab Experiment

The first study was a lab experiment that investigated recovery within controlled conditions, inducing work strain on participants and then giving them a break activity of either a digital game, a mindfulness app or the non-media control, where recovery and levels of energetic and tense arousal were measured.

As previously discussed, there were conflicting results from prior lab experiments as to whether media results in greater recovery over the non-media condition, with some [34] reporting increased recovery in terms of psychological detachment and relaxation with media over non-media condition, and others [32] reporting no significant differences or greater relaxation with the non-media conditions. This leads to the first research question:

RQ1: Will the media conditions (digital game or mindfulness app) result increased reports of recovery overall or in terms of the four recovery experiences compared to the non-media control?

Prior research also conflicts on the elements of recovery that digital games and mindfulness apps encourage. Some studies on digital games cite the medium as encouraging increased psychological detachment and relaxation [4], whilst others

find no significant differences in these areas, but do for mastery and control [32]. Similarly with mindfulness, one study may report significantly higher psychological detachment [22] whilst others do not [10]. The second and third research questions were:

RQ2: Will digital games or mindfulness apps be more effective for promoting post-work recovery?

RQ3: Will digital games or mindfulness apps be more effective for promoting any of the four experiences of recovery (psychological detachment, relaxation, mastery or control)?

Finally, Reinecke et al [32] found strong positive correlation between enjoyment and recovery experience which leads to the fourth research question:

RQ4: Will enjoyment be correlated with recovery experience?

Study 2: In-the-wild

By definition, lab experiments are artificial and a short work task within a controlled environment is no comparison to a real day at work and the resulting need for recovery. For this reason, a second study in-the-wild was carried out to establish whether the results within the controlled setting would be replicated in a natural setting, whether one activity was more effective than the other and to understand the other factors which could influence recovery. Upon arriving home participants used either a digital game or mindfulness app for ten minutes and reported on their recovery experience and subjective levels of energetic and tense arousal.

Similar to the lab experiment, the in-the-wild study investigated RQ2, RQ3 and RQ4. However, this study also involved the collection of qualitative data to capture more information about the overall user experiences and factors influencing recovery. Therefore, the final research question is:

RQ5: What are the users' experiences of using digital games or mindfulness apps to recover after work?

3. STUDY 1: LAB EXPERIMENT

Method

Participants

45 participants (26 female) aged between 19 and 36 years old undertook the lab experiment. Participants were recruited through word-of-mouth and through paper flyers around a university campus and student accommodation block. Students were targeted as they were an accessible participant group and because the lab experiment did not require a specific occupational status. All participants were computer literate and smartphone users. Participants were incentivised to take part in the study through entry into a raffle with Amazon vouchers worth £25 as prizes and offered snacks at the end of the study.

Design

The lab experiment was a between-subjects experiment with one independent variable. The independent variable was the break time activity. There were three conditions: playing a digital game, doing a meditation exercise using a mindfulness app, or the control condition of no assigned activity, but participants were provided with a fidget spinner for use at their own discretion. The dependent variables were self-reported work strain and self-reported levels of recovery.

Materials

The experiment took place in a university study room with a large desk and multiple chairs. On the desk was a laptop with 15.6 inch screen and mouse which were used during the work task. The study room had a transparent glass front or a window in the door through which the researcher observed the experiment to ensure that the participant was undertaking the tasks as instructed. The laptop and participant were faced towards the back of the room away from the window to avoid potential distractions.

The work task was a series of mathematical equations which were delivered and completed in an interactive PowerPoint presentation. The work task replicated an existing arithmetic task that prior research established as inducing work stress [23,26]. During this task participants undertook 10 arithmetic problems. For each problem the participant was shown the equation as a series of numbers one after another. Each number or operator which replaced the previously shown digit was shown for 1.5 seconds. After being shown the whole problem, which took 30 seconds, the participant entered an answer into a text box. The entire work task took around 15 minutes.

For the break task, the materials differed depending on the condition.

Digital Game

In the digital game condition participants were provided with a smartphone loaded with a digital game. The digital game was *Block! Hexa Puzzle*, a puzzle game which was selected as it is an easy game to play regardless of the participant's prior experience of playing games. This has been identified as an important factor when testing digital games in terms of recovery [32]. *Block! Hexa Puzzle* also allows players to play for the allotted break time without a paywall and is also gender neutral, which was highlighted as important during pilot testing.

Mindfulness App

In the mindfulness app condition participants were provided a smartphone loaded with a 10-minute mindfulness exercise from the app *Headspace*. This application was again chosen for its simplicity and clear instructions, meaning that participants could undertake the activity regardless of experience. *Headspace* has previously been identified by Zhu et al [54] as an example of digital mindfulness which provided guidance, but is not personalised to users' preferences or adaptive to quantifiable sensors. A guidance-

based app was chosen, as personalisation or quantified adaptive features could cause confounds in the experiment. The exercise was taken from the app's free beginners program, ensuring it was accessible to participants regardless of previous experience.

Fidget Widgets

For the control condition, there was no designated media activity for the participant. In prior lab experiments into the effect of media on recovery, non-media control conditions generally involved sitting in a room and resting [32,34]. However, this can feel artificial and thus could impact recovery. Therefore, a toy called a fidget spinner was placed on the desk which the participant could use at their discretion. A fidget spinner was selected for use in the control condition as it is a topical item and subject to controversy in both academia and the press. The media has highlighted the controversial wellbeing claims attached to these devices, which are often anecdotal and not based in research [50]. However, in HCI literature there is evidence that these items could have beneficial effects. Fidgets spinners fall under what Karlesky and Isbister [15] call "fidget widgets". These are objects that people use with their hands to help manage their attention and emotions, something that researchers describe as "embodied self-regulation". Karlesky and Isbister identify fidget widgets as allowing people to adjust their sensory stimulation to a level which is optimal to them as an individual. Although fidget widgets have been explored in terms of promoting focus and creativity there has been no investigation as to whether the activity of interacting with a fidget widget can promote recovery, although there are arguably some parallels. The benefits of fidget widgets include opportunities for mood regulation and self-regulation, two concepts included in the aforementioned literature on mindfulness and recovery. Fidget widgets have also been described as providing playful interactions and have been differentiated to games as a medium, with the former used for enjoyment and intrinsic motivation and the latter often pursued for extrinsic motivations such as achievements [14], again providing an interesting contrast.

There were numerous measures used in the lab experiment administered post-work (T1) and post-break (T2).

Energetic Arousal and Tense Arousal

The Activation Deactivation Adjective Checklist (ADACL) [49] was used to measure energy levels and tenseness which were recovery outcomes in the current research. Energetic arousal has been shown in previous experiments to indicate whether recovery has occurred from the participant's subjective perspective [32,33,35]. This measure involved words such as "energetic" and "drowsy", and the participant answered associated statements on 4 point Likert scales, from "I definitely feel [energetic] at the moment" to "I definitely do not feel [energetic] at the moment". Two of the items were reverse coded during data analysis. By comparing this measure collected post-work and post-break, the impact of the break task could be assessed in terms of whether recovery occurred and to what extent.

Recovery Experience

The Recovery Experience Questionnaire is a tool which can be used to measure recovery across Sonnentag and Fritz's [42] four recovery experiences. It contained 16 questions across the 4 dimensions for recovery, phrased into sentences similar to [29], such as "*When I (played the game/used the mindfulness app/had a break), I forgot about the work task.*" The participants answered on a 5 point Likert scale with 1 as "I do not agree at all" to 5 "I fully agree" as in [4]. This allows the four experiences of recovery to be assessed and compared for each activity to understand whether one activity was more successful at inhibiting recovery than another.

Enjoyment

Enjoyment was also measured as it has been shown to correlate with recovery in prior research (such as [32]). The measures replicate Reinecke et al [32] with five statements such as "*[Playing the game/Using the mindfulness app/Having a break] was fun*" using a 5 point Likert scale from 1 "I do not agree at all" to 5 "I fully agree".

Demographic Information

At the end the post-break task, the participants were again asked if they used the break activity and if so how frequently. They were also asked for their age and gender for demographic information.

Procedure

Prior to experiment during recruitment, participants were informed that the lab experiment would involve a 15 minute work task, a 10 minute break activity and several surveys. When the participant arrived for the experiment, they were greeted, shown into the study room, asked to place their belongings on the other side of the room and set their devices to silent. They were sat down at the desk with the laptop, a copy of the information sheet and consent form, which they were given time to read and sign if they agreed to participate. They were also provided with a participant ID number to enter on the survey. The researcher then asked the participant if they used mobile games or mindfulness apps on their phone and if so how often. Within the context of this experiment the participant was classified as a regular user of the medium if they had never used it or had not used it in the past 6 months. If the participant indicated that they used games or mindfulness apps regularly they were not assigned this condition to ensure that experience with the medium would not confound the results.

The first survey with the ADACL measures (T1) was on the laptop screen to assess the participant's energetic state at the beginning of the experiment. The researcher told the participant that the first survey would only take a couple of minutes and left the room to allow the participant to complete it. During this time the researcher used a random number generator to assign the participant a condition (following exclusion from any mediums the participant regularly used).

The participant then got the researcher's attention when they completed the first survey.

The researcher entered the room again and loaded the work task through PowerPoint in presentation mode. Participants were then told that the PowerPoint would guide them through the work task which would take around 15 minutes. They were also advised that at the end of the work task they should click the final arrow which would load a survey with the ADACL measure (T2). After completion of the measurement they moved to the next page, which instructed them not to move beyond this point, but to alert the researcher, at which point they would get a break.

