Testing the Feasibility of a Media Multitasking Self-regulation Intervention for Students: Behaviour Change, Attention, and Self-perception

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Abstract

Media multitasking has been associated with a number of adverse cognitive, psychosocial, and functional outcomes. In particular, associations between media multitasking and the *executive* or *cognitive control* processes theorised to underlie the execution of goal-directed behaviour have been shown. In response to calls for investigations considering the remedial efficacy of interventions targeting media multitasking and related cognitive effects, the present study investigates the feasibility of a self-regulation based media multitasking intervention for a student population. Through a mixed-methods study involving a between-subjects, pre/post experimental design, usage tracking, and follow-up interviews, four feasibility dimensions were investigated: demand, implementation, acceptability, and efficacy. The findings indicate, firstly, that a greater cognisance of media behaviour is key to behaviour change and goal-alignment, secondly, that such behavioural changes were perceived to enable more instances of single-tasking, goal-oriented task-execution and, as a result, engender state-level changes in attentional strategies and, thirdly, that short-term behavioural changes do not necessarily imply trait-level changes in cognitive functioning. Key implications for media-effects research in general and, more specifically, for research concerning media-related interference are discussed.

Keywords: Media Multitasking, Cognitive Control, Intervention, Feasibility, Self-regulation

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Introduction

The widespread accessibility and increasing utility of digital media are changing how information and communication technologies are used (Vorderer, Krömer & Schneider, 2016). Rather than separate interactions, people frequently use media alongside other activities (le Roux & Parry, 2017b; van Koningsbruggen, Hartmann & Du, 2018). This behaviour, termed *media multitasking*, has been defined as either the simultaneous use of two or more media, or media use in conjunction with other media or non-media activities (Zhang & Zhang, 2012, p. 1883). While it is particularly prevalent among students, media multitasking is common across generations (Voorveld & van der Goot, 2013).

Media multitasking has been associated with a number of adverse cognitive, psychosocial, and functional outcomes (see van der Schuur, Baumgartner, Sumter & Valkenburg, 2015, for a review). Drawing on theories of information processing and dual-tasking interference (Monsell, 2003), when multiple complex tasks are performed simultaneously, or in close succession, performance typically suffers. For media multitasking, examples include associations with diminished lecture outcomes (Abramova, Baumann, Krasnova & Lessmann, 2017), decreased academic performance (le Roux & Parry, 2017a; Rosen, Carrier & Cheever, 2013), reduced workplace productivity (Bannister & Remenyi, 2009), and impaired driving (Strayer & Johnston, 2001).

Noting these associations and media multitasking's widespread prevalence, researchers have raised concerns about the possible implications this behaviour might hold for attentional capacities (Gazzaley & Rosen, 2016). In particular, associations between media multitasking and the *executive* or *cognitive control* processes theorised to underlie the execution of goal-directed behaviour have been investigated (e.g., Baumgartner, Lemmens, Weeda & Huizinga, 2017; Ophir, Nass & Wagner, 2009; Ralph & Smilek, 2017; Ralph, Thomson, Cheyne & Smilek, 2014). In a recent review Uncapher and Wagner (2018,

p. 9890) conclude that, while extant research is characterised by both convergent and divergent findings, overall "the weight of current evidence shows that in some contexts heavier media multitaskers underperform relative to lighter media multitaskers in a number of cognitive domains". In particular, research suggests that, for some, frequent media multitasking is negatively associated with attentional capacities, working memory, task-switching ability, and interference management (see Uncapher & Wagner, 2018; van der Schuur et al., 2015, for reviews).

Acknowledging the associations between media multitasking and diminished attentional capacities, researchers have called for investigations considering the remedial efficacy of interventions targeting media multitasking and related cognitive effects (e.g., Gazzaley & Rosen, 2016; Uncapher et al., 2017; Uncapher & Wagner, 2018). As Parry and le Roux (2019a, p. 317) note, "in the face of increasingly mediated personal, social and work environments, the management of attentional demands and control over the direction of cognitive processes emerge as key challenges". It has been proposed that, just as media multitasking may affect cognitive functioning, changes in behaviour with technology can, firstly, address multitasking related interferences and, secondly, enhance cognitive control (Gazzaley & Rosen, 2016; Rothbart & Posner, 2015). Suggestions of possible approaches include: education, meditation, physical and cognitive exercise, self-regulation and, at an extreme, abstaining from media use (Gazzaley & Rosen, 2016; Levy, Wobbrock, Kaszniak & Ostergren, 2012; Parry & le Roux, 2019b).

In response to these calls, the prevalence of media multitasking, the associated attentional effects, and the need to understand how individuals can manage media interferences, the present study seeks to address the following research question:

RQ1: *Is a month-long self-regulation based intervention a feasible approach to improving the cognitive control of students who are heavy media multitaskers?*

Extending this question, in relation to the feasibility dimensions identified by Bowen et al.

(2010, p. 8), secondary research questions emerge. Of the eight[1] dimensions identified, four are relevant for this study: *demand* —the extent to which the intervention is likely to be used; *implementation* —the extent to which the intervention can be implemented; *acceptability* —the recipients' reaction to the intervention; and *limited efficacy testing* —the extent to which the intervention produces the targeted effects. For each dimension Bowen et al. (2010) identify core outcomes of interest. For demand, outcomes include recipients' perceptions of positive or negative effects, their application of the intervention, and their intentions to continue with the intervention. For implementation, outcomes include recipients' success and degree of execution. For acceptability, outcomes include the recipients' intentions to continue with the intervention, and perceptions of appropriateness and satisfaction. Finally, for efficacy testing, outcomes include testing intended effects. Extending from these areas of focus, secondary research questions are posed:

RQ1.1a: *Among the target population, is a self-regulation based intervention requiring reduced media use likely to be used?*

RQ1.1b: *What is the pattern of media use exhibited by those executing the intervention?*

RQ1.2a: *What are the factors that facilitate the implementation of the intervention?*

RQ1.2b: *What are the factors that hinder the implementation of the intervention?*

RQ1.3: *What are intervention recipients' reactions to the intervention?*

RQ1.4: *Is an intervention requiring heavy media multitaskers to reduce their media use, through self-regulation, effective at improving cognitive control ability?*

[1] The remaining dimensions include practicality, adaption, integration, and expansion. Practicality is excluded because it concerns the cost-effectiveness, the role of administrators, and other constraints on the intervention outside of the scope of this study. The remaining dimensions are excluded as they refer to the assessment of existing interventions applied to new populations or contexts.

To address these questions a mixed-methods study was conducted. To follow, background to the present investigation is provided with a brief review of relevant literature. Thereafter, along with an overview of the research design, the details of the intervention are outlined. The findings of the feasibility assessment are then presented, followed by a discussion.

Literature Review

To provide a foundation for the study, a brief review of research concerning links between self-regulation and media multitasking is presented, followed by a review of research into relevant interventions.

Self-Regulation and Media Multitasking

Self-regulation describes an individual's "motivation and capacity to inhibit/override a desire that stands in conflict with an endorsed self-regulatory goal or value" (Hoffmann, Reinecke & Meier, 2017, p. 5). As a basis, self-regulation requires a goal or *standard* for desirable behaviour in a given situation. Through the *monitoring* of thoughts and actions the current state can be evaluated in relation to the standard (Baumeister, Schmeichel & Vohs, 2007, p. 535). On the basis of these evaluations, *responses* can be issued. If behaviour corresponds to the standard, responses support its continuation. However, if behaviour is judged to be in conflict with the standard, responses involve *operating* to alter the current state to bring it in-line with the standard.

Drawing on executive processes of inhibitory control, through the inhibition of distractions and the suppression of self-interruptions, self-regulation is critical for effective multiple goal pursuit and has been associated with efficient multitasking (Adler & Benbunan-Fich, 2013; Baumeister et al., 2007; le Roux & Parry, 2019b; Neal, Ballard & Vancouver, 2017). Demonstrating that self-regulation ability (assessed at a reflective level through self-report and at a behavioural level through an experimental manipulation) moderates the ostensibly negative relationship between media multitasking and associated performance effects, Szumowska, Popławska-Boruc, Kuś, Osowiecka and Kramarczyk (2018) propose that media multitasking effects depend on self-regulation ability and task-execution strategies. Supporting this assertion, previous cross-sectional studies have shown positive associations between media multitasking tendencies and outcomes from scales assessing impulsivity, and negative associations with self-reported self-control outcomes (Minear, Brasher, Mccurdy, Lewis & Younggren, 2013; Sanbonmatsu, Strayer, Medeiros-Ward & Watson, 2013; Schutten, Stokes & Arnell, 2017; Uncapher, Thieu & Wagner, 2016). These findings, amongst others, suggest that behavioural choices or strategies —task-execution strategies, attentional allocation strategies, and self-regulation in particular— function as important dispositional factors underlying not only the engagement in media multitasking, but also the effects thereof (le Roux & Parry, 2019a; Ralph & Smilek, 2017; Ralph, Thomson, Seli, Carriere & Smilek, 2015; Reinecke et al., 2018; Szumowska et al., 2018).

Media Multitasking Interventions

Despite ongoing discourse about the conclusiveness of the current body of empirical evidence for associations between media multitasking and cognitive control, researchers have begun to develop and assess interventions in this regard. Parry and le Roux (2019a) conducted a systematic review of such studies, finding that, while positive effects on cognitive control have been shown (e.g., Gorman & Green, 2016), behavioural and cognitive effects are largely inconclusive. Considering 15 interventions meeting their eligibility criteria, these authors propose three intervention categories: *awareness* of media behaviour, *restriction* of media behaviour, and *mindfulness* training. Across these categories, intervention duration was a key limitation identified. Eight of the interventions were conducted in a single session and only three spanned more than a single week. Interpreting the review outcomes, the authors note that, while evidence is limited, improvements in metacognition of self-interruption tendencies and media multitasking behaviour were associated with behaviour change and perceptions of improved performance. Self-reported outcomes were, however, not reflected in performance-based assessments —an outcome common in this domain. To follow, relevant studies are briefly considered.

In an early awareness-based intervention, Adler, Adepu, Bestha and Gutstein (2015) assessed the effects of popup alerts reminding participants to return to a primary task whenever they switched away. The reminders did not reduce media switches, nor did they effect performance in a subsequent quiz. Similarly, in a more recent study conducted over a two-month period, alerts did not decrease smartphone use or checking behaviour (Loid, Täht & Rozgonjuk, 2019). In contrast to awareness of media behaviour, Terry, Mishra and Roseth (2016) investigated whether awareness of multitasking effects, metacognition, and self-regulation in general would affect behaviour. No significant effects on either behavioral, attitudinal, or metacognitive outcomes were found. Whittaker, Hollis and Guydish (2016) considered the effects of an application which displayed participants' computer-based activity over two days, as well as diary logs of media behaviour. Both forms of tracking were found to reduce media use. Following semi-structured interviews Whittaker et al. (2016) concluded that the participants considered themselves to have a greater command over the allocation of their attention when they were aware of their media behaviour. Whether these results hold across other media remains unknown and, while interviews indicate that, in the short-term, awareness of media behaviour improves attentional allocation, effects on cognitive control have not been empirically assessed.

