

Evaluating the impacts of AutonoMe on adolescent smartphone use,
wellbeing and self-control

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Abstract

Adolescents' ever-increasing exposure to digital technologies entails a host of behavioural and psychological implications, mandating effective self-regulation of device-use in a generation who crave the independence and autonomy afforded by adulthood. *AutonoMe* is an alternative screen-time application that encourages adolescents to refocus their device-use, whilst educating them on the understated hazards of their technology. This 4-week longitudinal study employs pre- and post- experimental tests to assess AutonoMe's efficacy in reducing adolescents'(n=260, ages 11-14) device-use, whilst also assessing changes to psychological wellbeing and perceived self-control. Measures of statistical significance will be used to examine the strength of possible relationships between device-use, wellbeing and self-control. It is anticipated that AutonoMe will reduce the screen-time of participants in experimental groups, and that this reduction will correlate with improvements in self-reported wellbeing and perceived control. If proven to be effective, AutonoMe holds potential for influencing future designs of digital behaviour-change tools and challenging perceived links between device-use and quality of life.

Keywords: AutonoMe, adolescents, self-control, wellbeing, behaviour-change

Evaluating the impacts of AutonoMe on adolescent smartphone use, wellbeing and self-control

The age of digital independence is declining, with reportedly half of ten-year-olds now possessing their own smartphone(Ofcom, 2019). Coupled with the rising level of harmful content proffered by the Internet and the established detriments of technology misuse, this rise in device exposure amongst young people spells bad news if mismanaged.

Screen-Time, Wellbeing and Addiction

69% of adolescents in the UK have at least one Social Networking account(Ofcom, 2017), and Social Networking Sites'(SNS) weighting as a motivator for prolonged screen-time should not be discredited(Lenhart et al., 2015). SNS-use has been correlated with poorer sleep, lower self-esteem and body image concerns – evidencing the potential consequences of elevated SNS exposure. Speculatively, dysfunctional and excess use of the internet hinders the offline activities of individuals(Pinna, 2015) and can be considered a risk factor for Internet Addiction Disorder(IAD), for which SNS-use is one of the strongest predictors(Tsitsika, 2014). Youth classified as experiencing IAD are supposedly at increased risk of displaying self-harming or suicidal behaviours(Abi-Jaoude et al., 2020). Whilst the specific issues arising from dysfunctional smartphone use(DSU) are not fully understood, engaging with electronic devices during development has been postulated to stimulate powerful behavioural and neurobiological reinforcement that promotes greater use(Guerrero et al., 2019). If untreated, this addictive spiral has been shown to result in impaired inhibitory control, perseverance and emotion regulation(Weinstein et al., 2017) as well as elevated delay discounting(Schulz van Endert & Mohr, 2020; Hou, 2019), all of which undermine the success of staging self-regulated interventions.

From observation, there exists much discordance in the literature as to whether the

psychological attributes mentioned are a cause or effect of smartphone addiction, as well as the directness of their association. A cross-sectional study of 668 Lebanese undergraduate students proposed that depression and anxiety are positive predictors of smartphone addiction (Boumosleh & Jaalouk, 2017). Other observational studies note the association between smartphone addiction and depression, anxiety and stress, but provide little insight into any causality present (Li et al., 2016; De-Sola Gutiérrez et al., 2016). Hopefully, this investigation will provide further understanding on this topic and help to resolve the academic irresolutions.

Adolescents and Screen-Time

The CDC reports that children aged 8-10 spend an average of 6 hours per day in front of a screen, a figure that climbs to 9 hours per day for adolescents aged 11-14 years (CDC, 2019). Congruently, Ofcom estimates that the proportion of young people with at least one SNS account more than quadruples between the ages of 9 and 12 (Ofcom, 2019).

Following Piaget's Stages of Cognitive Development (Piaget, 1952), our focus group (11-14-year-olds) fall under the formal operational stage (FOS). During this period, they gain competence in thinking about multiple variables in systematic ways, formulating hypotheses and considering abstract relationships and concepts. The lack of dependence on concrete manipulation of adolescents in this stage enables them to consider the potential outcomes of their actions (Inhelder & Piaget, 1958). This ought to make them more receptive to educational warnings regarding something as obscure and seemingly benign as screen-time, thus easier to mould than children in the concrete operational stage who rely on concrete manipulation to think logically. The desire of adolescents in the FOS for increased autonomy, personal space and credentials from their peers correlates with findings that communication is the most significant driver of SNS-use in adolescents (Tsitsika et al., 2014). SNS-use has the