The participant was then instructed to start the work task and the researcher left the room. When the participant finished the practice trials they proceeded to the work task, which took approximately 15 minutes (mirroring work and break times in [33]). After this the participant was informed that this was the end of the work task and was asked to complete the T2 measures.

When the participant got the researcher's attention to indicate they had completed the work task and T2 measures, the researcher brought in the break activity and locked the laptop screen. For the game condition and the mindfulness app condition, the participant was given a smartphone with the activity pre-loaded. For the control, the participant was given a fidget spinner which they were told could be used at their discretion, but were asked not to do anything apart from using the fidget spinner and sitting in the room. The participant was told that the break activity would take 10 minutes which would be timed by the researcher, who would inform the participant when the break time was over. With the mindfulness condition the activity indicated when the 10 minutes was finished at the end of the exercise. The time period of 10 minutes was selected as it should be long enough to allow the individual to recover, whilst not being excessively long, particularly as in the case of games it has been noted that spending extended time playing games does not affect wellbeing [4] or some cases can actually decrease wellbeing [53].

After 10 minutes, the researcher informed the participant that the break activity was over and took back the device. The participant was told that they should now complete the surveys which would mark the end of the task. The participant then completed the rest of the survey including the T3 measures. The T3 measures included the ADACL, the Recovery Experience Questionnaire, the enjoyment measures and demographic information. Completion of these measures marked the end of the experiment. The participant then alerted the researcher who returned to the room, debriefed the participant and answered any questions.

Results

Manipulation Check

The ADACL measure items were added together to form four subscales: energy, tiredness, tenseness and calmness. The tiredness subscale was subtracted from energy subscale resulting in a value for energetic arousal (energy – tiredness = energetic arousal) and the calmness subscale was subtracted from the tenseness subscale to give a value for tense arousal (tension – calmness = tense arousal).

Firstly, the work task was assessed to see whether it successfully changed the arousal states of participants. 41 of the participants were measured prior to the work task to assess baseline arousal (T1). The ADACL measurements at T1 were compared to the measures at T2 (after the work task) through a paired t-test.

Tense arousal at T2 (mean = 1.05, standard deviation = 5.924) was significantly higher than at T1 (mean = -2.80, standard deviation = 5.487), $t(40) = -3.449$, $p = 0.001$. However, energetic arousal showed no statistically significant difference between T1 (mean = 12.29, standard deviation = 5.883) and T2 (mean = 12.22, standard deviation = 6.806), $t(40) = 0.065$, $p = 0.949$.

The findings suggest that the work task made people feel tenser or stressed but did not make participants feel tired.

Post-work (T2) to Post-break (T3)

Tense Arousal

The mean tense arousal scores are presented in Figure 1.

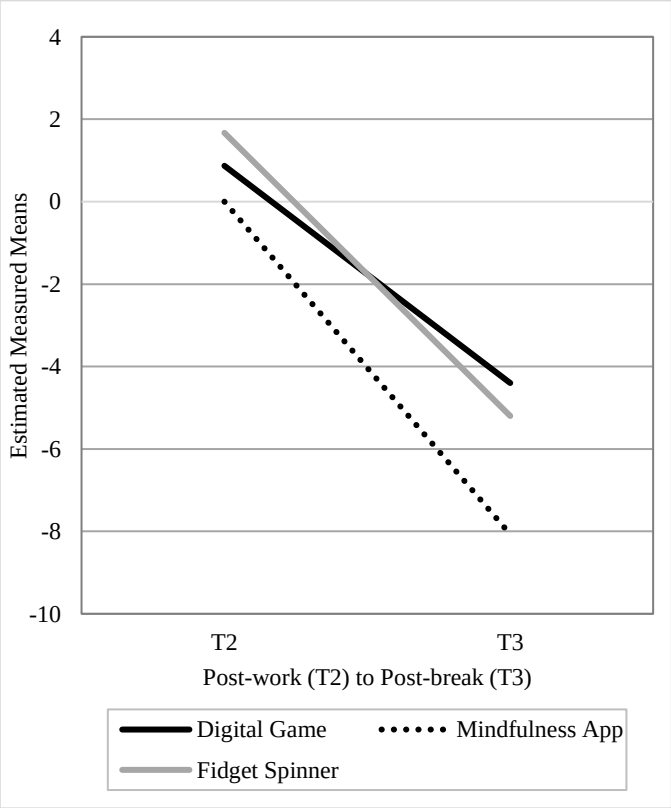

Figure 1: Line graph to show difference between T2 (post-work) and T3 (post-break) in tense arousal by each condition in the lab experiment

A 3 x 2 mixed ANOVA with the break activity (digital game, mindfulness app, fidget spinner) as the between-subjects factor and time (T2 post-work, T3 post-break) as the within-subjects factor was conducted. There was no main effect of break activity, $F(1, 42) = 1.185$, $p = 0.316$, $\eta^2 = 0.053$. There was a significant main effect of time (from T2 post-work to T3 post-break) $F(1,42) = 51.694$, $p < 0.001$, $\eta^2 = 0.543$. These main effects were not qualified by an interaction between break-activity and time, $F(1,42) = 0.750$, $p = 0.479$, $\eta^2 = 0.016$.

This suggests that all the break activities were successful in reducing tense arousal, though there were no significant differences between the conditions.

Energetic Arousal

Energetic arousal was then evaluated, which is displayed in Figure 2.

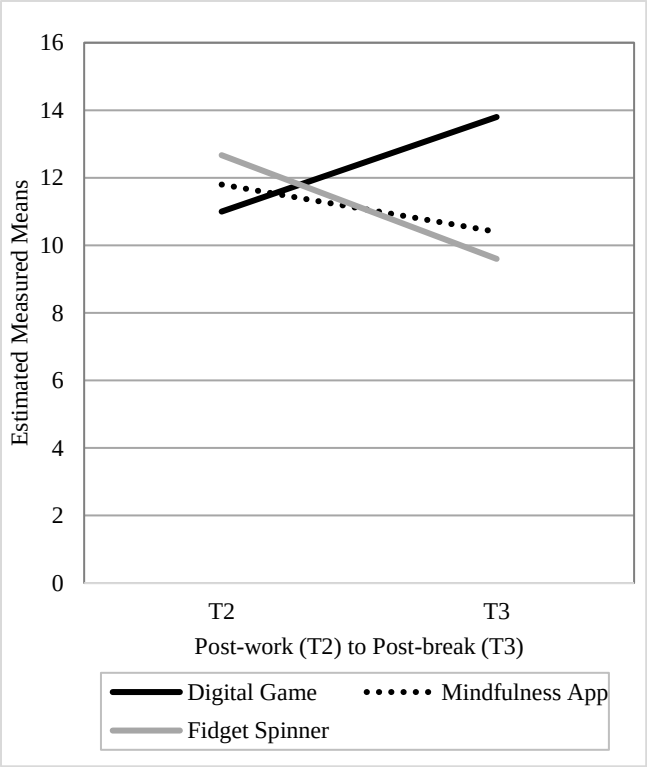

Figure 2: Line graph to show difference between T2 (post-work) and T3 (post-break) in energetic arousal by each condition in the lab experiment

As with tense arousal, a 3 x 2 mixed ANOVA was used. There was no main effect of the implementation of a break overall (from T2 post-work to T3 post-break) on energetic arousal, $F(1,42) = 0.396$, $p = 0.533$, $\eta^2 = 0.008$. There was also no significant effect of the break condition on energetic arousal, $F(1, 42) = 0.281$, $p = 0.756$, with a small effect size, $\eta^2 = 0.013$. However, there was a significant interaction between break time and condition in terms of energetic arousal ($F(1,42) = 3.909$, $p = 0.028$, $\eta^2 = 0.1557$.

Post hoc tests were performed through a repeated measures ANOVA for each break condition separately and analysing pairwise differences using the Bonferroni correction. There was a marginally statistically significant difference for the digital game ($p = 0.053$) with an increase in energetic arousal from T2 (mean = 11, standard deviation = 5.952) to T3 (mean = 13.80, standard deviation = 6.073). However, there was no significant differences for the mindfulness app ($p = 0.382$) or the fidget spinner ($p = 0.091$).

This tentatively suggests that the digital game may have slightly increased energetic arousal, though both the mindfulness app and the fidget spinner did not result in a significant difference.

Recovery Experience

Items from the Recovery Experience Questionnaire were added together to create four scales for each recovery experience. These four scales were then combined to provide a score for overall recovery experience.

When the normality of the recovery experience was assessed with a Shapiro-Wilk test, not all conditions exhibited normal distribution. For this reason a Kruskal-Wallis H test was used to compare the effect of the break task on recovery experience for each condition. For overall recovery experience there was no statistically significant difference between the three conditions, $\chi2(1) = 0.061$, $p = 0.970$.

When investigating the four experiences of recovery individually there was also no statistically significant differences between the three conditions for psychological detachment ($\chi2(1) = 0.489$, $p = 0.783$), relaxation ($\chi2(1) = 2.241$, $p = 0.326$), mastery ($\chi2(1) < 2.985$, $p = 0.225$) or control ($\chi2(1) = 1.636$, $p = 0.441$). This suggests that there were no significant differences in recovery experience between the three conditions. The means (and standard deviations) and medians (and interquartile range) for each condition and aspect of recovery experience can be viewed in Table 1.