Interventions relying on media restriction have either involved reducing the accessibility of media or imposed rules restricting certain media or actions. Examples include: activating silent, non-vibrating modes; disabling notifications; using software to separate tasks into distinct digital workspaces; batching notifications; restricting email activity; restricting off-task websites during work hours, voluntary smartphone restriction; and reducing media use by an hour per day (Fitz et al., 2019; Hartanto & Yang, 2016; Irwin, 2017; Jeuris & Bardram, 2016; I. Kim, Jung, Jung, Ko & Lee, 2017; Mark, Iqbal & Czerwinski, 2017; Mark, Voida & Cardello, 2012; Pielot & Rello, 2016). Restricting email was found to increase single-tasking and reduce switches between various software applications, while reductions in media use were associated with decreased self-reported media multitasking. The behavioural effects of other restriction interventions were either inconclusive, not reported, or enforced by the intervention design.

Across studies the effects on cognitive outcomes have been mixed with both positive and null effects of media restriction on measures of task efficiency, productivity, interruption, and attention (Fitz et al., 2019; Jeuris & Bardram, 2016; Mark et al., 2017; Parry, le Roux & Cornelissen, 2019; Pielot & Rello, 2016). Similarly, for cognitive control, media restriction has, for some, been associated with improvements in inhibitory control and executive attention while, for others it has been associated with decreased switching efficiency and working memory performance (Hartanto & Yang, 2016; Irwin, 2017). As with awareness-based interventions, interview reports for various restriction interventions indicate that, when restricting access to media, individuals perceive themselves to have a greater capacity to remain on-task and sustain attentional allocation. Additionally, in an intervention study relying on both awareness and restriction elements, Jeuris, Houben and Bardram (2014) found that awareness of switching (facilitated by a timeline view of applications), along with the restriction of actions to dedicated workspaces, engendered an increased awareness of behaviour and reductions in cognitive load. In another example of a restriction-based intervention targeting self-interruption tendencies, J. Kim, Cho and Lee (2017) developed an application which enabled users to set a timer for a fixed period. During this period interrupting applications across multiple devices were blocked (an example of the Pomodoro technique). While not directly investigating attention, J. Kim et al. (2017) found that participants did not perceive the feature to be coercive and that it helped them to reduce self-interruptions. Consequently, across all of these restriction studies, while not necessarily affecting cognitive control capacity, media restriction may bring about changes in how individuals allocate their attention, influencing task-execution, attentional strategies and performance (Parry & le Roux, 2019a).

Interventions drawing on principles of mindfulness — a process of “openly attending, with awareness, to one’s present moment experience” (Creswell, 2017, p. 495)— have aimed to foster a greater awareness of one’s present state and empower individuals to regulate their media multitasking or, in some instances, improve the general attentional abilities for those shown to be heavy media multitaskers. With one exception, studies have assessed brief mindfulness interventions occurring in a single session. Both Gorman and Green (2016) and Yildirim (2017) required participants with known media multitasking tendencies to listen to 10-minute guided mindfulness recordings, while Ie, Haller, Langer and Courvoisier (2012) assessed the effects of two brief mindfulness interventions on computer-based multitasking performance. Over an eight week period Levy et al. (2012) required participants to attend mindfulness training sessions and practice exercises in their own time, assessing the effects on media multitasking related work situations. Overall, effects are inconclusive. While short-term positive effects have been shown in some studies (Gorman & Green, 2016), null effects have been found in others (Ie et al., 2012; Yildirim, 2017). The sustainability of such effects, however, remains unknown. Over a longer period Levy et al. (2012) found that, while performance did not improve in a quasi-naturalistic test of multitasking performance, tendencies to multitask while working were reduced.

Methodology

The feasibility study adopted a mixed-methods, between-subjects, pre/post experimental design and was approved by the relevant review boards. To follow, details of the participants, procedures, measures, and hypotheses are provided. Additionally, the intervention itself is outlined in detail.

Participants

The study was conducted in South Africa with a population of university students who self-reported as heavier media multitaskers. Given the constraints of the study, an individual was eligible if, at the time of the study, he/she: was a student at the relevant institution; was a heavy media multitasker; used an *Android* smartphone; used the *Whatsapp* instant messaging service; did not use focus-management applications; did not use psychostimulants (e.g., *Ritalin*) in the month prior to the study, nor intended to during the study period; and had not had any previous diagnoses for neurodevelopmental disorders (e.g., ADHD). After a power analysis for an analysis of covariance (ANCOVA), with an effect size of $f = .35$[2], power of .80, α of .05, two groups (intervention and control), and one covariate (the baseline), a sample size of 67 was targeted. This intended sample size is larger than the average number of participants considered in the studies reviewed in Parry and le Roux (2019a, $M = 56.07$, $SD = 39.49$). It is also within the range Arain, Campbell, Cooper and Lancaster (2010) identified in a review of feasibility studies. Despite this, given the uncertainty surrounding prior effect sizes, a larger sample may be necessary in full intervention evaluations.

Students were recruited to participate through posters and flyers placed around the university campus and announcements in six undergraduate courses (3000 students across five faculties). Respondents were directed to a survey which, firstly, provided details of the study, secondly, collected eligibility, demographic and contact details and, thirdly, presented the *Media Multitasking Index-Short* (MMI-S; Baumgartner et al., 2017).

The intervention

A behaviour change intervention, grounded in self-regulation theory, was developed to support single-tasking and the reduction of media multitasking. Following a review of studies considering multitasking and attention, Rothbart and Posner (2015) note that practice in tasks requiring singular focus can lead to improved everyday attentional performance. Consequently, as with previous studies, the intervention adopted a theory of

[2] Noting the need to target effects of practical significance and not just statistical significance, we initially elected for a medium effect as our smallest effect size of interest. However, upon considering the effects reviewed in Parry and le Roux (2019a), we chose to target a minimum effect size of interest between medium and large.

change based on the value of single-tasking for promoting sustained attention (Bavelier, Green, Pouget & Schrater, 2012; Rothbart & Posner, 2015). Extending this, supported by a number of previous studies (e.g., Rosen et al., 2013; Szumowska et al., 2018), it is argued that an intervention supporting processes of goal-oriented self-regulation of media multitasking will engender more frequent single-tasking.

While some previous studies have considered interventions targeting all media use (e.g., Irwin, 2017), others have targeted a single artefact (e.g., Fitz et al., 2019). In this study media multitasking involving the use of a smartphone was targeted (i.e., the use of a smartphone alongside other media or non-media activities). For the intended population a majority of media use and, as a consequence, media multitasking, involves such devices (Pew Research Center, 2017). To support the self-regulation of media multitasking the intervention was designed to facilitate the monitoring of behaviour in relation to a goal. Additionally, as Klimmt, Hefner, Reinecke, Rieger and Vorderer (2018, p. 18) note "abstaining from media use and communication access is now an action that requires intentions, planning, and specific arrangements". Therefore, to support effective self-regulation of media multitasking the intervention involved the use of a pre-built mobile application —*Forest*.[3] This application enables users to track their phone usage as represented by the duration and number of screen-unlocks per day (see Figure 1). In addition to this dashboard, the application enables users to adopt the *Pomodoro technique*[4] to restrict their media use through the planting of virtual trees. These trees function as incentives to abstain from use for a pre-specified period of time. If the phone is used during this time, rather than growing, the virtual tree dies. Figure 2 provides a screen capture of this feature. The intervention involved using these two features of the application (daily usage tracking and usage restriction) to support the self-regulation necessary for facilitating single-tasking. Building on theories of self-regulation theory, the intervention

[3] See `https://www.forestapp.cc/` for more information about this application.

[4] A timer is used to separate tasks into set, uninterrupted intervals (Cirillo, 2006).

was developed to target the three core components of theorised to underlie self-regulation (goal setting, monitoring, and operating) (Baumeister et al., 2007; Hoffmann et al., 2017). To follow, the details of the intervention are outlined.

Smartphone Usage Goal: Based on usage statistics reported in previous studies participants were set a target of a *maximum of 90-minutes of smartphone usage per day.* While there is scope for individual differences, across a number of studies, it has been shown that, on average, students use these devices for more than four hours per day (Andrews, Ellis, Shaw & Piwek, 2015; Lepp, Barkley & Karpinski, 2013), and that between 30% and 80% of this use involves multitasking (Deng, Meng, Kononova & David, 2018; Rideout, Foehr & Roberts, 2010). Therefore, it is argued that the goal would, on average, require participants to reduce their media use and multitasking. Importantly, while the target may have required these reductions, the focus was not on the amount of time or extent of the reduction. Rather, the purpose of the target was to guide the self-regulation of behaviour with media in accordance with a goal. To support participants in meeting this target and provide them with an awareness of their media behaviour, *Forest* displays information on hourly usage per day.

Monitoring of Smartphone Usage: The second aspect of the intervention involved the self-monitoring of smartphone usage. While previous studies have relied on the provision of reminders or diary logging, here monitoring of behaviour was supported by *Forest*. Additionally, participants were required to share a report from the application (providing data on the number of pickups and the time of day and number of minutes for which the smartphone was used) to the researchers each day (examples of which are displayed in Figure 1).

Operating for goal-alignment: While awareness may itself produce behaviour change, in self-regulation theory, the purpose of monitoring is the evaluation of actions and, on this basis, operating as necessary. In this case, participants could, themselves, operate and bring their behaviour in-line with the target. Additionally, participants were able to use *Forest* to

Figure 1. Example of hourly smartphone usage displayed to participants.

initiate set periods for which they wished to restrict their smartphones. In the language of the application these sessions are termed ‘planting a tree’ and are run for a self-determined period of time (see Figure 2). Along with the previous report, the participants shared a report on their ‘forest’ each day (indicating the number of restriction sessions initiated).

The intervention was implemented for a period of 28 days. While this duration corresponds with Kushlev, Proulx and Dunn (2016)’s suggestion that interventions involving reductions in media use be implemented for at least a month, as Irwin (2017) notes, the duration required to identify an effect, if any, remains uncertain. In related research, as Parry and le Roux (2019a) found, a majority of studies have assessed interventions in a single session. Of the 15 studies reviewed only three spanned more than a week. In other intervention studies where cognitive control was targeted, while some studies have shown effects of behaviour change or cognitive training on outcomes for cognitive control in periods as short as a single session (e.g., Jaeggi, Buschkuehl, Shah & Jonides, 2014), others have shown effects after periods of three to four weeks (e.g., Anguera et al., 2013), and yet others have found effects after eight weeks or longer (e.g., Jha, Krompinger & Baime, 2007).

Figure 2. Example of the 'planting a tree' restriction feature.