capacity to provide adolescents with a sense of social belonging, along with mechanisms for exploring their emerging personal and social identities(Quinn & Oldmeadow, 2013). Other benefits of device-use for those in the FOS include the facilitation of socioemotional needs(Roe & Minnebo, 2007) and the provision of opportunities for learning, civic action and engagement(Hill et al., 2016). It is apparent that any screen-use policies, guidance or interventions need not only consider risks, but also the potential benefits and opportunities for young people that digital media affords. The AAP provides guidelines on how parents can incite healthier device relationships in their children; however, such regulations typically focus on minimizing risk as opposed to helping young people to exploit the opportunities offered by digital media. More so, parents' digital aptitude often lags that of their children making it difficult for them to provide adequate guidance, let alone without compromising their child's sense of autonomy and privacy.

Design of AutonoMe

AutonoMe is an assistive tool for young people to exert self-discipline in refocusing their screen-time which also educates them on the ulterior motives and manipulative aspects of their technology. Studies have found that notifications regarding excessive smartphone use are ineffective in lowering self-reported DSU, screen-time or the frequency of phone-checking behaviour(Muraven et al., 2008). AutonoMe comprises a range of screen-time metrics which feed into a configurable portfolio of 'Encouragement Tools'(Table 1). These serve to disincentivize screen-time, but with less rigidity than existing applications.

Hypothetically, the customizability of said portfolio will help users retain a sense of autonomy throughout the app's use duration, which has in-turn been linked to the strengthening of both state and dispositional self-control(Hou, 2019; Muraven et al., 2008).

AutonoMe also flaunts a range of Educative Tools which serve to raise awareness of the

threats of technology use and facilitate more mindful, well-informed cost-benefit decisions regarding how adolescents spend their time (Table 1). Transparency and trust are key to childhood development (Bernath & Feshbach, 1995); therefore, it is theorized that these Educative Tools will help adolescents to develop a sense of agency and self-regulation, with the potential for improving the use satisfaction experienced from their interactions with technology.

Study Objective

In evaluating whether AutonoMe is effective in improving adolescents' control over their device-use, longitudinal repeated measures will be taken to compare the focus group's behaviour before, during and after engaging with our app. Based on the current research findings, the study aims to evaluate the following hypotheses:

***H1:** Engagement with the Educative Tools provided results in greater perceived autonomy and control.*

***H2:** Use of the Encouragement Tools drives a net reduction in screen-time and progresses user-defined goals during the study timeframe.*

- ***H2-I:** Use of Feature 1 correlates with a reduction in SNS app launches and the resultant use duration of these apps.*
- ***H2-II:** Use of Feature 2 results in a reduction in the mean net session duration.*
- ***H2-III:** Use of Feature 3 correlates with a reduction in the number of device unlocks and the frequency of interaction with the lock screen.*
- ***H2-IV:** Use of Feature 4 results in a reduction in the mean session duration for specific applications.*

H3: Adolescents who report greater perceived control over their device-use and/ or exhibit progression towards their goals show an improvement in their wellbeing.

Method

Participants

To evaluate the use of AutonoMe against the above hypotheses, a total of 5 sample groups are required. This comprises 4 groups for testing the respective sub-hypotheses of H2, each of which will also be examined against H1 and H3, and a separate control group. Based on a priori power analysis(Cohen's $d = 0.5$, $p\text{-value} = 0.05$), the minimum group sample size for testing a one-tailed hypothesis is 52(26 girls and 26 boys). Consequently, a total of 260 students aged 11-14 will be required. Recruitment will take the form of information leaflets distributed to secondary schools across the 32 London boroughs, with this catchment area chosen to provide unbiased representation the UK population's socioeconomic status. The sample size was deemed realistic as the average secondary school class constitutes 21.7 students and there are a total of 790 secondary schools in the London boroughs(Department for Education, 2019). Adolescents with known learning disabilities form the exclusion criteria for this study as AutonoMe is not tailored to the specific needs of these individuals. The presence of any learning impairments will be self-declared upon sign-up.

Materials

Smartphone Addiction. Symptoms of smartphone addiction will be assessed using a shortened version of the Smartphone Addiction Scale(SAS) and Smartphone Addiction Proneness Scale(SAPS), termed SAS-SV(Kwon et al., 2013). A Cronbach's alpha correlation coefficient of 0.91 was obtained for this instrument in a validation study of 540 participants,

denoting high internal consistency reliability. From ROC analysis, the SAS-SV was deemed an appropriate tool for evaluating smartphone addiction with a 95% confidence interval consistently higher than 0.88. The measure comprises 10 statements relating to symptoms of smartphone addiction in adolescents, with response items forming a 6-point Likert scale ranging from 'Strongly Disagree' to 'Strongly Agree'. Statements include '*I feel impatient and fretful when I am not holding my smartphone*', '*I have a hard time concentrating in class, while doing assignments, or while working due to smartphone use*', and '*the people around me tell me that I use my smartphone too much*'.