Table 1: Means (standard deviation) and medians (interquartile range) for each recovery experience by condition in the lab experiment

	Mean (Standard Deviation)			Median (Interquartile Range)		
	Digital Game	**Mindfulness App**	**Fidget Spinner**	**Digital Game**	**Mindfulness App**	**Fidget Spinner**
Overall Recovery Experience	53.40 (10.66)	53.80 (11.81)	53.60 (10.75)	53 (48 to 64)	55 (50 to 62)	58 (45 to 62)
Psychological Detachment	16.80 (3.47)	15.80 (4.46)	16.40 (2.50)	17 (16 to 20)	17 (13 to 20)	17 (14 to 19)
Relaxation	13.60 (4.44)	15.67 (4.72)	15.27 (4.30)	13 (11 to 19)	17 (14 to 19)	18 (13 to 18)
Mastery	11.13 (3.38)	11.13 (4.03)	9.27 (3.49)	12 (10 to 14)	11 (9 to 14)	9 (6 to 12)
Control	11.87 (4.75)	11.20 (2.83)	12.67 (5.04)	13 (9 to 14)	11 (10 to 14)	15 (8 to 17)

Enjoyment

A Spearman's rank-order correlation was used to investigate the relationship between recovery experience and enjoyment. There was a strong, positive correlation between the two variables, r_s (45) = 0.636, p < 0.001. These results can be observed through a scatterplot in Figure 3.

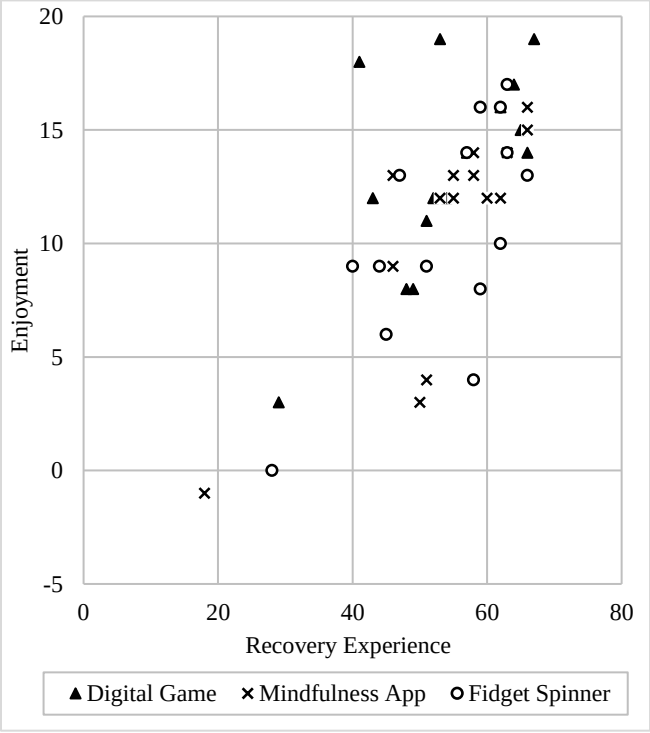

Figure 3: Scatterplot to show the relationship between reported levels of enjoyment against overall recovery experience for the lab experiment

Overall, the results indicate that individuals who enjoyed the break activity reported higher levels of recovery.

Discussion

The comparison between T1 (pre-work) and T2 (post-work) demonstrated that the work task was successful in inducing tenseness in participants and thus inducing a need for recovery. The work task did not fatigue participants in terms of energetic arousal, which could have been due to the nature of the task. Whilst the work task was successful in placing work stress upon participants, the work task may not have resulted in participants feeling tired, as the work task itself involved quickly appearing numbers which required alertness. Steinborn and Huestegge [46], who also implemented a speed task when comparing active and passive breaks, noted that fast-paced tasks tend to result in energetic variables reducing less than detection tasks like those used in prior research such as with Reinecke et al [32].

The results demonstrated that all break conditions were successful in reducing tense arousal, which was a recovery outcome, thus participants successfully recovered after the break task. Regarding RQ1, there was no significant difference between either of the media conditions to the non-media condition of a fidget spinner with tense arousal, overall recovery experience or any of the four aspects of recovery. This both supports prior studies where there were few significant differences between media and the non-media control [32] and contrasts with studies where the media condition resulted in higher reported recovery [34]. A possibility for this occurrence could be that whilst media can promote recovery, the medium itself is not what induces recovery, suggesting there are other aspects to media that induce recovery experiences. Another suggestion could be that the fidget spinner provides the same recovery experiences that the media conditions provided. This could potentially be related to the interactive elements that were present in all three conditions. Prior research has found that the level of interactivity in media has been linked to increased recovery experience [32] or different elements of enjoyment being satisfied [48]. Reinecke et al [32] demonstrated that interactivity is linked to involvement; as

fidget spinners occupy a person's hands and are kinaesthetically involving [15], fidget spinners could be argued to be an interactive (though non-digital) medium. It could be possible that all three conditions were equally interactive and thus this interactive component promoted recovery. Karlesky and Isbister [14] also argue that fidget widgets are a playful activity and intrinsically motivated, whilst games provide extrinsic motivation in the form of elements like achievements. The similarities between these mediums could also explain the lack of significant differences, though this seems less plausible as the mindfulness app was not significantly different to either of the other activities and has not been identified as possessing playful or game-like qualities.

Similarly with RQ2 and RQ3, there was no significant difference between the digital game and mindfulness apps in terms of overall recovery or the four aspects of recovery. There was also no significant difference in reduction of tense arousal between the conditions. Although the digital game possibly showed a marginally significant increase in energetic arousal, this assumption is not robust enough to presume that the digital game was more successful overall. Similar to RQ1, this could suggest that both the digital game and mindfulness app satisfy recovery experiences in equal ways, although the digital game may potentially be more energising (this would require additional testing to ascertain). However, RQ4 provides some clarification. There was a strong positive correlation between recovery experience and enjoyment, demonstrating that generally if a participant enjoyed the activity, they experienced higher levels of recovery and likewise, if they disliked the activity, they reported lower levels of recovery. This supports Reinecke et al's [32] observation that enjoyment and recovery are related. As Figure 3 illustrates, enjoyment was distributed across all three conditions; essentially, every break activity had participants who liked it or disliked it to varying degrees. This raises some questions about factors which may have influenced the enjoyment of the activity and therefore the recovery experience, which will be addressed in the second study.

Fidget Spinner Observations

One element that was not captured in the quantitative data was observations made during the data collection phase with participants using the fidget spinner. Whilst the digital game and mindfulness app participants followed the structure of the activity, participants using the fidget spinner condition displayed variation in their actions during the break. Some participants played with the fidget spinner once and then left it alone, sitting in silence and even almost falling asleep. Other participants continued to use the fidget spinner throughout the break whilst sitting in the chair in a relaxed manner. However, other participants were observed to use the fidget spinner more dynamically, including trying different moves with the object or testing it on different surfaces within the study room. This means that the break experience varied widely for participants depending on their choices. It could suggest that the participants were using the fidget spinner to address their recovery needs as they saw fit, for example sleeping if they felt tired or playing with it if they found this more engaging and satisfying, which would link to the self-regulation aspects of fidget spinners observed in past research [15]. However, it could also be suggested that participants had different ideas about how the object should be used.

Limitations

In terms of limitations, there were a few occasions where participants reported after the study that they did not understand the meaning of the words in the ADACL. This was also observed in the pilot study, so one term ("drowsy") was removed from the measures in the live version of the lab experiment. However, during data collection a few participants reported that they did not understand some of the words (specifically "clutched up" and "placid") and that they marked it as "I cannot decide if I feel this way". This may have skewed the results.

Another limitation, which was not tracked in demographic data but was mentioned colloquially during the debrief at the end of the lab experiment, was the effect of educational background. As the participants were all students some commented that they believed their backgrounds helped or hindered them during the work task, namely that students who had studied numerically-based subjects found the work task easier and less stressful than students of subjects without a mathematical basis. This could suggest that the work task did not equally strain participants, which should be considered if the work task was replicated in future experiments.

Finally, another limitation was using measurements which were subjective. Unlike previous lab experiments on media-induced recovery [32,33], this study did not assess cognitive performance. This was due to the general difficulties inducing errors which tend to be infrequent [6], particularly in lab experiments which are often short and where participants are driven to do well, which makes errors unlikely [38]. Instead, the focus was upon the subjective assessments of recovery with an experiential focus. To explore the results in more depth and investigate overall user experience and factors which influence recovery, a second study was performed in the wild.

4. STUDY 2: IN-THE-WILD STUDY

Results from the lab experiment suggested that factors such as enjoyment had a significant influence on recovery experience. However, it did not capture additional information around why this have influenced recovery or around other factors which may have influenced user experience. Furthermore, a temporary work task restricted to the lab environment is no substitute for a real work day, where there may be other factors which could influence recovery. For these reasons, the second study was an in-the-wild field experiment to understand whether and how digital games and mindfulness apps affect recovery, as well as to

see if the lab results were replicated and to further understand other influencing factors.

Method

Participants

A total of 20 participants took part in the in-the-wild study. There were 12 female and 8 male participants aged between 19 and 58 years old. All participants were white-collar workers. A requirement for the study was that the participants were working professionals who worked full time or for a minimum of 7.5 hours per day at least 4 days a week. Participants were recruited through word-of-mouth and social media. One participant took part in both the lab experiment and the in-the-wild study, but was assigned to different conditions (non-media control in the lab experiment, mindfulness app in the in-the-wild study) to avoid confounding variables. All participants were technically literate, possessed smartphones and actively used them. Participants were incentivised to take part through the reward of a £5 Amazon voucher on completion of the study.

Design

The study was a between-subjects design with one independent variable, the recovery activity. The two conditions for the recovery activity were either a digital game or a mindfulness app. The fidget spinner condition was not included in this study because the focus was on the digital mediums and as the media conditions were easy for participants to access on their own smartphones which they already habitually used. The dependent variable was self-reported recovery and levels of energetic and tense arousal.