Procedures

The study began with a baseline assessment to establish measures for cognitive control and everyday executive functioning before the intervention. In separate sessions, participants completed a series of performance-based tasks and self-report scales. All instructions were standardised and the testing procedures were automated. For those in the intervention group, instructions for the intervention were provided. Instructions covered the installation and configuration of *Forest*, and training in its use. These sessions took place over a single week and were followed by the intervention period during which those in the intervention group altered their behaviour in accordance with the intervention, while those in the control group maintained normal behaviour. The first 19 days of the period fell within term, while the next nine fell within recess. Following the intervention period the baseline assessments were repeated. As Parry and le Roux (2019a) found, adherence to intervention procedures has negatively affected the implementation of previous interventions in this regard. To promote adherence participants were provided with a financial incentive commensurate to their success at achieving the usage target (An amount of 10 ZAR per day in which the target was met, totalling 280 ZAR for all days – approximately 20 USD).

Measures

To enable the assessment to take place at both a reflective and a functional level both self-report and performance-based measures were used. Prior to the study, all measures were piloted with seven students from the target population. To follow, the measures adopted from each paradigm are explained in detail. Additionally, for each task and scale, hypotheses are specified. These hypotheses were preregistered and are available through the Open Science Framework (OSF).[5]

Self-report Measures. The **Media Multitasking Index-Short** (MMI-S), developed by Baumgartner et al. (2017) as a modification to the MMI (Ophir et al., 2009) considers media multitasking across three primary activities (watching TV, using SNSs, and sending messages via phone or computer) and four secondary activities (the three primary activities and listening to music). The 'watching TV' activity was amended to include a broader scope for video-related behaviour and was represented as 'watching video content'. Through Likert scales ranging from one (*not at all*) to six (*3 hours or more*), respondents indicate how long they use each primary medium on an average day. For each of the secondary items respondents indicate, on a scale from one (*never*) to four (*very often*), how often they engage simultaneously with each of the primary items. To calculate the MMI-S these values were combined using the formula specified by Ophir et al. (2009).

The **Attention Related Cognitive Errors Scale** (ARCES; Carriere, Cheyne & Smilek, 2008) assesses the frequency of everyday performance errors associated with lapses in attention. Participants provide responses through Likert scales ranging from one (*never*) to five (*very often*). A score is produced by averaging all 12 items, with a higher value representing greater self-reported failures of attention.

The **Mindful Attention Awareness Scale - Lapses Only** (MAAS-LO; Carriere et al., 2008), assesses the frequency of lapses in attention in the course of everyday life. For each of the 12-items responses are provided through Likert scales ranging from one (*almost*

[5] [link redacted for anonymous peer review]

never) to six (*almost always*). In contrast to the original version, as Cheyne, Carriere and Smilek (2006) suggest, responses are not reversed. Therefore, with a minimum of one and a maximum of six, higher ratings indicate a greater frequency of attentional lapses.

The **Attentional Control: Switching and Distractibility** (AC-S and AC-D; Carriere, Seli & Smilek, 2013) scales assess tendencies to become distracted or difficulties shifting attention between stimuli. Each scale consists of four items, with responses provided through Likert scales ranging from one (*almost never*) to five (*always*). For each scale scores are independently averaged, with higher scores representing a greater degree of distractibility or a greater difficulty in switching attention between tasks.

The **Spontaneous and Deliberate Mind-wandering** (MW-S and MW-D) scales were developed by Carriere et al. (2013) to assess tendencies to engage in intentional (MW-D) and unintentional (MW-S) mind-wandering. Each scale consists of four items, with responses provided through Likert scales ranging from one (*almost never*) to five (*very often*). Responses are independently averaged, with higher values reflecting a greater tendency to engage in mind wandering.

The **Brief Self-control Scale** (BSCS; Tangney, Baumeister & Boone, 2004) is a 13-item measure of self-control. Through Likert scales ranging from one (*not at all like me*) to five (*completely like me*) responses are provided for items such as "I often act without thinking through all the alternatives". Items one, six, eight and eleven are summed and added to the remaining items which are reversed scored. This total is then averaged, with a higher value representing greater self-control.

The **Irrational Procrastination Scale** (IPS; Steel, 2002) is a nine-item measure for trait irrational procrastination. Responses are provided through Likert scales ranging from one (*not true of me*) to five (*true of me*). Items two, five, and eight are reverse scored and then summed with the remaining six items. This total is then averaged to produce a score ranging from one to five. A higher value indicates greater trait procrastination.

It was expected that, in comparison to the control group, those in the intervention group would experience general improvements in their everyday executive functioning. Therefore, in relation to the relevant instruments, seven hypotheses were formulated. Following the intervention period, those in the intervention group will indicate a greater degree of mindfulness as represented by higher MAAS-LO scores ($H1_a$) and more self-control as represented by higher BSCS scores ($H1_b$) compared to those in the control group. Additionally, following the intervention period, in comparison to the control group, those in the intervention group will report fewer attention-related errors, as represented by lower ARCES scores ($H1_c$), less difficulty shifting attention as represented by lower AC-S scores ($H1_d$), less difficulty inhibiting distractions as represented by lower AC-D scores ($H1_e$), less spontaneous mind wandering as represented by lower MW-S scores ($H1_f$) and, finally, less deliberate mind wandering as represented by lower MW-D scores ($H1_g$). For trait irrational procrastination no hypothesis was specified —this analysis was exploratory.

Performance-based Measures. To assess cognitive control from a performance-based perspective, four tasks were constructed using *PsyToolKit* (Stoet, 2017) and implemented online. The tasks were run on a 21.5-inch Apple iMac with OS X 10.13.5, a 3.1 Ghz Intel Core i7 processor and 16 GB of RAM. Participants were seated approximately 55cm from this screen and issued responses through an 'Apple Wired Keyboard'. The order of presentation was randomised, with each task requiring approximately 10-minutes.

The **n-back Task** was used to assess working memory. In this task a sequence of stimuli (eight phonologically distinct letters: B, F, K, H, M, Q, R, and X) are displayed one at a time. For each letter, participants indicate, with a key press, whether it matches the letter presented n letters back in the sequence (Sweet, 2011). Performance is assessed under two cognitive loads run in separate blocks. In the two-back condition participants indicate if the current letter corresponds to the letter displayed two letters previously and, in the three-back (representing a greater cognitive load), participants indicate if the letter corresponds to the letter displayed three letters back. *Hits* represent the proportion of target trials correctly identified as targets. *False alarms* represent the proportion of non-target trials incorrectly identified as targets. Participants performed a practice block of 15 trials for each condition. Subsequently, four blocks of 48 trials were presented (alternating between conditions). Within each block each letter appeared six times (five as a non-target and once as a target), and was displayed for 500ms.

To assess cognitive inhibition the **Eriksen Flanker task** (Ridderinkhof & van der Molen, 1995) was used. In each trial five stimuli are presented horizontally in the centre of the screen. Participants react, through key presses, to a target stimulus presented in the middle of four distractor stimuli, indicating in which direction (either left or right) the target arrow is pointing. The stimuli flanking the target can either point in the same direction as the target (congruent flankers: $\rightarrow \rightarrow \rightarrow \rightarrow \rightarrow$), or point in the opposite direction to the target (incongruent flankers: $\rightarrow \rightarrow \leftarrow \rightarrow \rightarrow$). These conditions are randomly interspersed. Results are computed by calculating the average response time (RT) for congruent and incongruent conditions and calculating a ratio of the two —the flanker congruency effect. A higher ratio indicates greater difficulty with inhibiting irrelevant information. Additionally, response accuracy is considered through an inverse efficiency score, with a lower score indicating greater task efficiency. Participants completed a practice block of 30 trials with error feedback, followed by a test block of 140 trials (70 congruent and 70 incongruent). For each trial participants had 2500ms to respond. Once a response was provided the stimuli disappeared and, after 1000ms, new stimuli were displayed.

The **Sustained Attention to Response Task** (SART; Robertson, Manly, Andrade, Baddeley & Yiend, 1997) is a Go/No-Go style continuous performance task designed to assess sustained attention. It involves responding, through key presses, to frequently presented non-targets (Go-stimuli) as quickly as possible, while withholding such responses to less frequent targets (No-Go stimuli). Each trial consists of a single digit (1 to 9) in the centre of the screen, followed by a mask (a 29mm diameter ring with a diagonal cross in the centre). Two indices assess performance. *SART errors* represent failures to refrain from responding to No-Go stimuli —a drift of attention from the task. *RT variability* (calculated as the standard deviation for non-target RTs divided by the mean RT) to Go stimuli represents fluctuations in attentional allocation. Each digit was displayed for 250ms followed by a 900ms mask, with '3' being the No-Go digit. Participants completed 18 practice trials before seven blocks of 60 trials. Each block contained 54 non-targets and six targets (randomly dispersed). Each digit was presented in one of five randomly allocated font sizes (8, 72, 94, 100, or 120).

To assess shifting aspects of cognitive flexibility the **Number-Letter task-switching paradigm** was used. In Rogers and Monsell (1995)'s alternating runs approach participants perform two trials of task A, followed by two trials of task B, and then switch back to task A. Switch costs are calculated as the difference in mean RT between switch and repeat trials for correct responses. Each trial consisted of a grid displayed as in Figure 3. Within each quadrant, letter-number pairs (e.g., "E2") were displayed one at a time. Possible letters were drawn from a set of vowels (A, E, I, U) and consonants (G, K, M, R). Possible numbers were drawn from a set of even numbers (2, 4, 6, 8) and a set of odd numbers (3, 5, 7, 9). If the pair appeared in the top quadrants participants performed a classification task with the letter (indicating whether it was a consonant or a noun). If the pair appeared in the bottom quadrants participants performed a classification task with the number (indicating whether it was odd or even). Prior to the assessment (implemented in four blocks of 60 trials) participants performed three practice blocks of 20 trials each, with feedback.

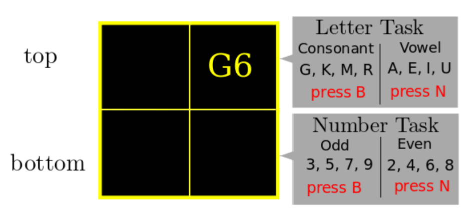

Figure 3. Trial grid with example stimuli and options for the number and letter tasks.

It was expected that, in contrast to the control group, those in the intervention group would experience improvements in their performance-based cognitive control. Therefore, in relation to the relevant instruments, four hypotheses were formulated. Following the intervention period, in comparison with the control group, those in the intervention group will demonstrate greater working memory performance, as indicated for each of the indices in the n-back task ($H2_a$), improved filtering of irrelevant information, as indicated for each of the indices in the Eriksen Flanker task ($H2_b$), a larger capacity to sustain attention, as indicated by the indices in the sustained attention to response task ($H2_c$) and, finally, better shifting performance, as indicated by the number-letter task-switching task ($H2_d$).