Psychological Wellbeing This will be measured using the Brief Scale of Psychological Wellbeing for Adolescents(BSPWB-A; Ryff, 1989). The scale is made up of 20 items which are assessed on a 6-point Likert scale and cover 4 areas: self-acceptance, positive interpersonal relationships, life development and autonomy. Examples of questions are '*The tasks and responsibilities of everyday often get me down*', '*I have confidence in my own opinions, even if they are contrary to the consensus*', and '*I think it is important to have new experiences that challenge me*'. A validation study(Viejo et al., 2018) showed acceptable internal reliability for each scale and the questionnaire in full, measured with the Alpha Ordinal to have values of over 0.79 in all cases.

Self-Control As a significant factor of self-regulation and autonomy(Baumeister et al., 2007), participants' self-control will be assessed using a variation of the Brief Self-Control Scale(BSCS; Tangney et al., 2004) with a two-factor correlated structure(Morean et al., 2014). The BSCS focuses on operational aspects of self-discipline(factor 1) and impulse-control(factor 2) and consists of 13 items measured on a 5-point Likert scale. Example items include '*I am good at resisting temptation*', '*I do certain things that are bad for me, if they*

are fun' and *'I am able to work effectively toward long-term goals'*. A validation study on 693 Spanish adolescents displayed adequate evidence of reliability for this measure($\alpha_{ordinal} = 0.67$), and excellent test-retest temporal stability($ICC=0.82$).

Screen-Time Metrics AutonoMe grants multifaceted data collection regarding participants' use of their smartphones. Parameters such as device unlock number, app use duration, net session duration and device engagement frequency can be recorded for analysis and cross-validation with the above measures.

Procedure

The experiment will be conducted by trained research volunteers and requires participants to attend Imperial College London bi-weekly for a maximum of 1 hour over the 4-week study duration. Additional introductory and closing sessions, each lasting 2 hours, will be held on day 1 and 28, respectively. Eligible households who have registered for the study will be contacted with the location, date and time of the first session no less than 1 week in advance. The introductory session explains the nature of the experiment to participants in-person, answering any initial questions prior to obtaining written consent from both participants and their parents. With consent established, participants will be randomly allocated to one of 5 groups(4 experimental and 1 controlled). Groups are then directed to breakout rooms, where the premise of AutonoMe is explained to all in-full bar the control group, who are pitched a dummy version of the app with only activity tracking capabilities. Directions for installing the correct version of AutonoMe are then provided, with those in the experimental groups instructed to leave all tools deactivated for the time being and continue using their devices as usual.

The bi-weekly drop-in sessions over the course of the study provide all participants with controlled timeslots in which to repeatedly complete the assessments detailed in the *materials* section. Participants will be identified by a randomly assigned participant number noted on their script, enabling assessors to gauge any changes in individual wellbeing, addiction symptoms or perceived self-control during the study.

After the first 2 weeks of data collection, members of the 4 experimental groups will be required to attend a one-off group workshop. During this, they will be instructed to activate all the Educational Tools on the AutonoMe app, along with 1 of the 4 Encouragement Tools (corresponding to their group number). Participants will be asked to retain these settings for the final 2 weeks of the study.

Come the end of the 4th week, a closing session will be held to thank participants and guide them in deactivating/ uninstalling the AutonoMe application. An evaluative questionnaire with additional fields for personal data will also be distributed in the interest of preventing self-imposed stereotypes bias.

Ethics

Following the BPS Code of Human Research Ethics, parents of study participants will be informed of the nature of the experiment, including eligibility criteria and potential risks, via a postal information leaflet prior to its commencement. Having received this, parents must provide passive consent on behalf of their adolescent offspring. The participants themselves must provide active consent on the day the study commences; however, this can be inconsequentially withdrawn at any time. Developmental studies have shown that the provision of consent by both parties has the potential to reduce sampling bias (Shaw et al., 2015). Ethics approval will be requested from Imperial College London's Ethics Board in advance of the study. A briefing on professional boundaries and accountability will be

delivered to facilitators in advance of the study and it is expected that these standards are adhered to throughout. All participant data will be kept anonymous, confidential and within GDPR guidelines to mitigate any privacy/ data breach risks.