Materials

The in-the-wild study delivered the break task to the participant via the participant's existing smartphone. The primary materials were the post-work recovery task, which differed depending on the condition. The materials used in the in-the-wild study mirrored those used in the lab experiment. For the digital game condition, the app *Block! Hexa Puzzle* was installed onto the participants' phone and for the mindfulness app *Headspace* was used. Participants in the mindfulness app condition were instructed to follow the free 5-day beginners program provided by Headspace. Daily reminders and surveys were sent to participants via email.

Job Content Questionnaire

The Job Content Questionnaire [13] was used to measure job stress, which could be a confounding variable in the levels of recovery reported. The Job Content Questionnaire originally had 49 items where the questions can be combined into specific subscales. Mirroring Collins and Cox [4], this study measured 7 subscales: skill discretion, decision making authority, psychological demands, supervisor social support, co-worker social support, physical job demands and job security. Following this, participants were also asked if they already played digital games or used mindfulness apps, which was answerable on a 5 point Likert scale, of "daily", "a few times a week", "weekly" "monthly" or "less than once per month" (similar to [28]).

Activation Deactivation Adjective Checklist

The ADACL [49] was also used in the naturalistic environment and presented in the same format as the lab experiment, allowing work stress and fatigue to be measured before and after the recovery activity.

Recovery Experience Questionnaire

The Recovery Experience Questionnaire [42] was presented in the same format as the lab experiment with sentences answerable through 5 point Likert scales. Again, this allowed for the four recovery experiences to be assessed.

Enjoyment

The participants' enjoyment was also assessed with the same measures as the lab experiment, replicating [29] with 5 statements around enjoyment, which were answered using 5 point Likert scales.

Procedure

When participants indicated interest in participating in the project they were initially contacted through email and a phone call if requested. They were sent an information sheet which informed them that the study was focussing on understanding how people recover and recharge after work and how certain activities and applications can influence this. Once participants returned signed consent forms at the beginning of the study, they completed an initial set-up survey which contained details from the Job Content Questionnaire. They were also asked if they already played digital games or used mindfulness apps and if so how often, as previous experience with the apps could have a confounding influence. Like the lab experiment, participants were assigned to the mediums which they did not use or had not used in the past six months. Participants were then given an information sheet for their respective activity which included guidance on installing the applications and other information on how to use the app each day. For the digital game condition, participants were asked to load the game in aeroplane mode to prevent adverts which could potentially hinder the recovery experience. Information on the series of activities to undertake was provided for the mindfulness app condition.

The participants were instructed to carry out the activity at the end of their working day just after arriving home. The evening time slot for the recovery activity was selected as the participants were more likely to have control over their home environment; some workers may have been unable to do the recovery activity during work due to workplace restrictions. Furthermore, implications from previous research found that people can struggle to undertake activities on mindfulness apps in locations where they have less control [19]. Participants were asked when they usually arrive home, so that they received timely reminder notifications to undertake the activity. The notifications were delivered by email.

Each day over a period of 5 working days, participants were sent the first survey, titled the "before the app" (T1) survey, at the time they indicated they usually arrived home. The T1 survey contained the ADACL measures to assess arousal

levels after a day's work. After completion, participants undertook the recovery activity for 10 minutes. Participants with the digital game timed 10 minutes on their smartphones, whilst participants with the mindfulness app completed the day's assigned activity which was set to 10 minutes long. The notification for the T2 measures, titled the "after the app" survey, was sent 13 minutes after the T1 measures, which allowed them to be received approximately when the participant would have finished the recovery activity. The T2 measures again included the ADACL to assess the impact of the recovery activity, as well as the Recovery Experience Questionnaire and the enjoyment measures. If a participant missed a day of the activity they were informed that the day's activity could roll over to the following day.

When all 5 days of the activity had been completed a semi-structured interview was held over the phone or video conferencing software to understand the participant's experiences and debrief them on the study. The interviews took approximately 10 to 15 minutes each. After this was complete the participant received their reward. In total there were 100 survey responses recorded (twice per day from 20 participants over a 5 day period).

Results

Quantitative Analysis

As the quantitative data was collected 5 times from each participant over the study period, the data underwent person-mean centring prior to analysis [24]. This involved aggregating scores over the 5 days to generate singular mean per participant for the respective measure. These person-centred means then underwent the respective statistical tests below.

Post-work (T1) to Post-break (T2)

To assess whether the recovery activity had any effect on the participants, statistical tests were performed between the T1 and T2 measures of the ADACL for each condition.

Tense Arousal

The mean tense arousal scores are presented in Figure 4.

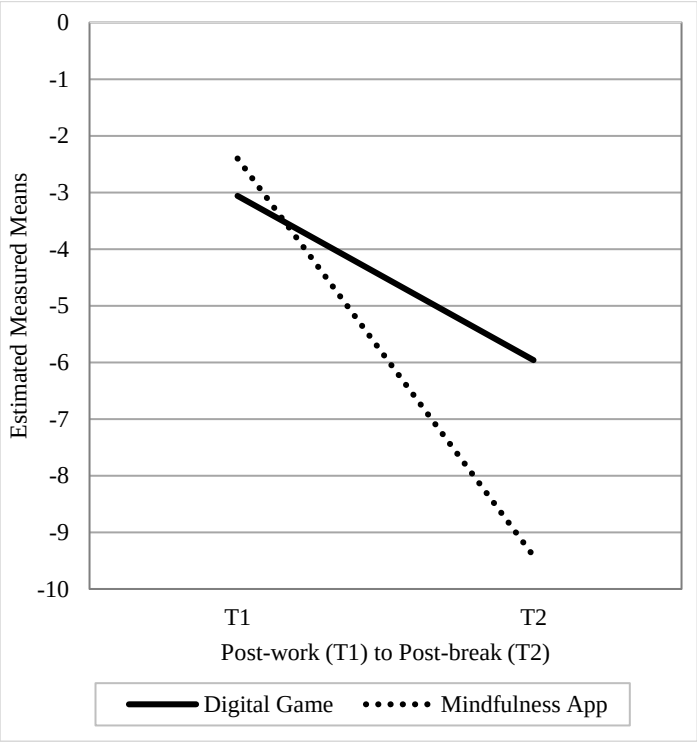

Figure 4: Line graph to show difference between T1 (post-work) and T2 (post-break) in tense arousal by each condition for the in-the-wild study

A 3 x 2 mixed ANOVA with the recovery activity (digital game, mindfulness app) as the between-subject variable and time (T1 post-work, T2 post-break) as the within-subject variable was carried out. There was a significant main effect of the within-subjects factor of time (from T1 post-work to T2 post-break), $F(1,18) = 24.941$, $p < 0.001$, $\eta^2 = 0.528$. There was no statistically significant main effect for the break activity, $F(1,18) = 0.588$, $p = 0.453$, $\eta^2 = 0.032$. However in terms of interaction between tense arousal and condition, there could be argued to be marginal significance, $F(1,18) = 4.302$, $p = 0.053$, $\eta^2 = 0.091$.

Post hoc tests using the Bonferroni correction found that there was a significant difference for the mindfulness app ($p < 0.001$) with a decrease in tense arousal from T1 (mean = -2.4, standard deviation = 4.495) to T2 (mean = -9.42, standard deviation = 3.249). However, there was no significant difference for the digital game ($p = 0.094$).

As the interaction is marginally significant, this tentatively suggests that the mindfulness app was more effective at reducing tense arousal than the digital game. Accepting the interaction effect as significant could also suggest that only the mindfulness app was more effective at reducing tense arousal, as the post hoc test did not identify a significant difference for the digital game.

Energetic Arousal

The mean scores for energetic arousal are shown in Figure 5.

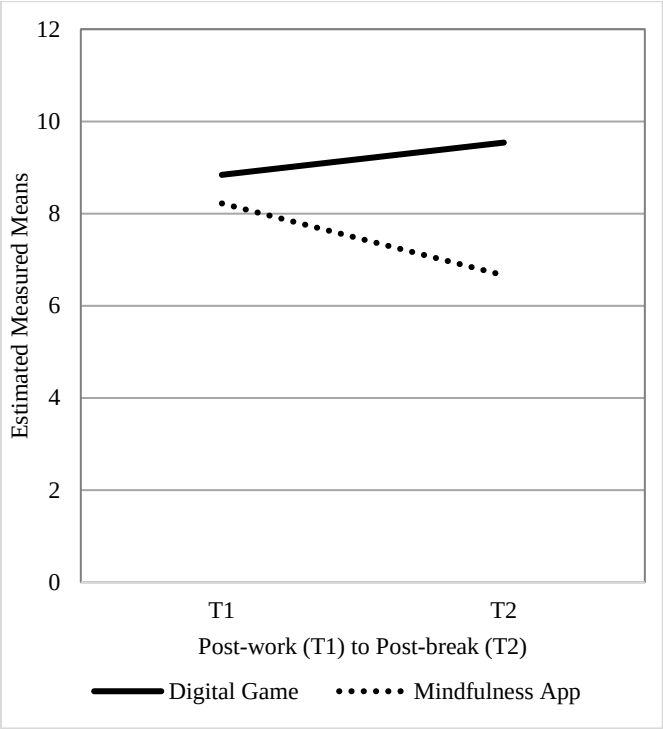

Figure 5: Line graph to show difference between T1 (post-work) and T2 (post-break) in energetic arousal by each condition for the in-the-wild study

Like tense arousal, a 3 x 2 mixed ANOVA was used. There was no significant main effect of time (between T1 and T2) for energetic arousal, $F(1,18) = 0.195$, $p = 0.664$, $\eta^2 = 0.001$. There was also no significant main effect of the break condition, $F(1,18) = 0.735$, $p = 0.403$, $\eta^2 = 0.0392$. Finally, there was no significant interaction between time and break activity, $F(1,18) = 1.348$, $p = 0.261$, $\eta^2 = 0.069$. Overall, there were no significant differences in terms of energetic arousal in the in-the-wild study.