Interview Follow up

Following the post-intervention assessment 10 participants from the intervention group were randomly selected and invited for an individual interview. For a relatively homogeneous sample, Guest, Bunce and Johnson (2006) suggest that 10 interviews should produce sufficient data to reach a point of saturation for the reporting of new themes. Each interview, lasting between 30 and 60 minutes, was audio-recorded to enable analysis. The interviews were semi-structured and based around a question guide focusing discussion on the following aspects of the participants' experiences:

1. Media use prior to commencing the study.
2. Expectations for the study.
3. Initial impressions and experiences of the intervention.
4. Experiences with meeting the target, in terms of:
   (a) Obstructions to goal achievement.
   (b) Enablers of goal achievement.
5. Perceptions of the intervention, in terms of:
   (a) Attitudes to media use and media multitasking.

(b) Concentration, focus, and productivity.

6. Intentions to maintain or modify the intervention.

Interview analysis procedures. To analyse the interview data *thematic analysis* was used to identify, interpret, and report patterns present as recurrent themes. As Braun and Clarke (2006) suggest, themes were initially produced at a semantic level and, as the analysis progressed, the interpretation of the importance and implications of the themes imply that the data were, subsequently, considered at a latent level.

Findings

To follow, the analysis of the data collected and the results thereof are reported. This begins with an overview of the sample, before intervention execution and device usage is considered. Next, the self-report and performance-based data before and after the intervention are analysed. Finally, the thematic analysis of the interview data is described.

Sample

During the advertisement period 202 respondents signed up, with 42 initially excluded due to their ineligibility, leaving a sample of 160. The MMI-S had a mean of 1.84 ($SD = 0.65$). To target heavier media multitaskers, those in the lowest third of the MMI-S distribution were excluded ($M = 1.10$, $SD = 0.35$). From those remaining ($M = 2.20$, $SD = 0.41$), 68 were randomly selected to receive invitations to participate in the study. Of those invited one declined, and seven did not respond. Therefore, an additional eight participants were randomly selected from the remaining 39. The sample was then randomly separated into an intervention group and a control group. With no significant differences, the demographic characteristics of each group are summarised in Table 1.

Figure 4 depicts the flow of participants through the study procedures. Of the 68 participants allocated to the experimental groups, 62 participated in the baseline assessment, with six withdrawing during the procedure. Consequently, the sample for

Table 1

Demographic characteristics of the two experimental groups.

Group	MMI-S	Age	Study Year	Gender	
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	Male	Female
Intervention ($n = 34$)	2.26 (0.42)	20.3 (1.47)	1.79 (0.98)	12	22
Control ($n = 34$)	2.21 (0.39)	20.4 (1.31)	2.12 (1.32)	8	26
Overall ($n = 68$)	*2.23 (0.40)*	*20.3 (1.39)*	*1.96 (1.16)*	*20*	*48*

which an intention to treat (ITT) was specified consisted of 62 individuals, with 29 in the intervention group and 33 in the control group. During the intervention period, two members of the intervention group and one from the control group withdrew from the study. After these withdrawals, the final sample included 27 participants in the intervention group and 32 in the control group.

Intervention execution and device usage

Figure 5 depicts the mean daily phone usage and mean number of daily pickups over the 28-day period. The grey shaded background represents the 19 days during the term, while the white shaded background represents the 9 days of recess. On average, participants used their devices for less than the daily usage target (represented with the dotted line at the 90th-intercept; $M = 59.37$, $SD = 15.76$). While there was no significant difference between usage for weekdays (57.17, SD=16.60) and weekends (59.18, $SD = 12.00$), there was a significant difference in usage between term time ($M = 62.79$, $SD = 13.95$) and recess ($M = 47.11$, $SD = 12.50$), with participants using their smartphones more during the term than recess ($t(17.52) = 2.99, p < .01, d = 1.16$). This outcome was reflected with pickups ($t(255.50) = 2.72, p < 0.01, d = .27$), with more during the term ($M = 26.45$, $SD = 26.66$) than recess (19.61, $SD = 20.53$). The target was met by all participants on only three days (19, 23, 26; represented by the blue dotted lines in Figure 5) and was, on average, exceeded

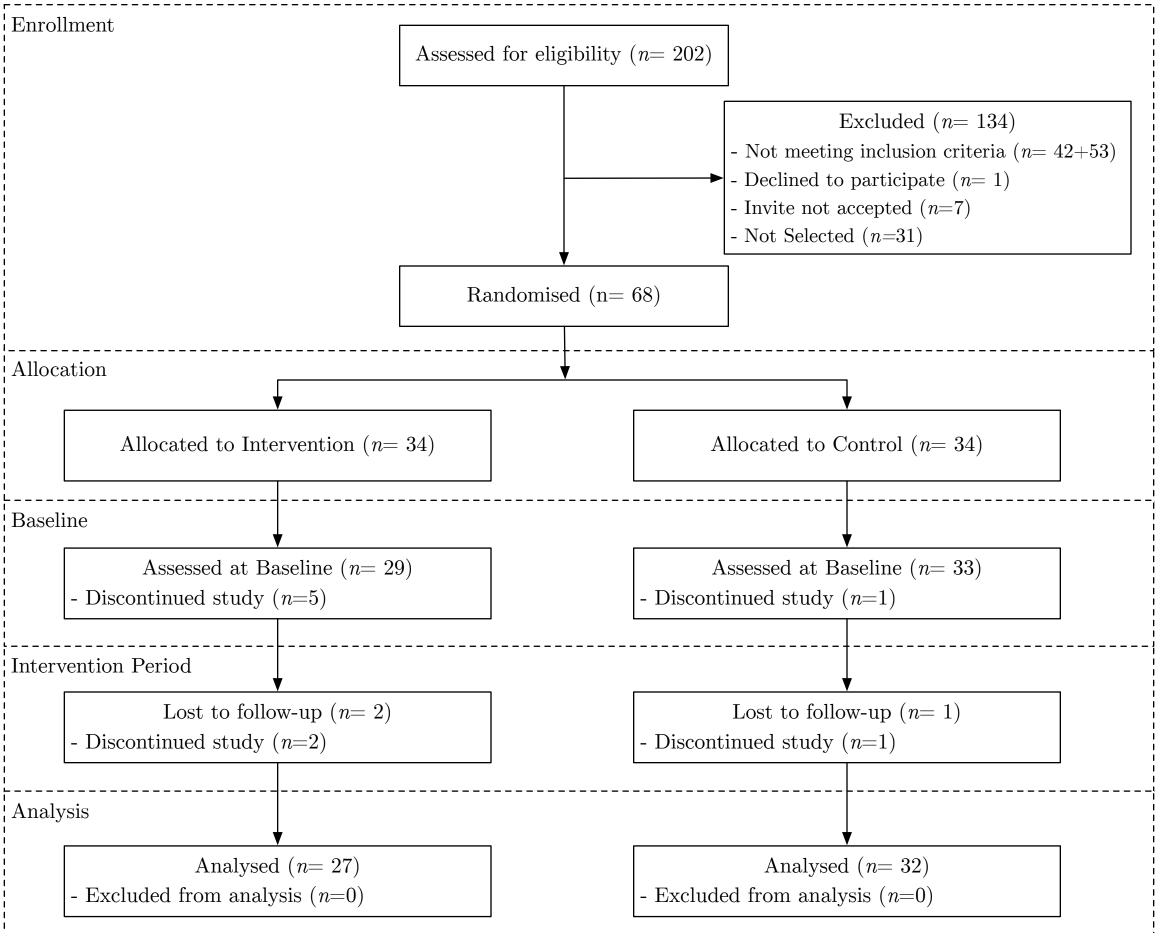

Figure 4. CONSORT flow diagram of participation in the experimental assessment.

by 2.7 participants ($SD = 1.5$) per day. 15 participants reported usage greater than the target more than once, five only surpassed the target once, and 12 (44.44%) remained below the target on all the days.

The data indicate that few participants used the applications' restriction feature, with 11 (44.0%) using it at least once, and only two using it for more than 50% of the period. Overall, 342 sessions were initiated. For those who did use the feature, on average, it was used on 7.82 days ($SD = 6.54$), with two participants using it on only a single day and one using it on 21 days. For those who used the feature the median number of sessions was 8.00. The number of participants using the feature decreased over the intervention period. In the first week 128 sessions were completed ($M = 18.29, SD = 7.98$), in the second 78

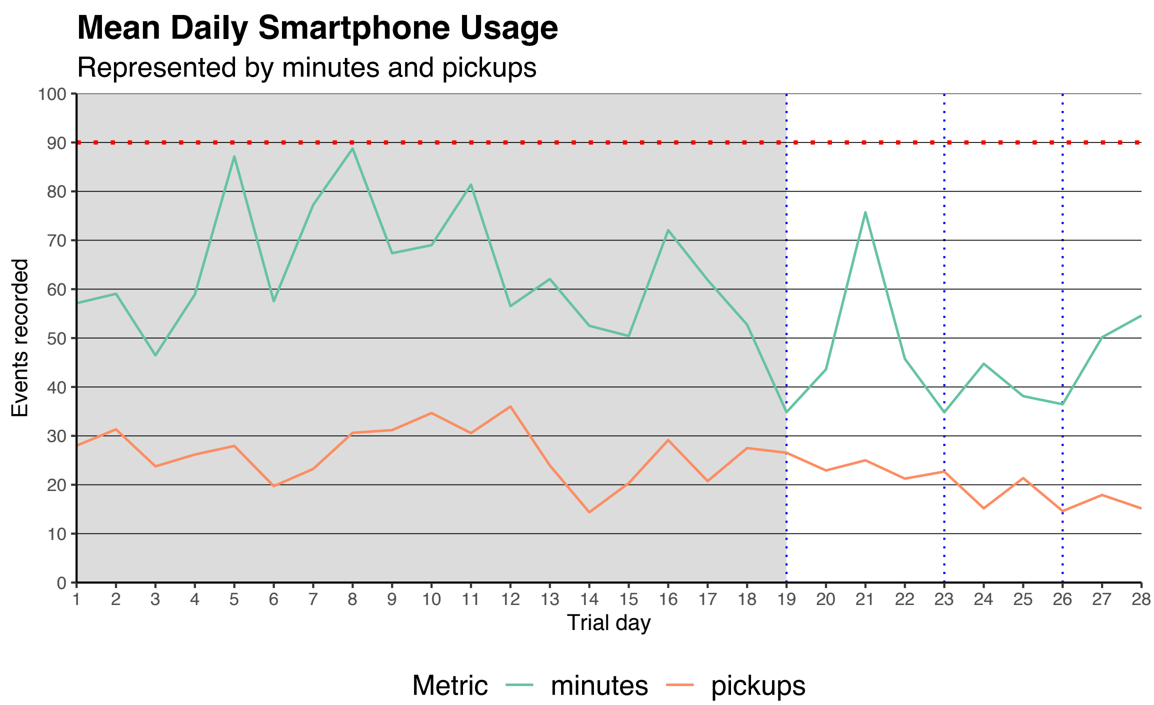

Figure 5. Daily smartphone usage for each of the 28 days of the intervention period.

were completed ($M = 11.14, SD = 6.82$), in the third 84 were completed ($M = 12.00, SD = 10.28$) and, in the fourth week only 45 sessions were completed ($M = 6.43, SD = 7.30$).