Recovery Experience

A Shapiro-Wilk test indicated that some recovery experiences were not normally distributed in each condition. For this reason, a Mann-Whitney U test was used to compare the digital game and mindfulness app in terms of recovery experiences. For overall recovery experience, there was no statistically significant difference between the game and mindfulness app, $U = 38$, $p = 0.364$.

However, there was a statistically significant difference for psychological detachment between the game and mindfulness app, $U = 22.5$, $p = 0.037$. The digital game had a mean rank of 13.25, whilst the mindfulness app had a mean rank of 7.75. Additional descriptive statistics can be found in Table 2. This suggests that the digital game was significantly more successful at promoting psychological detachment over the mindfulness app.

There was no significant difference between the game and the mindfulness app in terms of relaxation ($U = 49$, $p = 0.940$), mastery ($U = 44.5$, $p = 0.677$) or control ($U = 37.5$, $p = 0.344$).

Table 2: Means (standard deviation) and medians (interquartile range) for each recovery experience by condition in the in-the-wild study

	Mean (Standard Deviation)		**Median (Interquartile Range)**	
	Digital Game	**Mindfulness App**	**Digital Game**	**Mindfulness App**
Overall Recovery Experience	60.90 (8.91)	55.20 (10.58)	58.80 (52.70 to 68.75)	60.70 (41.30 to 61.05)
Psychological Detachment	18.46 (1.74)	15.58 (3.14)	19.30 (16.65 to 19.85)	15.20 (13.40 to 18.70)
Relaxation	15.84 (2.62)	15.88 (2.97)	15.70 (13.30 to 18.45)	16.30 (14.70 to 17.50)
Mastery	11.50 (4.13)	10.62 (3.09)	11.80 (7.95 to 15.50)	11.70 (7.05 to 13.25)
Control	15.10 (3.11)	13.12 (4.13)	15.30 (13.10 to 18.10)	14.80 (8.60 to 16.45)

Enjoyment

A Spearman's rank correlation coefficient was used to look at the relationship between enjoyment and recovery. There was a strong positive correlation between enjoyment and recovery, r_s (20) = 0.635, p = 0.003. These results can be observed in a scatterplot in Figure 6.

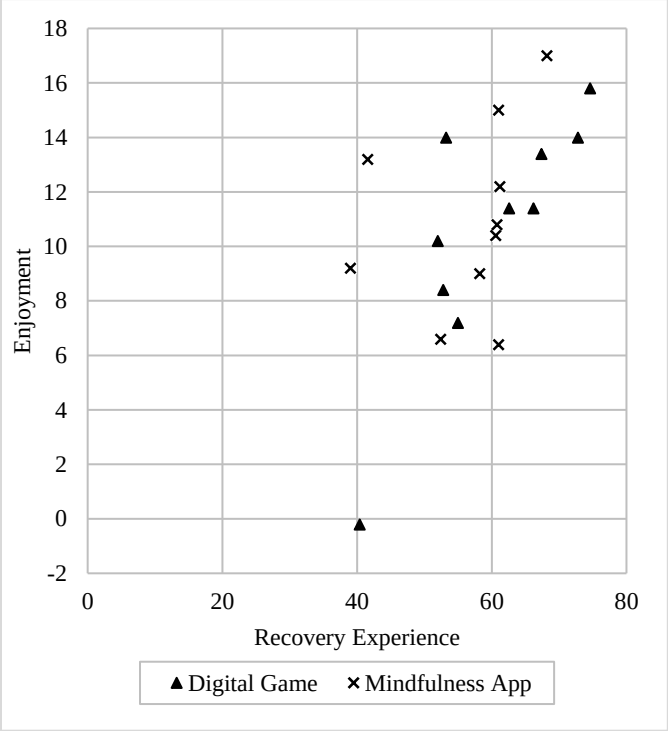

Figure 6: Scatterplot to show the relationship between reported levels of enjoyment against overall recovery experience for in-the-wild results

This suggests that higher levels of enjoyment correlated with higher levels of recovery.

Job Content Questionnaire

Finally, the effect of job strain on recovery for both activities was investigated to understand if one activity was more effective for people in more stressful jobs. Job strain was assessed using scales from the Job Content Questionnaire and associated guidance on assessing job strain [13]. The subscales skill discretion and decision-making authority were combined to produce a value for decision latitude. The value for psychological job demands was also assessed. Occupations with job strain are generally identified as possessing a combination of low scores for decision latitude and high scores for psychological job demands. These scales were analysed separately so they could undergo statistical testing. For the participants using the digital game a Spearman's rank correlation coefficient was used to investigate the relationship between decision latitude and recovery experience, where no significant correlation was identified, r_s (10) = -0.079, p = 0.828. Similarly, there was also no significant correlation between psychological job demands and recovery experience, r_s (10) = 0.030, p = 0.933.

The mindfulness app condition delivered similar results: a Spearman's rank correlation coefficient found no significant relationship between decision latitude and recovery experience, r_s (10) = -0.180, p = 0.618, or between psychological job demands and recovery experience, r_s = -0.059, n = 10, p = 0.872. This suggests that occupational job strain did not impact the efficacy of the recovery activities.

Qualitative Analysis

After the five-day data collection period each participant took part in a semi-structured interview to understand their experiences. Following transcription the qualitative data was analysed through thematic analysis [2] with a bottom-up approach to understand emerging codes and themes from the data. These themes were then reviewed and defined as the subsections below.

Overall, participants in both conditions reported mixed experiences, but almost all participants reported benefits to differing extents. For the game condition all participants said they experienced some benefit, though this ranged from minimal to feeling completely refreshed. With the mindfulness app most participants also reported some benefit (again to varying degrees), with the exception of P10, who found the activity boring and P16, who said that events in their home-life made it difficult for them to focus on the mindfulness app. Mirroring the quantitative data, participants in both activities who enjoyed the activity more tended to report greater recovery benefits. However, enjoyment did not translate into participants' using the app after the study. When asked if they would continue to use the app, 7 out of 10 mindfulness app participants said they would not use it again, even though 6 of the participants said they liked the activity. In contrast, only 4 out of 10 of the game participants said they would not use the app again; interestingly one participant who said they did not enjoy the activity overall admitted they had played the game since the study ended:

"*I did actually find myself clicking into it the other day when I was on the tube, yeah, it was more just a way, if you don't have anything to do and you need to focus your mind somewhere, you just think well, it's there so I may as well*." (P9)

This quote also highlights one of the themes around psychological detachment.

Psychological Detachment and Focus

All participants in the game condition mentioned that the activity acted as a distraction and thus helped them to detach from their workday:

"*I found it really helpful to focus on one thing, so I think if I was feeling stressed, or needed to occupy my brain for a little bit… like a distraction almost*." (P1)

"*Even if you had a lot racing through your mind after a busy day at work, it was a good way to actually switch off from*

that, and once you'd finished the game, you felt as if you were actually relaxed and actually out of that work zone." (P2)

This was felt to varying degrees, with P7 citing the distraction was present but minimal ("*it did distract my mind a bit from work, but it's minimal*" (P7)), to a participant like P20 who analogised the experience to being restarted:

"*I felt like I was restarted, you know, like a computer… It was such a short period of time, and then I felt very refreshed, and then I didn't think about work for the whole evening.*" (P20)

Following psychological detachment some participants described a renewed sense of focus when moving onto the next task. The tasks that the participants moved onto varied from watching television to attending the gym. Two participants needed to work at home every night yet still reported the benefits of the game in helping them detach and then refocus on their next work objective:

"*It put you in that productive mood for that evening and enables you to sort of have a clear picture in your head of what you wanted to do and what was more achievable*." (P1)

"*Definitely have ten minutes without thinking about work. Which helps you progress as it takes your mind off it for a few minutes*." (P19)

In the words of P15, participants frequently reported that after playing the game and successfully detaching from work, they "*felt like doing something*" (P15). However, when further questioned, some participants said they felt this was more because they had the game as a scheduled task:

"*I think it was good to have a set routine when I got home that I had to do something instead of just kind of like sitting down and not really having a plan. It focussed me a little bit more, to know that when I got home, sat down, did the game, and then I moved on with the rest of my day then*." (P11)

"*It does help order the evening a bit, but it's because you know you have committed a certain amount of time to doing it… alright I need to do this first, and then I don't know, you just go about doing other things.*" (P9)

This suggests that the scheduled activity may have acted as a break point between work and home time. Whilst all the games participants reported psychological detachment to different degrees in the interviews, there were more mixed results for the mindfulness app. Only one of the mindfulness app participants mentioned renewed focus post-app:

"It's the whole refocussing. It's like okay, you've put that work behind you, but now you can get on with what other stuff you want to do, so it is that divide." (P3)

One participant noted that the mindfulness activity was generally less about distancing themselves from their thoughts and instead acknowledging that they were having those thoughts:

"*I guess it brings myself away from work, but I didn't distance myself away, I guess I was just able to acknowledge that I have work stress, but I still was separate from feeling stressed as much because I was able to control the ideas with the meditation, I think, let me know why I am a certain way*." (P4)

This is arguably a different concept to psychological detachment. However, a few participants using the mindfulness app did comment that they experienced detachment from the outside world and enjoyed having some time to themselves:

"*Having that time to yourself was quite useful, and I quite enjoyed that, and it was just completely you and you just zoned out of everything else, I thought that was quite good*." (P8)

"*It was taking time out I suppose. I guess it's a bit like going to have a facial or something [laughs]*." (P5)

The awareness of how participants were spending their time was another salient element in the interview data. Several mindfulness app participants reported that they felt the 10 minute activity length was a little long and that they lost focus on the activity:

"*I did find that around 7-8 minutes my mind was starting to wander from the app a bit more. Like I know it's meant to do that, but it was just completely like going off from it*." (P18)

"I think I would have enjoyed it if it was less time… I didn't enjoy it in the first place probably because it was so long, or it felt long." (P6)

The digital games participants did not mention this awareness of time when playing the game, with some commenting that they felt 10 minutes was the right amount of time, as games had a danger of being addictive. Several mindfulness app participants said that they already played mobile games, usually to fill time, or arguably to detach from the current place and time for a brief period. This could suggest that an individual's need for psychological detachment could fluctuate depending on difference circumstances, a theme which was identified elsewhere in the data and later discussed.