Comparisons before and after the intervention period

To test whether the post-intervention outcomes differed between the experimental groups, while controlling for the baseline, ANCOVA were used with a pre-specified significance level of .05. Due to the unequal sample sizes, *Type III Sums of Squares* were used in these analyses. Additionally, given the discrepancies between the sample considered at baseline and the sample considered after the intervention, both per-protocol and ITT analyses were conducted. The "last value carried forward" was used to account for withdrawals (Montori & Guyatt, 2001). For the performance-based assessments, for tasks involving RTs, to minimise the effect of outlying RTs due to aberrant key presses, a winsorizing method (Tabachnick & Fiddell, 1996) was applied. As was the case in Murphy, McLauchlan and

Lee (2017), RTs three or more SDs from the mean for each participant were adjusted to this cut-off value. Additionally, for tasks involving multiple outcome metrics, a separate *Holm-Bonferroni* adjustment was made to the significance level, if necessary.

Self-reported everyday executive functioning. Table 2 summarises the per-protocol outcomes for each group for both assessments, and Table 3 provides a summary of the results of the separate ANCOVA for both the per protocol and intention to treat (ITT) analyses. As indicated by separate independent samples *t*-tests no significant differences between the groups existed at baseline. Unless otherwise indicated, all assumptions for ANCOVA were satisfied. Across all self-reported assessments no practically or statistically significant effect was found *in the hypothesised direction* for any of the self-report indicators in either the per-protocol or intention to treat (ITT) analyses. Consequently $H1_{a\text{-}g}$ were not supported. The only statistically significant effect of experimental group on post-intervention outcomes after controlling for the baseline was found for the shifting of attention (**AC-S**). While the effect size was small, controlling for the baseline, those in the intervention group reported greater difficulty shifting attention than those in the control group after the intervention period. This was, however, opposite to the direction hypothesised. In addition to the confirmatory analyses, an exploratory analysis of the effect of the intervention on procrastination (**IPS**) was conducted (this analysis was only conducted on a per-protocol basis). The results of this analysis are also provided in Table 3.

Performance-based assessments of cognitive control. For all four of the performance-based assessments of cognitive control, across all metrics considered, no statistically significant effect of the intervention on post-intervention outcomes was found after controlling for baseline outcomes. Consequently, $H2_{a\text{-}d}$ were not supported. Descriptive statistics for each task for both experimental groups and assessments are provided in the Supplementary Material. To follow, we provide a brief description of the analysis and results for each task.

Sustained Attention (**SART**) was assessed with two metrics: *error proportion* and *Go RT*

Table 2

Self-report outcomes at the baseline and post-intervention assessments.

Scale	Intervention Group		Control Group	
	Baseline	Post	Baseline	Post
	M (*SD*)	*M* (*SD*)	*M* (*SD*)	*M* (*SD*)
ARCES	3.28 (0.60)	2.94 (0.60)	3.26 (0.52)	3.15 (0.58)
MAAS-LO	3.61 (0.61)	3.67 (0.62)	3.49 (0.72)	3.54 (0.78)
AC-S	2.84 (0.81)	2.94 (0.89)	2.95 (1.13)	2.59 (1.09)
AC-D	2.72 (0.84)	2.33 (0.79)	2.69 (1.01)	2.66 (1.02)
MW-S	3.64 (0.82)	3.52 (0.98)	3.86 (0.99)	3.91 (0.87)
MW-D	3.47 (0.83)	3.29 (1.06)	3.49 (0.91)	3.52 (0.87)
BSCS	3.00 (0.57)	3.10 (0.42)	2.80 (0.63)	2.84 (0.55)
IPS	3.15 (0.49)	3.16 (0.38)	3.20 (0.49)	3.17 (0.50)

variability. For both metrics negligible changes in outcomes were observed for both groups. Consequently, after controlling for baseline outcomes, no statistically significant effect of experimental group on post-intervention error proportions ($F(1, 56) = .19, p = .67, \eta_p^2 = .003$) or Go RT variability ($F(1, 56) = .04, p = .83, \eta_p^2 = .001$) was found. The outcome was confirmed with the ITT analysis for both error proportions ($F(1, 57) = .18, p = .67, \eta_p^2 = .003$) and go RT variability ($F(1, 57) = .12, p = .89, \eta_p^2 = .004$).

Cognitive Flexibility (Number letter task) was assessed with a single metric, the *switch cost*. The winsorizing procedure resulted in the replacement of 3.71% of trials at baseline and 2.93% of trials at the post-intervention assessment. RTs were only considered for correct responses. The decrease in switch costs was greater in the intervention group (123.13 ms) than in the control group (44.12 ms). Despite this difference, no statistically significant effect of experimental group on post-intervention switch costs after controlling for baseline outcomes was found ($F(1, 56) = 1.59, p = .21, \eta_p^2 = .028$). This outcome was

Table 3

ANCOVA results for the self-report assessments.

Scale	ANCOVA Outcomes							
	Per protocol				ITT			
	df	*F*	*p*	η_p^2	*df*	*F*	*p*	η_p^2
ARCES	(1, 56)	1.86	.18	.032	(1, 59)	.91	.34	.015
MAAS-LO	(1, 56)	.16	.69	.003	(1, 59)	.18	.67	.003
AC-S	(1, 56)	5.30	.03*	.086	(1, 59)	5.20	.04*	.081
AC-D	(1, 56)	3.34	.07	.056	(1, 59)	3.15	.08	.051
MW-S	(1, 56)	1.66	.20	.029	(1, 59)	1.66	.20	.029
MW-D	(1, 56)	.95	.33	.017	(1, 59)	.81	.37	.014
BSCS	(1, 56)	.99	.32	.017	(1, 59)	.44	.51	.007
IPS	(1, 56)	.17	.68	.003				

repeated when the analysis was conducted on an ITT basis ($F(1, 58) = 1.50, p = .23, \eta_p^2 = .049$).

Working Memory (N-back task) was assessed with two metrics: *hits* and *false alarms*. Due to aberrant responses (false alarms 5 SDs above the mean) data from three participants were removed. For hits, at both cognitive loads the homogeneity of outcome variances was confirmed with *Levene's test*. However, while the regression slopes were homogeneous for the 3-back condition, for the 2-back, this assumption was violated. To account for this a multiple regression model was produced ($F(3, 52) = 10.32, p < .001$), with an R^2 of .37. Baseline hits ($\beta_1 = .52, p < .001$), group ($\beta_2 = -.22, p < .05$), and the interaction between baseline and group ($\beta_3 = .30, p < .05$) were all statistically significant predictors of post-intervention 2-back hits. Due to the increased likelihood of family-wise errors, the *Holm-Bonferroni* adjustment was applied to the group outcome. Following this adjustment the effect was no longer significant ($p = .08$). For 3-back hits, using an ANCOVA, after accounting for the baseline, no statistically significant effect of group

$(F(1,53) = .079, p = .78, \eta_p^2 = .001)$ was found. The ITT analysis further indicated no statistically significant effect of group on hits at either 2-back $(F(1,56) = .49, p = .62, \eta_p^2 = .017)$ or 3-back $(F(1,56) = .05, p = .95, \eta_p^2 = .002)$.[6] For false alarms, in the 2-back condition, after controlling for baseline outcomes, no statistically significant effect of group on post-intervention outcomes was found $((F(1,53) = .07, p = .79, \eta_p^2 = .001)$. Similarly, no statistically significant effect of group on post-intervention false alarms was found in the 3-back condition $(F(1,53) = 1.62, p = .21, \eta_p^2 = .030)$. The ITT analysis confirmed this result for both 2-back $(F(1,56) = .26, p = .77, \eta_p^2 = .009)$ and 3-back $(F(1,56) = 1.13, p = .33, \eta_p^2 = .039)$ conditions.

Inhibitory control was assessed with the **Flanker task** through two metrics: the flanker congruency effect (FCE) and the inverse efficiency score (IES). RTs were only considered for correct responses. The winsorizing procedure resulted in the replacement of 2.33% of trials at baseline and 2.21% at the post-intervention assessment. Additionally, data for five participants were removed from the analysis due to notably aberrant responses (an overall error-rate five SDs greater than the mean and RTs close to the maximum possible). For both groups, changes in the FCE were negligible and, consequently, no statistically significant effect of experimental group on post-intervention FCEs after controlling for baseline FCEs was found $(F(1,51) = .12, p = .72, \eta_p^2 = .002)$. This outcome was supported when the analysis was conducted on an ITT basis $(F(1,54) = .31, p = .73, \eta_p^2 = .012)$. For response accuracy, *Levene's test* indicated significant heterogeneity of the outcome variances $(F(1,52) = 6.08, p < .05)$. To account for this heteroscedasticity, as recommended by Long and Ervin (2000), the ANCOVA were based on a heteroscedasticity consistent covariance matrix. Consistent with the FCE, no statistically significant effect of group on post-intervention IESs, after controlling for baseline IESs, was found in the per protocol $(F(1,51) = 3.47, p = .068, \eta_p^2 = .081)$ and ITT $(F(1,54) = 2.04, p = .14, \eta_P^2 = .071)$

[6] In the ITT analysis all relevant assumptions held true.

analyses.

Interview Follow-Up Analysis

Thematic analysis began with the transcription of the interview-recordings, followed by coding in two stages. First, a set of a priori codes (provided in Table A1), developed on the basis of the research questions, were applied to the transcriptions. Second, open coding was conducted with a posteriori codes developed on the basis of the text and applied iteratively. Table A2 presents the codes developed in this process. Next, patterns in the codes were identified and clustered into themes which were, subsequently, compared to the text extracts to assess the extent to which they reflect the participants' experiences. Table A3 provides a summary of the relation between the codes and the final set of descriptive themes. To follow, supported by relevant excerpts, the eight resulting themes are described.

Pervasive Media Multitasking. Participants' media use prior to the intervention was characterised by pervasive multitasking, with the phone seen to be a key connection to the world. In comparison to studying, attending to lectures, or interacting with others, this connection, through various social networking and instant messaging services, was simultaneously a source of entertainment, communication, information, and a driver of goal-conflict and interference.

> *I used it from the moment I was in lectures until the end of the day. Even when I was studying or doing work I would be on my phone, a lot of multitasking.* (P2)

For some, this behaviour was seen to be automatic or habitual. Without prior deliberation or consideration of intentions participants would initiate media multitasking, irrespective of the present setting.

> *It was very uncontrolled and like whenever I would get a text I would answer it immediately.* (P3)

Despite the frequency with which they media multitasked, participants were not ignorant of the potential consequences of their behaviour. Simultaneous use of media was seen to divert attention away from primary tasks, and lead to unplanned, prolonged instances of procrastination.

> *The break in concentration from the lecture is really, like I don't think it helped at all. I feel like you totally lose track of what is going on and it was definitely bad.* (P1)

Deficient Cognition of Media Behaviour. Participants' cognisance of the frequency with which they media multitask was poor prior to the study. Moreover, their metacognition of their self-interruption tendencies was limited. Despite the acknowledgements of the continuous use of their phones in conjunction with other activities, when provided with time-specific data on their own usage patterns, the participants realised that their self-perception of their media behaviour was lacking.

> *I was surprised by how much and when I was actually using my phone. So, it was really interesting to see how much I multitask. I didn't realise it until now, but it is quite insane. So that is why my focus isn't where it should be.* (P3)

As a consequence of their poor metacognition, participants underestimated the effort required to regulate their media multitasking. Prior to the intervention period, in relation to their present understanding of their behaviour, the 90-minute target and reduction in multitasking was seen to be an easy goal to achieve.

> *I didn't actually comprehend what 90 minutes was. In my head it didn't click. I thought it was easy. I thought I used less than that. I did, I really did.* (P5)

The Intervention Engendered Greater Cognisance of Behaviour. The intervention was understood by participants to engender a greater awareness of, firstly, their behaviour with media, secondly, the allocation of their time in relation to their goals and, thirdly, the effects that their behavioural choices have for their cognitive functioning.

> *I am definitely more aware of phone use and how it affects you more than you think and how you can only do one thing at a time.* (P3)

A greater awareness of media multitasking tendencies was a key driver of behaviour change. The awareness engendered by the intervention enabled participants to consider whether their behavioural patterns aligned with their goals and, on this basis, operate to bring their behaviour in-line with their intentions. Participants considered how they allocated their time and attention, and how this aligned with their goals. Moreover, in considering their behaviour, participants reported being more mindful of their goals themselves.

> *Being aware of your behaviour makes you want to change it.* (P5)

> *The big thing was being aware of how and when I was using my phone. I would rather use that time to spend it either with friends drinking coffee or just working.* (P3)

Participants noted the value of the reports on their media use provided by the application. The tracking was seen to support them in the monitoring of their behaviour and, on this basis, evaluating how their behaviour corresponded to the intervention target and their own behavioural goals.

> *You can see how long you have been on for each hour. You can then think about what you were doing then. Then you know you can just cut back on that.* (P1)

Structuring of Time to Regulate Media Multitasking. While the intervention specified a target and the use of the application, the approaches used to ensure goal adherence were left to the participants. Consequently, a variety of self-regulation strategies were adopted. Across these strategies an explicit consideration of how available time was structured emerged as a common pattern. Extending from the cognisance of their behaviour participants endeavoured to use their time in a constructive manner.

> *I just realised that the phone was just connected to how I was using my time now. So I would try to plan my time better so that I have things to do, so that I am doing something specific and not just being lazy. That this is study time, this is dinner time and stuff like that. I think during this study I was more aware of my schedule and my time.* (P8)

One strategy used to achieve an alignment between behaviour and goals was the use of time-blocking. Participants would set aside specific times for different activities. While a minority of participants used *Forest's* restriction feature to support their time-blocking, most participants did not use any mobile application or device-features to facilitate it.

> *I set specific times of the day that I was going to be on my phone. So I set up a timetable and said in the mornings when I wake up I am going to be on my phone for 15 minutes check for the day and then during lunch time half an hour and then after dinner another half an hour or the remainder of the time I had.* (P10)

One way in which time-blocking was implemented was the batching of responses to incoming messages. Participants would delay responding to messages until they had completed a task and, upon completion, respond to all of the messages received in a single batch. In this way, rather than responding to individual messages, participants aimed to single-task and inhibit externally driven interruptions.

> *Individual conversations I would try and delay it until I could single task and actually reply. So, I would wait until five or six messages had accumulated and then reply to them all and then put my phone away.* (P9)

Another strategy adopted by participants corresponds to Gazzaley and Rosen (2016)'s suggestion that limiting the accessibility of media will facilitate single-tasking. Participants reported placing their phones in locations that were either outside of their direct line-of-sight or required effort to gain access to. Additionally, some participants indicated that they would switch their phones off while in class or studying. This was the only form of device-level access control reported. Rather than using restriction applications, device settings, or other features, the participants elected to alter their physical proximity to their devices when wanting to avoid interruptions.

> *In class time I would switch off my phone put it somewhere and then focus on the lecture.* (P10)

> *I just put it in my drawer and closed the drawer while studying, and if it vibrated I would just let it go.* (P6)

In relation to strategic choices, a number of sub-themes pertaining to the use of the prescribed application merit consideration. Primarily, the participants used the application as a means to understand their own media behaviour. The participants compared the application to other health and fitness related applications they used and felt that, without the availability of such information, they would struggle to effectively operate to regulate their behaviour. Moreover, participants understood that, without support, they could deceive themselves about their behaviour and the extent to which they multitasked.

> *If you just have to cut back yourself I think you are going to not always achieve your goal for each day. So for me, I think having an app or just some record of how long you have been on your phone is useful.* (P1)

Despite this, the restriction feature was not regarded to be beneficial. Participants reported initially using the feature but, as they gained control of their behaviour, curtailed this usage.

> *I used it a lot in the beginning but in the end when I got my phone more under control I didn't grow a forest that much.* (P10)

For those who did use the feature, it was used to support time-blocking, allocating lecture and study periods to restrict their device use.

> *I did use the tree feature. The planting trees, for lectures mostly. That was beneficial in that I stopped using my phone during lectures, like a lot. Then I also would set my self study times and I would use the tree thing a few times there.* (P8)

Intervention Implementation as a Function of Situation. The participants were cognisant that there exists a situational dimension to their actions. This awareness was expressed in relation to factors which either hindered or facilitated their media multitasking self-regulation. While initially struggling to regulate their media multitasking, as they formed new habits, participants became cognisant of their behaviour, and developed strategies for regulating their media multitasking in different situations, the task became easier.

> *The first day was really hard. It was so hard not being on my phone. But then, I adapted on using my phone only after lectures. Like the first week was very difficult, but then you get used to it. Even now, I am rarely on my phone. I have gotten used to it. Even now that I know the period is over, I still try not to use my phone during lectures.* (P2)

Many participants considered it easier to regulate their media multitasking when studying or in lectures but, when presented with free time, struggled to regulate their behaviour. This pattern was associated with a greater awareness of academic goals and a desire to adhere to a behavioural and task-execution strategy. However, in the absence of an academic goal-driven incentive, when socialising or relaxing on weekends, participants struggled to regulate their media multitasking. Additionally, for some, while striving to adhere to their adopted strategy, subjective experiences of boredom, especially during lectures, presented a particular challenge. Media were used as a form of *escapism* from the subjectively aversive nature of these settings.

> *I think during the week it was a lot easier because you have a routine. When you were studying it was definitely a lot easier. During the weekends when you have a lot more free time it is a lot more difficult. When you go out to places you do end up on your phone quite often without realising it. It is a lot easier when you have to study for something. When you don't have any studies then the time can rack up on the phone.* (P1)

> *The times that it was most difficult for me was in the really boring classes when I actually have to pay attention to what they are saying.* (P9)

Media Multitasking Self-regulation Supported Single-tasking. Drawing on the structuring of their time and the strategies adopted, the intervention was seen to provide the participants with increased instances within which they could single-task. By disconnecting from media engagement, the participants shaped their present situations to create the circumstances within which they could sustain attentional allocation. This was seen to positively affect their studies.

> *I saw that I completed my assignments days before I usually completed them, I didn't leave them for the last minute because I was occupied with my phone.* (P10)

Extending from this, the participants realised that, when necessary, they could spend periods of time without using media. In disengaging from their phones to allocate attention elsewhere they were able to function without undue consequences for their personal or social or lives.

> *I feel like, in general, it kind of made me realise that you don't actually need your phone with you all the time. In most situations you don't actually need to be on it.* (P1)

While participants perceived themselves to have more opportunities to single-task, they did not perceive the intervention to have an effect on their capacity to concentrate. Rather, it was seen to produce more instances in which they were concentrating. Whether in a lecture or studying on their own, the participants equated not using their phone with the allocation of attention to various situation-specific tasks.

> *Before the study I would be using my phone in class and I would realise that I missed something and then I would be trying to catch up. So then, if I am not using my phone I was concentrating more, obviously. I also was keeping up with what the lecturer was saying. So it wasn't like there was space to fill, because now I was actually concentrating. I think it was more like my focus was just on one task. So I think I was focusing more just single view. Single like focus.* (P8)

The participants indicated that, by single-tasking more, they felt more present in their current situations. Rather than allocating attention to irrelevant thoughts, memories or activities, they were more cognisant of their surroundings and the requirements of their present tasks.

> *Being more present is a lot more enjoyable than being half focused on one thing and half focused on another thing. Also, in lectures, now I feel I am a lot more focused on one thing. I think with, for example, family times sometimes I used to go on my phone and just reply to a message. Now, I was more involved with my family because I figured I shouldn't actually be on my phone, I am not meant to be on my phone now. So it was helpful to have the goal. You are more involved in everyday activities basically.* (P1)

Experiences of Negative Affect Associated with Media Multitasking Self-Regulation. While the intervention was primarily viewed by the participants as beneficial, for some, it induced negative affective responses. In gaining a greater awareness of their behaviour with media, participants felt explicitly attuned to their behaviour and, when not conforming to their goals or the target, felt guilty.

> *I think during the beginning I got a bit stressed out because I didn't meet the target. I told myself '90 minutes is your max' and when I didn't get it I was upset with myself.* (P10)

Despite Positive Reactions, Limited Intentions to Continue With the Intervention. Despite generally regarding the intervention to have been beneficial, participants did not intend to continue with it. Rather, they opted to continue with some aspects of the intervention, and abandon others. Although participants indicated that they would continue structuring their phone use around their goals and abstain from using when in lectures or studying, they did not intend to continue using the application or adhering to the limit. Additionally, rather than constantly regulating their behaviour, participants indicated that, because it was useful when studying, they would continue to regulate their media multitasking when in lectures or studying, but not in other situations.

> *Overall, it was beneficial. I learned that I could actually do it. I could actually stay without my phone. I could study without my phone. It is such a bad habit that our lives revolve around cellphones and social media.* (P2)

> *I think I would use it. But, not all the time. If I am for example knowing that I have to get something done like studying, then I would open this up and make sure that its tracking everything that I am doing. Because then I know that I am not wasting time. So, I will probably continue managing when I have studies to do.* (P1)

Discussion

In response to indications that chronic media multitasking is associated with a range of interferences which, for some, are linked to diminished performance across a number of domains, and patterns of cognitive control emphasizing a broad, rather than narrow, focus of attention, this mixed-methods study sought to investigate the feasibility of a self-regulation based behavioural intervention. To this end, for each of the four dimensions of feasibility considered, a brief discussion is presented. This culminates in an overall evaluation of intervention feasibility before limitations in the present investigation are noted and recommendations for future research are outlined.