Energy Levels and Relaxation

Another theme from the interview data was that many participants described their feelings after the activity in terms of arousal and energy. With the digital game condition participants reported mixed feelings of energy. One participant described feeling relaxed, but also more tired (P11). Several participants reported that they found the game calming, even if they did not enjoy the activity ("*It was calming in a way, like I think because it's quite a monotonous type of activity*" (P9). Conversely, other participants reported feeling more energetic after the digital game:

"*When you're tired from work, it just gets you a bit more alert*." (P15)

"*Straight after work I always felt very tired and very sleepy, but - and straight after the game I felt very refreshed and very energetic and stuff, so it really shifted my feelings actually*." (P20)

With the mindfulness app several participants described feelings of calm and relaxation, but also sometimes tiredness ("*I'd say all days I was more tired. But, definitely a few days it made me feel calmer. It was on like a scale*" (P6)). However, participants evaluated these feelings in different ways; some did not like feeling sleepy having just returned home from work, with one participant describing how they unintentionally fell asleep and attributing this to boredom:

"*One day I just fell asleep [laughs]. But because it was just so boring*." (P10)

Other participants appreciated the tiredness that the mindfulness app encouraged as it helped with sleeping or bringing down energy levels when they were unwelcomingly high:

"*It really helped me sleep very well, it kind of calmed my mind*." (P18)

"Sometimes if I have like a late football match and I get back late, sometimes I've still got the adrenaline going all over my body before I go to bed, and it takes a while to go to sleep. So I think [the mindfulness app] kind of did help as well, so that was nice." (P8)

The latter quote also illustrates how participants felt the activities were more effective during some circumstances than others, which links to the following theme.

Differences at Day-level and Person-level

Although the difference between days was not the focus of the quantitative analysis, 9 participants commented upon daily variations in how they found the activities. Several participants in both conditions commented that they found the activity more beneficial when they returned from a busier or more stressful day at work:

"*It depended on the day I'd had at work… I felt on the days that work was very busy I got a lot more out of the game*." (P2, digital game)

"If [the day] was more stressed, I might have been slightly more resistant to relax, but it definitely helped… probably helps more on the stressful days." (P3, mindfulness app)

Multiple participants commented on this initial feeling of resistance when starting the activity on stressful days but subsequently felt that it was more effective. However, there were exceptions with 2 participants who used the mindfulness app. P6 reported they found the activity more calming after less stressful workdays *("The day it seemed to work most was the day when I was not winding myself up anyway all day with the same problem*." (P6)) and P16, who found the activity difficult on most days due to problems in their home life ("*I don't think it was quite right for me at this particular time.*" (P16)).

Individually, the participants did differ in terms of enjoyment and personal preference for recovery activities. One prevalent aspect amongst the digital game participants was that several said they generally did not enjoy playing games ("*I'm not really a gamey person*." (P12)) and that the activity was not their preference. However, the participants in the mindfulness app did not report a predisposition against mindfulness apps from the beginning as often this was their first time in trying the activity, although through the study some did learn that they did not enjoy them.

Some participants mentioned that they felt they could get similar recovery benefits from other activities which they preferred, or in the case of the digital game from playing a different game which they may enjoy more ("*If I was going to do a game, I'd rather - it would be more kind of word based or something like that*." (P12)). One participant said that after the study period finished they had started doing a regular scheduled activity on arriving home, but replaced the digital game with going for a walk:

"*Which I've actually taken into this week as well. The first thing I do when I get back now, is I get changed and I go for a walk straight away. I don't do anything else, I just go for a walk.*" (P11)

This highlights the importance of enjoyment and personal preference.

Discussion

The quantitative results for tense arousal differed to the lab experiment. The marginally significant interaction effect tentatively suggests that the mindfulness app was more effective at reducing tense arousal than the digital game. However, if the interaction is considered significant, this could also suggest that the digital game did not significantly lower tense arousal. Despite this, it seems inaccurate to dismiss the game as not promoting recovery due to other observations in the data: the game resulted in significantly higher psychological detachment than the mindfulness app, the game and mindfulness app had no significant differences in overall recovery experience (inferring that both activities were equally successful) and the interviews with the game participants indicated that the activity did help them recover (albeit to varying extents and in different respects). The interviews also indicated that the game resulted in participants having different energetic reactions, with some feeling more tired and others feeling refreshed, which again may have impacted the quantitative results. Due to these inconsistencies, it is inadequate to assume for RQ2 that the mindfulness app was more successful than the digital game based solely on the tense arousal scores. Rather, the other observations suggest that neither the digital game nor the mindfulness app was more effective overall. This highlights several limitations with both the sample and the measures, which will be discussed later.

With RQ3 around the four experiences of recovery, there was evidence that the digital game was more effective than the

mindfulness app at promoting psychological detachment, which supports some previous literature on digital games and recovery [4]. Multiple participants identified mobile games as a time-killer, which may suggest that digital games can also allow participants to psychologically detach from a situation (such as waiting or commuting) when there is no underlying need for recovery. Psychological detachment could be linked to the immersive quality of digital games as a medium. Although the game used in this study was a puzzle game and thus does not provide a feeling of presence or total escapism, previous studies have demonstrated that players can still become immersed in them [12], which is supported by this study. Conversely, the mindfulness app participants mentioned feelings of detachment less frequently, with a few finding it difficult to detach from stressful situations and being more aware of time dragging towards the end of the sessions, implying they were not detached from the present moment. This could be due to the nature of the activity, which involved staying present and acknowledging existing thoughts, an observation made by a participant. However, this is not an outright negative aspect of the activity, as some participants enjoyed this element. Alternatively, it could suggest that, like the need for recovery, the need for psychological detachment may fluctuate and different activities may satisfy this need to different extents or according to personal preference. Other elements of the activities were evaluated in different ways by participants depending on their current needs. An example is how mindfulness app participants reported that the activity made them feel calmer but also more tired. Whilst one participant said that the mindfulness app was helpful in reducing their adrenaline after a football match, other people may not want to feel more tired after work. This could indicate that the activities can be used to alter a person's state or promote certain recovery experiences depending on what they need at the time, but that one app may not be universally suitable.

For RQ4, the quantitative data demonstrated a strong positive correlation between enjoyment and recovery for both the game and the mindfulness app. This was also evident in the interview responses, where the participants who most enjoyed the activity reported the strongest recovery benefits. Participants also mentioned activities which they thought they would enjoy more and help them recover, which demonstrates that personal preference and subsequent enjoyment has an impact on recovery activities, again suggesting that one activity may not be universally more effective than another at promoting recovery.

Finally, RQ5 was interested in the user experience of undertaking both activities. As previously mentioned, participants reported varying experiences and identified factors which moderated their recovery experiences. They also had different views in terms of the time taken to do the activity, with mindfulness apps sometimes described as feeling too long, although some participants commented that they may get benefits from the mindfulness app if the activity was shorter. None of the game participants said that they felt the activity was too long, which could relate to the previous discussion on psychological detachment. Instead, several commented that they felt ten minutes was about the right amount of time for playing the game, as playing games for long periods or getting addicted to games can be problematic. This supports previous literature which identified that when is media used for procrastination, it is often negatively evaluated by the user [31].

One question raised in the qualitative data was whether individuals felt that the psychological detachment and subsequent focus they reported came from the specific activity or because the activity acted as a break point. Five participants over both conditions reported this, which suggests the break point was influential. Sonnentag and Fritz [43] noted that implementing specific routines into the day between work and rest can enable individuals to psychologically detach more easily from the stressors of work, giving the example of creating a to-do list for the following day. In a separate study it was found that individuals who undertook a goal-planning session at the end of their workday experienced greater levels of psychological detachment from work [39]. The results in the current research implies that these scheduled activities do not need to be goal-setting to result in greater levels of psychological detachment, but can be general recreational activities. Indeed, one participant (P11) said that although they no longer used the game, they had continued with having a scheduled activity (a walk) when arriving home to facilitate detachment from work. It could be suggested that any activity scheduled into an individual's day acts as a break point and may promote psychological detachment, which could be point for future research.

Limitations

In terms of limitations, a general limitation to in-the-wild studies is that the researcher cannot check that the participants followed the instructions every day. Although the survey management software (Qualtrics) used to distribute the daily questionnaires via email could be used to check when participants completed both of the day's surveys, it could not be guaranteed that participants always did the activity just as they arrived home and the interview data indicated that occasionally participants would leave the recovery exercise until later in the evening. This means that the time when the recovery exercise was undertaken was not fully controlled, which may have affected the results.