Intervention Implementation

As in a number of studies (Irwin, 2017; Jeuris et al., 2014; Mark et al., 2012; Pielot & Rello, 2016), the intervention was implemented in situ, with participants attempting to change their behaviour during their everyday lives. In addition to ecological validity, this enabled the identification of factors which either facilitated or hindered intervention execution. Prior to the study participants' media use was characterised by high-levels of multitasking across personal and academic contexts. This behaviour was seen to be automatic and in conflict with longer-term goals. As shown in the usage tracking data, on average, participants achieved the specified target and, as indicated in the interviews, behavioural changes were required to accomplish this. Such changes required time to be achieved and, only once participants became cognisant of their behaviour and formed new habits and regulation strategies, could the regulation of media multitasking be realised. For intervention implementation this implies, firstly, that intervention execution improved over time, secondly, that behaviour change with media takes time to achieve in real-world situations and, thirdly, that the design of behavioural interventions with media should account for the time taken for behavioural changes in addition to other targeted effects. In addition to time, there is a situational dimension to media multitasking self-regulation.

Supporting Ralph, Seli, Wilson and Smilek (2018), the recounted patterns indicate that, for some, media multitasking occurs as a function of the demands of a present task. Furthermore, supporting le Roux and Parry (2019b), it is suggested that, in a given situation, the alignment between present activities and longer-term goals contributes positively to media multitasking self-regulation. In contrast, when there is misalignment, regulating simultaneous media use to remain on-task is hindered. Despite this outcome, it is important to acknowledge the possibility that, in some situations, individuals single-task across multiple devices. A task can extend across multiple devices, which may, for instance, include the use of a smartphone in relation to other activities (e.g., using a smartphone as a communication link during a collaborative group project). Jokela, Ojala and Olsson (2015) provide an overview of a number of common instances of related parallel use of different devices in the course of everyday life. Such use instances, if related to a primary task do not constitute multitasking. Consequently, it is not surprising that there exists a situational dimension to self-regulation. Given goal-alignment, participants endeavoured to regulate their smartphone use in situations where the device was not considered to align with present goals (e.g., in a lecture). But, if the device could conceivably support the attainment of a particular goal (e.g., collaborative work or social interactions), simultaneous use was not curtailed.

Intervention Efficacy

For the 11 hypotheses, at either a functional or reflective level, no effect of the intervention in the hypothesised direction, after accounting for the baseline values, was found. Seven of the eight self-report assessments produced null outcomes, with negligible effect sizes, while all four of the performance-based assays indicated null, negligible effects. This suggests that the self-regulation intervention failed to have the intended effect on participants' cognitive control abilities in the specified time frame. In comparison with previous studies, only four assessments have shown positive effects indicated by self-report measures (Mark et al., 2017; Pielot & Rello, 2016; Whittaker et al., 2016), with all but one of these involving custom measures. Similarly, for performance-based assays, previous evidence is limited with all of null, negative, and positive outcomes shown (Gorman & Green, 2016; Hartanto & Yang, 2016; Irwin, 2017), with positive effects primarily shown with brief interventions.

While an effect was observed for difficulties shifting attention, it was opposite to the direction hypothesised. Those in the control group reported experiencing less difficulties shifting attention between tasks than those in the intervention group. Given the small effect size, the practical significance of this difference is negligible. While it was hypothesised that shifting ability would improve, it is acknowledged that, in comparison to the intervention group, the control group were expected to have maintained a higher level of task-switching. Consequently, it may be that, in focusing on single-tasking, those in the intervention group perceived greater difficulties shifting between tasks. While only a single study has shown improvements in switching ability associated with media multitasking (Alzahabi & Becker, 2013), subsequent intervention studies should not discount the possibility that, along with other changes, task-switching may be adversely affected.

Three possible explanations are provided for the apparent failure of the intervention to bring about changes in cognitive control. First, noting the implementation patterns indicated by both the usage and interview data, the degree of execution may account for the absence of intended effects. While, on average, participants adhered to the target and, as the changes in cognisance and self-regulation strategies indicate, participants endeavoured to reduce their media multitasking, because media multitasking itself was not measured, adherence to the intervention may have been poor. The limited use of the restriction feature provides some support for this interpretation. While the participants felt that they changed their behaviour, they may not have reduced the extent of their media multitasking overall. Second, while increases in single-tasking may bring about changes in cognitive control, the intervention period of 28 days may have been insufficient for this to occur. A longer duration may be required to account for the time associated with behaviour changes and, secondly, the time required for changes in cognitive control.

Third, irrespective of execution, the nature of the intervention itself may account for the absence of the intended effect. This does, however, not preclude the possibility that the intervention engendered momentary changes in cognitive control. Gorman and Green (2016) for instance, found that mindfulness exercises produced short-term (or momentary) positive effects on cognitive control. It may be that the intervention modified the attentional state of the participants during instances of single-tasking, when restricting their media multitasking without transferring to general improvements in cognitive control at a trait level. In accordance with Ralph et al. (2015, p. 400), who suggest that "in-the-moment media multitasking is likely to impair one's ability to perform the primary task", it is argued that in-the-moment single-tasking should improve one's ability to perform a primary task. Despite this assertion, given the timing of the assessments used in this study, any momentary effects of single-tasking were not observable. Consequently, further investigation is required to determine the value of self-regulation for state-level attention in relation to typical multitasking scenarios. While the reports provided in the interviews seem to support the assertion that, when regulating their media multitasking, participants were single-tasking and maintaining the allocation of their attention to a task at hand, further statistical evidence is required to determine if this was indeed the case. Moreover, in addition to determining the value of the present or similar interventions for momentary performance, it is worth considering whether interventions *should* target state or trait-level outcomes. As many studies have shown that in-the-moment media multitasking negatively affects performance outcomes (e.g., media use while studying or in a lecture; van der Schuur et al., 2015), it could be that, to address the potential interference produced by such behaviour targeting momentary effects holds greater value than targeting trait-level effects.

Intervention Acceptability and Demand

Prior to the intervention, feeling that they underestimated how much they used their phones and how much this use coincided with other activities, participants' cognisance of their media behaviour was poor. This finding holds important implications for the interpretation of studies relying on self-reports of media multitasking. Recent studies indicate that digital trace data of media use correlates poorly with self-reports (Ellis, Davidson, Shaw & Geyer, 2018). The findings in this study, produced on the basis of qualitative data, support this assertion. Additionally, they corroborate suggestions that, over time, media use becomes driven, to a greater extent, by habit and situation than goals or processes of reasoned action (Shaw, Ellis & Ziegler, 2018). It is, therefore, proposed that, while media multitasking may initially be driven by goal-directed actions, over time, through repeated patterns of covariation between situations and responses, it becomes habitual and automatic. This interpretation —media multitasking as both goal-driven and automatic behaviour— potentially accounts for conflicting findings in previous studies where some show that media multitasking is automatic and others find it to be goal-directed (Aagaard, 2015; van Koningsbruggen et al., 2018; Wang, Irwin, Cooper & Srivastava, 2015).

While previous media multitasking interventions have primarily relied on a single behaviour change approach, the intervention in this study incorporated elements of awareness and restriction. Extending Rosen et al. (2013), this decision was based on the interpretation that metacognition was a key aspect present across the three intervention categories outlined by Parry and le Roux (2019a). Consequently, in using the application to monitor their actions, the participants gained a greater awareness of, firstly, their media behaviour, secondly, the allocation of their time in relation to their goals and, thirdly, the effects that their behavioural choices have for their goals. Corroborating Whittaker et al. (2016) and Jeuris et al. (2014), this indicates that, when provided with indications of how and when they engage with media, people become more cognisant of their time and attention allocation strategies, and how their actual behaviour aligns with their intended behaviour. This outcome provides support for recent behaviour tracking features available on the two most popular mobile operating systems (*iOS Screen Time* and *Android Digital Wellbeing*). Notably, the availability of information on media use was seen to be essential to successfully regulating media multitasking. In the absence of such information participants felt that they could deceive themselves about their behaviour. While such features may support the clarification of goals and enable ongoing monitoring of behaviour, without an explicit goal or intention to manage media multitasking or other media behaviours, such features may not be effective at bringing about changes in behaviour.

Although the restriction target forced a particular goal, the changes required to operate and bring behaviour in-line with the target were left to the participants. While this limits the extent to which causality can be attributed to any particular strategy, it enables insights into the nature of and motives for the various self-regulation strategies adopted. Across these strategies, extending from their greater behavioural cognisance and metacognition of interruption tendencies, participants endeavoured to use their time and attentional resources in a manner that aligned with their goals. This finding extends Whittaker et al. (2016) who found that awareness of computer-based activities over two days led to reductions in hedonic activities but not work-related, utilitarian activities.

Primarily, goal-alignment manifested through the allocation of specific times for different activities. This involved using media outside of academic settings. Additionally, in-line with these time-blocks, participants delayed responding to incoming messages until they had completed a task and, upon completion, responded in a single batch. This emergent strategy resembles the intervention assessed by Fitz et al. (2019). Another strategy adopted to regulate simultaneous media use was to limit the accessibility of phones during a time-block designated to other activities. This strategy supports Parry and le Roux (2019b)'s indication that, in academic settings, control over technology presents a viable approach to managing media-related interference. While viable, the participants' behaviour suggests that, rather than enacting various affordances, besides turning the device off, they did not use other features or settings to regulate their usage and, rather, relied on will-power.

As was evident with the usage data, while the application was useful for understanding behaviour, the restriction feature was not adopted as a key component of the participants' media multitasking self-regulation. Rather, after initially using the feature, the participants opted to structure their time without initiating restriction sessions. The reluctance to use application-level features or other operating system features (e.g., 'do not disturb mode') and, instead, rely on willpower, may have occurred either due to an absence of knowledge of such features, the inability to use such features, or an unwillingness to restrict connectivity in such ways. Chokalingam, Mathee and Hattingh (2018), for instance, indicate that many students are unaware of how applications can be used to support self-regulation of smartphone use. Moreover, the centrality of media in students' lives suggests that, despite goal-alignment and intentions to restrict access, some participants may not have wanted to entirely restrict access to their devices and, in this way, undermined their regulation efforts. A consequence of this strategy, irrespective of its cause, was the opening of a 'back door' to their devices. In not completely restricting access, participants indicated that they perceived notifications on their nearby phones and allocated attention to considering their potential contents. Consequently, their single-tasking efforts were, in some cases, undermined by the manner in which they implemented their time-blocking strategy.

The structuring of behaviour around single-tasking can be interpreted as the adoption of a task-execution strategy which, at state-level, fostered the inhibition of interferences and a narrower distribution of attention. Consequently, as Ralph et al. (2015) argue, reported indications of improved focus are indicative of changes in behavioural and attention-related strategies and not changes in cognitive control. While this task-execution strategy may not have affected cognitive control ability, as indicated in the interviews, it aided task-performance and goal-achievement. This supports the distinction suggested between state-level effects and trait-level effects. At a functional level, as confirmed by the assessments of cognitive control, participants' abilities to sustain attention and inhibit interferences did not improve. Despite this, as the participants reported, the regulation of their media multitasking was seen to enable them to enact changes which brought about more instances in which they were single-tasking and sustaining their attentional allocation to individual tasks.

While participants generally regard the intervention to have been positive, negative affective responses were reported. The improvements in behavioural cognisance led participants to feel guilty when their behaviour was considered to be incongruent with their goals. Considering their subjective evaluations of both the positive and negative effects of the intervention, participants did not intend to continue with the intervention as proposed. Specifically, noting the value for their academic goals, the participants indicated that they would continue structuring their phone use around their goals and regulate their media multitasking when in academic settings, but not in other situations and not through the use of an application or adhering to a time limit.

Overall Intervention Evaluation

To address the primary research question and provide an evaluation of the feasibility of the media multitasking intervention, outcomes for the relevant feasibility dimensions are evaluated. For *implementation*, while there existed situational and temporal effects on implementation, given the in situ assessment, it is concluded that the intervention can be implemented as proposed. For *acceptability*, despite acknowledging positive effects associated with the intervention, only limited intentions to continue were reported. Consequently, while the intervention was deemed to be appropriate and, for the task of supporting changes in behaviour, satisfactory, such an intervention is unlikely to be used by the target population in its present form. For *efficacy*, both the self-reported and performance-based assessments of cognitive control indicate that, within the parameters of this study, it can be concluded that mobile-application supported self-regulation, as a media multitasking intervention, did not have a practical effect on cognitive control at a trait level. The intended efficacy of the proposed intervention, therefore, is not supported. Notwithstanding this result, considering the *demand* dimension, the intervention was seen to bring about a greater cognisance of media use patterns and considerations of the alignment between actual behaviour and intended behaviour. Additionally, the intervention was understood to enable behavioural changes which brought about more instances of single-tasking. Considering the perceived positive effects of the intervention and its apparent failure to bring about trait-level changes in cognitive control, it is concluded that the intervention enabled participants to structure their time to align more closely with their goals and, in this way, brought about momentary changes in their attentional states. These momentary changes, however, did not transfer to trait-level changes in cognitive control over a 28-day period.

Overall, the intervention was implementable and regarded as appropriate and satisfactory by the target population. Nevertheless, it is unlikely to be adopted by members of the target population. Moreover, the intervention did not produce the intended effect. Despite this, positive effects were associated with the intervention. On this basis, it is proposed that, while such an intervention is not feasible as a means of improving trait-level cognitive control, it is a feasible approach to bring about increased instances of single-tasking and potentially enable momentary occurrences of narrower attentional states. Given the nature of the assessments used in this study, future research is required to confirm the validity of this assertion and determine how such an intervention can be designed in a way that is acceptable for the target population.

Limitations

The in-situ nature of the study and the population targeted limit the extent to which the findings can be generalised to other populations (i.e., working professionals or adolescents).

The study is further limited by the sample size considered. Despite being larger than the average sample used in previous media multitasking intervention studies, and in the typical range for feasibility studies (Arain et al., 2010), due to non-compliance and attrition, the final sample size may have affected the degree to which statistically significant effects could be determined.

The intervention itself presents another limitation. The intervention targeted only a single device. While participants indicated that they did not increase their usage of other media, their behaviour across other devices was not assessed. While a majority of media use for the targeted population involves smartphones (Pew Research Center, 2017), there remains the possibility that media multitasking persisted. In prescribing the behavioural changes for 28-days, and only testing at the end, the study was unable to determine, firstly, if changes occurred earlier in the period or, secondly, what the required time is for changes to occur. Additionally, shorter-term, momentary affects were not perceptible, nor is the long-term sustainability of any changes.

A final limitation relates to the instruments of the investigation. A commercial application, not designed for research purposes, was used in the study. While use of such applications is becoming increasingly common, this does, however, present a potential limitation in terms of accuracy or reliability. Furthermore, while the study targeted media multitasking, the measures collected primarily concerned use time. Consequently, while participants reported reductions in multitasking, the accuracy of these reports is unknown. In addition to the intervention instruments, while the assessment instruments used were all standard, widely adopted measures of cognitive control and everyday executive functioning, inherently they are limited. Self-report assessments (both the reflective assessments and the interviews) are subject to a number of well-known biases, including: selective memory, telescoping, attribution, and exaggeration. Performance-based assays are also subject to biases and limitations, including: ecological validity, demographic and socio-economic differences, and construct-validity.

Recommendations for future research

Building on the findings described in this feasibility assessment, it is recommended that subsequent studies investigate the assertion that media multitasking self-regulation, supported by feedback from a mobile tracking application, is a feasible approach to produce increased instances of single-tasking and enable momentary occurrences of narrower attentional states. Future research testing such outcomes will need to assess momentary changes in attentional states in relation to behavioural changes. It is therefore recommended that, in conjunction with objective assessments of behaviour, some form of experience-sampling investigation be conducted to enable ecological momentary assessment. Moreover, to determine the effects of behavioural changes on single-tasking and attentional states it is recommended that investigations adopting randomised, controlled designs be conducted with larger samples and, to account for the time required for both behavioural changes and targeted effects, over longer a duration. Moreover, because the sustainability of any changes or effects are unknown at this stage, it is recommended that studies consider adopting longitudinal designs involving multiple waves of data collection. Failing this, as with Pielot and Rello (2016), it is suggested that studies use time-lagged follow-up periods to assess the sustainability and long-term effect of behavioural changes.

Finally, it is recommended that studies use objective measures of media behaviour when considering possible associations with well-being, cognitive functioning, or task-performance. Objective assessments of both media use and media multitasking are needed to advance research in this domain. Such approaches will not only support the investigation of associations between media multitasking and cognitive control but, in addition, they will aid assessments of related interventions, behavioural changes, and effects. Moreover, it is also recommended that specific instruments be developed to more accurately assess media multitasking. Future studies should endeavour to objectively assess both media to media and media to non-media multitasking and, through more subjective measures, consider the relevance of such actions for current goals and tasks. In this regard, ethnographic studies may present an interesting approach to understanding situational factors that drive media multitasking.

Conclusion

Building on indications that media multitasking is associated with changes in cognitive control and diminished task performance, this study aimed to assess the feasibility of an intervention targeting media multitasking and the effects thereof. Notwithstanding the aforementioned limitations, the study outcomes are of interest because of the need to understand behaviour with technology, the interferences that this can present for some, and how such interferences can be addressed.

The intervention drew on principles of self-regulation, requiring participants to target a goal, use a tracking application to monitor their behaviour and, if necessary, operate to bring their beheviour in-line with goal. While the intervention was able to be implemented and was, broadly, in demand by the targeted population, it is unlikely to be adopted in its present form and did not have the intended effects on cognitive control at a trait-level. Despite this, positive effects were associated with the intervention. While not affecting cognitive control abilities, participants reported that, in the course of their everyday lives, they perceived themselves to be more mindful of their current situations, single-tasked to a greater extent and, as a consequence, were spending more time on goal-related activities. More research is required to investigate these state-level effects and determine what is needed for self-regulation based behavioural changes to be acceptable for the target population.

To conclude, the study has shown that engendering a greater cognisance of media behaviour is key to behaviour change and goal-alignment. Adopting a behavioural and task-execution strategy promoting single-tasking may support task performance through momentary changes in attentional states. Such self-motivated changes, while not transferring to general changes in cognitive control, through greater goal-alignment and time spent on task, are likely to support performance across a number of domains. While the qualitative findings in the present study provide a first indication that this is the case, further quantitative investigation is required to support this assertion.

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Appendix

Codes developed during the thematic analysis

Table A1

A priori codes used in the interview analysis.

Code	Description
MOT	Motivations for regulating media multitasking
CON	Continuance of aspects of the intervention
STR	Strategies adopted to self-regulate media multitasking
POS	Positive effects associated with the intervention
NEG	Negative effects associated with the intervention
SUP	Factors supporting self-regulation of media multitasking
OBS	Factors obstructing self-regulation of media multitasking
DEG	Degree of execution of the intervention
SUC	Successful implementation of the intervention
FAI	Failure to implement the intervention
RES	Resources required to implement the intervention
REA	Reactions to the intervention
SAT	Satisfaction with the intervention
EFF	Perceptions of intervention efficacy

Table A2

A posteriori codes used in the interview analysis.

Code	Description
AWA	Awareness of behaviour with media
TYP	Type of media restricted
WHY	Reason for restricting particular media or behaviour
OTH	The other activities in-place of simultaneous media use
OPE	Instances of operating on behaviour
APP	Use of application (Forest) features
CHA	Change over time
DIF	Aspects of the intervention that were difficult to enact
AME	Recommendations of amendments to the intervention
TIM	Use/structuring of time
GOA	Alignment between behaviour and goals
END	Endorsement of aspects of the intervention to others
GOC	Instances of goal-conflict in relation to media
OVE	Overall evaluation of the intervention
BAT	Response batching strategy
ACC	Alter accessibility of device strategy
BLO	Time blocking of media use strategy
UND	Underestimation of effort required
PRI	Prior intervention attempts
PRM	Prior media use patterns
IMP	Assessment of impact of prior behaviour with media
SIF	Situational factor
INF	individual factor
AFF	Affordance of medium
NOR	Normative factor
ABS	The absence of a negative effect associated with the intervention

Table A3

Relation between final themes and codes.

Theme	Codes
Pervasive Media Multitasking	MOT; AWA; GOC; PRI; PRM; IMP
Deficient Cognition of Media Behaviour	MOT; AWA; UND
The Intervention Engendered Greater Cognisance of Behaviour.	CON; STR; POS; AWA; CHA; GOA; UND; INF
Structuring of Time to Regulate Media Multitasking.	EFF; RES; SUP; OBS; STR; POS; TYP; WHY; OPE; APP; TIM; GOA; BAT; BLO; SIF; AFF; NOR
Intervention Implementation as a Function of Situation.	EFF; RES; SUP, OBS; STR; TYP; WHY; OPE; CHA; DIF; GOA; BAT; ACC; SIF; AFF; NOR
Media Multitasking Self-regulation Supported Single-tasking.	EFF; STR; POS; TYP; WHY; OTH; OPE; GOA; BAT; ACC
Experiences of Negative Affect Associated with Media Multitasking Self-Regulation.	REA; FAI; NEG; DIF; INF; ABS
Despite Positive Reactions, Limited Intentions to Continue With the Intervention.	CON; SAT; REA; NEG; POS; AME; OVE; ABS