The sample of participants may not have been the ideal group with whom to administer the intervention. Although the quantitative results indicated that the group was relatively homogenous in terms of job content, there were comments in the interviews from several participants that they didn't think much about work when they returned home, so psychological detachment may not be a problem for them. This suggests the intervention may not have been as effective as it could have been because some participants did not necessarily have a problem switching off.

Another limitation could be related to the way the data was processed. As the focus of the study was to understand the difference between people rather than between each day, the data was person-mean centred [24]. However, this may have resulted in the loss of some variation and complexities within the data. It also drastically reduced the sample size of the data from 100 data points to 20 data points, which may have impacted statistical testing. Nevertheless, the qualitative data collected in the interviews supported some of the results and assertions from the quantitative analysis.

Finally, another limitation may have been related to individual preferences, including aversion to certain activities, specifically digital games. As stated in the method, to avoid an individual's experience with the break activities from skewing the data, participants were excluded from the respective conditions if they already used digital games or mindfulness apps on their smartphone or had done in the past six months. Although this may have avoided experiential bias, there appeared to be an "anti-game" bias amongst some participants who did not play digital games, which was not present with participants in the mindfulness app condition. Participants who did not use mindfulness apps had usually never used them beforehand and were generally curious to see how they would find the activity. However, some participants who did not play games expressed that they didn't like games or found games boring. This could mean that the sample of non-gamers began with more negative presuppositions about this activity than those who were given the mindfulness app. Previous studies have identified that negative presuppositions can negatively influence recovery [28,30]. This could indicate that a bias against games could have skewed the results and impacted the population validity of the sample. A suggestion for future investigation could be to extend the sample size and test the intervention amongst participants with different experience levels of each activity.

5. GENERAL DISCUSSION

Overall, the digital game and mindfulness app were both successful at promoting post-work recovery. However, both studies demonstrated that neither the digital game nor the mindfulness app was universally more effective than the other. This supports assertions from previous research that there is no singular break activity effective for everyone [37]. Whilst there were no significant differences between each activity in terms of relaxation, mastery or control in either study, the in-the-wild results suggest that the digital game is more effective than the mindfulness app at promoting psychological detachment. The mindfulness app was also identified in both studies as successfully reducing tense arousal, arguably more so than the game in the field experiment. However, overall it cannot be asserted that one activity will consistently be more effective than the other, as there appears to be factors that influence the extent to which recovery is successful. These factors can be discussed in terms of two overarching topics; enjoyment, where individual preference influences recovery, and changing needs for recovery, where an individual pursues an activity which will meet their specific recovery needs at the time.

Enjoyment, Appraisal and Preference

In both studies enjoyment of an activity showed strong positive correlation with the levels of recovery reported by participants. This suggests that for successful recovery it is important that a participant enjoys doing the activity. This supports past literature on both mediums, such as studies on mindfulness, which identified stronger recovery and wellbeing benefits when participants enjoyed an activity or were intrinsically motivated [8,9] and prior research which determined greater recovery benefits if people enjoyed the media or game [32]. Other studies into recovery and digital games have postulated that recovery efficacy is influenced by whether the user positively associates games with recovery [28] or how they appraise the media use, with procrastination depleting the recovery effect due to reduced enjoyment and guilt acting as a stressor on resources [30]. As discussed during the in-the-wild limitations, there could have been a bias against games in the sample of participants, thus another tentative argument could be that the results in this study may also demonstrate that an individual's appraisal of an activity impacts the efficacy of recovery.

As the results indicate that enjoyment is key for successful recovery, the concept of enjoyment itself should be discussed. Although historically enjoyment was theorised as a purely hedonistic, pleasure-seeking concept, Tamborini et al [47] postulated and demonstrated that enjoyment can be conceptualised by the satisfaction of psychological wellbeing needs, specifically the three needs in the self-determination theory of autonomy, competence and relatedness [36]. In a later paper Tamborini et al [48] expanded on this model, combining the non-hedonic need satisfaction from the earlier paper with hedonic needs to explain enjoyment and its variance. Reinecke et al [32], who found a clear link between recovery experience and enjoyment, noted that their results, though based on the theoretical concept of recovery experiences as opposed to needs in self-determination theory, suggested that enjoyment involves the satisfaction of intrinsic wellbeing needs.

However, one element of enjoyment which these studies and models did not consider is personal preference. Indeed, Tamborini et al [47] noted that they did not include personal preference within their model of enjoyment. The in-the-wild interviews indicated that personal preference may have had an impact on enjoyment, supporting prior research which identified that different people can evaluate the same activity as relaxing or as a chore [51] and that individual preference could result in whether a person enjoys and subsequently recovers from an activity [17,37]. This could suggest that personal preference should be considered in models of enjoyment and as a potential influencing factor in recovery.

The impact of enjoyment on recovery has been defined in prior research as experience quality [45], where the perception of the activity being enjoyable reduces the need

for recovery, which arguably is supported by this study's data. A separate but related concept is recovery quality [27], where an individual evaluates recovery as successful if the underlying four experiences of recovery are satisfied, as opposed to evaluating the activity itself. This concept of satisfying the underlying four experiences of recovery links to the next factor the study identified as influencing recovery: fluctuating needs for recovery.

Changing Needs for Recovery

One observation from the in-the-wild interviews was how participants recalled their experiences with each recovery activity fluctuating from day-to-day. They sometimes associated these experiential differences with their mood at the time. These changes in state could also be described as changes in their specific need for recovery, which arguably a single activity cannot always satisfy, but may provide the recovery experience that the individual needs at the time. An example of this from the in-the-wild data is how the mindfulness app participants sometimes described the activity as making them feel calm (reducing tense arousal) but also lethargic. On the one hand, tiredness could be evaluated as negative if an individual instead wants to feel more energised after work, however one participant found the calming, tiring effect of the mindfulness app helpful in reducing adrenaline after a sports match and consequently helping them sleep easier. People may feel they need certain recovery experiences or types of sensory stimulation at specific times, which links to the concept of self-regulation.

Self-regulation is where an individual generates thoughts, actions or emotions to mediate their behaviour or state in order to achieve a certain goal [18,56]. This was previously discussed in terms of fidget spinners and fidget widgets, which have previously been identified as allowing individuals to self-regulate sensory stimulation to an optimal baseline [15]. Self-regulation is also discussed in Sonnentag and Fritz's [42] theory of recovery experience in terms of mood regulation and repair. They cite that people pursue different strategies to improve their mood, such as diversionary strategies from mood regulation literature [25] like psychological detachment, relaxation and mastery, which is clearly reflected in their model.

Arguably as part of promoting recovery, the digital game, mindfulness app and fidget spinner could be described as mechanisms that allow individuals to self-regulate and adjust their current state, thereby satisfying their needs for recovery. However, as these needs fluctuate and change due to influencing factors (without also accounting for the personal preference factor), one activity may not always satisfy these needs for recovery, as with the example of individual participants wanting to be either energised or calmed. As both the lab experiment and field experiment were controlled, this reduced the participants' ability to adjust the activity to meet their overall needs. One such example in the lab experiment was where the fidget spinner was used in different ways, which could have been to satisfy an individual's specific need for recovery at the time.

This is not to say that the underlying four aspects of recovery experience do not occur. Instead, these suggestions build on these concepts and postulate that individuals may need different degrees of these experiences at certain times to recover successfully. An example of this is psychological detachment. The in-the-wild study indicated the digital game was more successful than the mindfulness app at promoting psychological detachment. However, this did not result in the digital game being identified as more effective on the whole than the mindfulness app. Indeed, as mentioned in the limitations for that study, some participants felt they did not need to promote psychological detachment as they did not ruminate on work at home. This suggests that the negative activation from work stress may not necessarily be present in leisure time (as in the stressor detachment model [43]) and thus the psychological detachment that the game provided was not required to help the individual recover. Yet there were some participants who found the digital game extremely beneficial in helping them switch off, perhaps because they had a greater need for psychological detachment. This may also explain why games were cited as being used to fill time as during different occasions people may need to psychologically detach, for example, playing games when commuting to disengage from the situation and avoid boredom. This could also tentatively propose why in the lab experiment there were no significant differences in psychological detachment; the work task was confined to this environment, and as participants knew that the experiment would end shortly, there may have been no reason for them to ruminate on the work task. Thus the need for psychological detachment from the work task may have been low to begin with (similar observations were made in previous lab experiments [8]).

Conversely, mindfulness apps, which focussed on participants observing but not detaching from work-related thoughts, may not have been useful for participants who needed psychological detachment, but were well suited for individuals who required a reduction in tense arousal. Generally, this suggests that individuals have fluctuating needs for recovery both overall and individually in terms of psychological detachment, relaxation, mastery and control, and a singular activity such as a game or a mindfulness app cannot consistently meet these changing needs for recovery. However, one activity may be more effective at meeting specific needs, especially if the participant also enjoys that activity.

Limitations

In addition to the limitations discussed in the two individual studies, there were other overarching limitations for the whole project. The first was the use of the ADACL measures on energetic and tense arousal as the only recovery outcome outside the recovery experience measures. Apart from the limitations in the lab experiment with participants not

understanding some of the Likert items, the ADACL may have obscured what was happening in the data. For example, with the in-the-wild study, the digital game participants reported differing energy levels in the post-activity interviews, with some feeling energised and others feeling tired, but the quantitative measures indicated that there was no change in arousal, perhaps as these opposing feelings counterbalanced each other. This could indicate a limitation in the study as the ADACL measures may have not have accurately captured how the participants were feeling in terms of recovery. It is possible that the reliance on these measures in the lab experiment could also have missed some important insights. In the future it may be better to combine the ADACL with other measures (as in previous research like [32] which also measured for cognitive performance). On a similar note, all measures were self-reported and arguably subjective, thus a future recommendation would be to implement more objective measures of recovery. However, recovery in this study arguably appears to be influenced heavily by subjective factors such as personal preference, so additional objective measures may have had little impact.

Another limitation across both studies was that imposing certain activities on participants removed an element of control from them. Prior lab experiments have shown that allowing participants to self-determine how they use their breaks results in higher feelings of control [33], but participants in the current research were not allowed to choose the recovery activity. As control is one of the four recovery experiences it is probable that by the nature of the study's methodology the individuals were prevented from experiencing control. A further previously discussed limitation is that the participants in the field experiment may have been biased against games as a medium. It is possible that this bias may also have been present in the lab experiment as participants were also only assigned the digital game condition if they did not play games regularly. As enjoyment correlated with recovery and as personal preference seems to have had an impact, this could mean that the participants could have been biased against digital games. Therefore, comparisons between the individual activities may not be accurate and may not possess population validity.

Implications and Future Work

Overall, the current research has presented some suggestions on factors which influence recovery and implications for activities which can promote recovery. Firstly, it suggests an important aspect of recovery is that the individual enjoys the activity and that recovery will be much more successful if they do so. This indicates that both digital games and mindfulness apps can be equally effective at promoting recovery overall, but that this depends on individual preference. This could be viewed as somewhat surprising to the general media as mindfulness apps are generally presented as more of a wellness activity than games, particularly as the link between games and recovery is less well known to the public. This study argues that both activities could be publicised as recovery inducing. This study also illustrates that other activities have potential to be effective at promoting recovery providing that the person enjoys using them. Regarding future work, one suggestion could be further investigation into the role that enjoyment plays in recovery as this seems to be an influential factor. This could involve including participants who already have experience with the activity in question, thereby denoting that they probably already enjoy these activities. This could help to avoid any bias against a specific activity which was a limitation in the current research. Alternatively, a study contrasting two recovery activities in-the-wild could include a within-subjects factor of participants undertaking both activities, which may allow for additional insights.

Similarly, this study identified fluctuating needs for recovery, both overall and in terms of the four recovery experiences, which means that some activities may satisfy current recovery needs more effectively. These factors demonstrate that there is no single activity which is universally effective at promoting recovery, but that there could be many different activities that people can use to help them successfully recover. For future work, an understanding of which specific activities influence each of the four recovery experiences could be interesting, as the results in this study found that specific activities could be recommended to satisfy certain recovery needs, such as the digital game satisfying psychological detachment. An area for investigation could be the potential for digital games to be energising and within what contexts, following the marginally significant result in the lab study and the conflicting reports from the in-the-wild participants in the current research.

The study also highlights the potential for delivering recovery promoting activities through a smartphone. It is promising that activities delivered this way and used for just ten minutes can help people successfully recover. Whilst prior research has identified that smartphone usage can reduce relaxation [33], this was not substantiated in the current research, as the lab experiment demonstrated there was no significant difference in relaxation between the media conditions and the non-media control. As a medium to deliver recovery activities, smartphones have advantages because they are portable and are accessible regardless of an individual's location. This was mentioned by participants who use digital games on-the-go as a time-filler. This suggests that there are opportunities to deliver recovery activities via this device.

Another related implication was the observation from the in-the-wild participants that the act of having to undertake a scheduled activity on their smartphone for ten minutes allowed participants to detach and resulted in a more productive and enjoyable evening. This implies that scheduling a recovery-promoting activity into a person's day, regardless of the nature of the activity, can also be

beneficial for recovery and the individual's general wellbeing.

When combined, these implications present some design opportunities for recovery activities and smartphone applications that promote recovery. A suggestion could be a recovery promoting smartphone application or related digital tool. Specific needs of recovery at the current time could be assessed through a diagnostic quiz. Following this, customised recommendations of the most effective activity could be given, such as a digital game to help people stop ruminating about work, or a mindfulness app to induce calmness. Other features could involve including or excluding certain activities according to personal preference, or the option to schedule the activity into a pre-existing calendar.

6. CONCLUSION

In terms of promoting post-work recovery, both the digital game and the mindfulness app were equally successful. Neither activity was universally more effective than the other; instead, recovery was frequently impacted by two influencing factors, enjoyment and changing needs for recovery. Enjoyment was strongly correlated with overall recovery experience; if an individual enjoyed the activity, they tended to report stronger recovery from it. Fluctuating needs for recovery, which could be described as needs for psychological detachment, relaxation, mastery and control respectively, meant that some activities could be more effective than others if the activity meets the specific recovery need. Tentative observations of both activities were made in terms of what they were more effective at promoting, that the digital game may promote psychological detachment, whereas the mindfulness app can reduce tense arousal. The results from this study also demonstrate that smartphones can be a valuable medium to deliver activities that promote recovery, particularly as the device is portable and easy to access. Further investigation into recovery activities through smartphones, as well as specifically digital games and mindfulness apps, could reveal additional insights around post-work recovery and how to help people to switch-off in an increasingly connected world.

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APPENDIX A – ADACL MEASUREMENT

Each of the words below describes a feeling or mood.
Please use the rating scales against each word to describe your feelings at this exact moment, following the work task you have completed.
For example, if the scale is for the word "happy":
I definitely feel happy
I feel slightly happy
I cannot decide if I feel happy
I definitely do not feel happy
You should work quickly but mark all of the words. Your first reaction is best. This should take only a minute or two.

	I definitely feel this way.	I feel slightly this way.	I cannot decide if I feel this way.	I definitely do not feel this way.
active				
still				
tense				
wide-awake				
energetic				
quiet				
intense				
wakeful				
vigorous				
placid				
clutched up				
sleepy				
full of pep				
calm				
fearful				
lively				
at rest				
jittery				
tired				

Data Analysis Equations

Energetic Arousal = energy subscale (active + energetic + vigorous + full of pep + lively) – tiredness subscale ((sleepy + tired) – (wide-awake + wakeful))

Tense Arousal = tension subscale (tense + intense + clutched up + fearful + jittery) – calmness subscale (still + quiet + placid + calm + at rest)

APPENDIX B – RECOVERY EXPERIENCE QUESTIONNAIRE

Now you are going to be asked some different questions about playing the game during the break.
Please rate the following statements about the break.

	Subscale	I fully agree	I partially agree	Neither agree nor disagree	I partially disagree	I do not agree at all
"When playing the game, I forgot about the work task."	*Psychological detachment*					
"When playing the game, I didn't think about the work task at all."	*Psychological detachment*					
"When playing the game, I distanced myself from the work task."	*Psychological detachment*					
"When playing the game, I got a break from the demands of the work task."	*Psychological detachment*					
"When playing the game, I kicked back and relaxed."	*Relaxation*					
"Playing the game was a relaxing thing to do."	*Relaxation*					
"When playing the game in the break, I used the time to relax."	*Relaxation*					
"When playing the game, it felt like I was taking the time for a leisure activity."	*Relaxation*					
"When playing the game, I learnt new things."	*Mastery*					
"The game felt like an intellectual challenge."	*Mastery*					
"The game was something that challenged me."	*Mastery*					
"When playing the game, I felt I was doing something that broadened my horizons."	*Mastery*					
"When playing the game, I felt like I could decide for myself what to do."	*Control*					
"When playing the game, I decided my own schedule."	*Control*					
"When playing the game, I determined for myself how I spent my time."	*Control*					
"When playing the game, I took care of things the way I wanted them done."	*Control*					

APPENDIX C – ENJOYMENT MEASUREMENT

	I fully agree	I partially agree	Neither agree nor disagree	I partially disagree	I do not agree at all
"Playing the game was fun."					
"I liked playing the game."					
"The game was enjoyable."					
"I'm glad the game did not last any longer."					
"I enjoyed playing the game."					

APPENDIX D – JOB CONTENT QUESTIONNAIRE

Thank you for agreeing to take part in the study. This is an initial survey to set you up in the study. You'll be getting some different surveys next week when the activity begins. These questions are about your job in general.

	Strongly Disagree	Partially Disagree	Partially Agree	Strongly Agree
In my job, I learn new things.				
My job is repetitive work.				
My job requires creativity.				
My job requires a high skill level.				
My job has variety.				
My job lets me develop my own abilities.				
My job allows my own decisions.				
My job has little decision freedom.				
I have a lot of say in my job.				
I have to work fast in my job.				
I have to work hard in my job.				
There is no excessive work in my job.				
I have enough time in my job.				
There are conflicting demands in my job.				
My supervisor shows concern for me.				
My supervisor pays attention to me.				
I have a helpful supervisor.				
My supervisor is a good organiser.				
My coworkers are competent.				
My coworkers take an interest in me.				
I have friendly coworkers.				
My coworkers are helpful.				
My job requires a lot of physical effort.				
My job is steady work.				
My job offers security.				
My job is not under threat of job loss.				

APPENDIX E – SEMI-STRUCTURED INTERVIEW QUESTIONS

How did you find the activity in general?

Over the course of the week, how did you feel directly after using the app?

Over the course of the week, how did you feel in the evening generally, in comparison to a previous week when you were not undertaking the study?

Was there anything you liked about the app?

Was there anything you disliked about the app?

Did you work at home after work any days over the 5 day period? If yes, did the activity have any effect?

Was there any time you thought, “this is great, I’m glad I’m using it” or “this is a waste of time, I wish wasn’t doing this”? (from [19])

Would you continue using this app? Why/why not?

Throughout the study period, did you notice any differences in how you felt the next morning or how you slept?

You said at the start of the study that you [play games/use mindfulness apps]. When do you carry out this activity and why do you think you use it?