Results

Based on current evidence of adolescents' smartphone use habits and wellbeing characteristics, it is expected that improvements will be seen in participants' self-evaluations across the board (in the SAS-SV, BSPWB-A and BSCS) following the implementation of AutonoMe. *Before* (weeks 1&2) and *after* (weeks 3&4) comparisons will be conducted using descriptive statistics for face-value understanding and repeated measures ANOVA to gauge the level of statistical significance between datasets and assist with evaluating the validity of H1 and H3. Per existing analysis of the BSPWB-A (Viejo et al., 2018), incidence of smartphone addiction within the sample group is predicted to be similar to other mean levels in the age group, with a greater proportion of girls reporting symptoms of addiction in the first 2 weeks and a pronounced decline in self-evaluated addiction following AutonoMe's implementation. Self-reported psychological wellbeing scores are expected to be normally distributed throughout the study, with no major variation between genders.

Per H2, a sharp decline in recorded device-use is predicted following the activation of AutonoMe in week 3. Cross-comparisons between subjective self-evaluation data and measured use parameters will be conducted using similar methods to those detailed above to gauge whether participant perception is in-line with the objective measures regarding device-use.

Discussion

This study aims to supplement existing research into adolescent smartphone usage in assessing whether AutonoMe has significant potential for reducing device-use whilst improving psychological wellbeing and perceived self-control. If the hypotheses outlined prove correct, it can not only be assumed that an inverse correlation between smartphone use/misuse and psychological wellbeing exists, but that the relationship is indeed causal.

The large sample size and wide socioeconomic catchment of this study may result in some geographic variability with respect to academic performance and family financial status, which are reportedly linked to psychological wellbeing and self-control (Gabel, 2017; Boals et al., 2011). The randomisation of study grouping is likely to correct these effects, and to further mitigate order effects, the order of written questions should be randomised by individual. Additionally, the study requires a high level of commitment from participants, some of whom will likely miss their sessions at the Imperial College test site due to unforeseen circumstances necessitating their removal from the study.

Use of self-reporting as an assessment tool also presents some limitations. It is expected that test scores will vary over time due to factors such as concentration level, though this is unlikely to significantly skew results granted the omission of anomalies. Gender effects are also foreseen since female participants tend to be more self-aware and open in expressing themselves via this method (Kwon et al., 2013). A potential correction method would hence be to moderate results by gender to permit unbiased cross-comparison.

The proportion of 12-year-olds with their own smartphone has grown by 68% since 2015, however only 15% of pre-teens use tools to monitor their screen-time (Rideout et al., 2019). Considering the detrimental implications of adolescent device overuse and addiction, understanding how to encourage healthy technology-use behaviours among this group is crucial to their self-regulatory development and wellbeing. The proposed research

aims to test whether AutonoMe can reduce an individual's screen-time without compromising their sense of control or perceived wellbeing. If the proposed features prove effective, this will refocus the design of digital behaviour-change tools targeting adolescents with the potential to challenge the focus group's perceived links between screen-time and quality of life.

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Tables

Table 1

AutonoMe application features and use metrics

Category	Feature	Purpose	Metric(s)
<i>Educative Tools</i>	1. <i>Not-So-Infinite Scroll</i>	<i>Interrupting mindless scrolling by highlighting the distance scrolled and questioning user intentions.</i>	• <i>Degree of engagement with notifications.</i> • <i>Level of perceived autonomy and control during use session.</i> • <i>Degree of contentment / satisfaction relating to use.</i>
	2. <i>Automation Prompts</i>	<i>Flagging notifications as non-human and reminding users of their manipulative intent.</i>	
	3. <i>Form Alerts</i>	<i>Cautioning users of personal data provision and questioning its necessity.</i>	
	4. <i>Cookie Bombardment</i>	<i>Reminding the user of their capacity to disable tracking cookies.</i>	
<i>Encouragement Tools</i>	1. <i>Lock Screen Revisited</i>	<i>Imposing self-regulated app launch limits and session duration allowances.</i>	• <i>Unlock number.</i> • <i>Use duration of specific applications.</i> • <i>Net session duration.</i> • <i>App launch number.</i> • <i>Frequency of engagement with lock screen.</i>
	2. <i>Dear Future Self</i>	<i>Prompting the user to consider the nature and necessity of their session.</i>	
	3. <i>Vacuum Mode</i>	<i>Withholding notifications during focus periods and batch delivering them at intervals.</i>	
	4. <i>Black & White World</i>	<i>Display grey scaling to reduce device distraction potential.</i>	

Figures

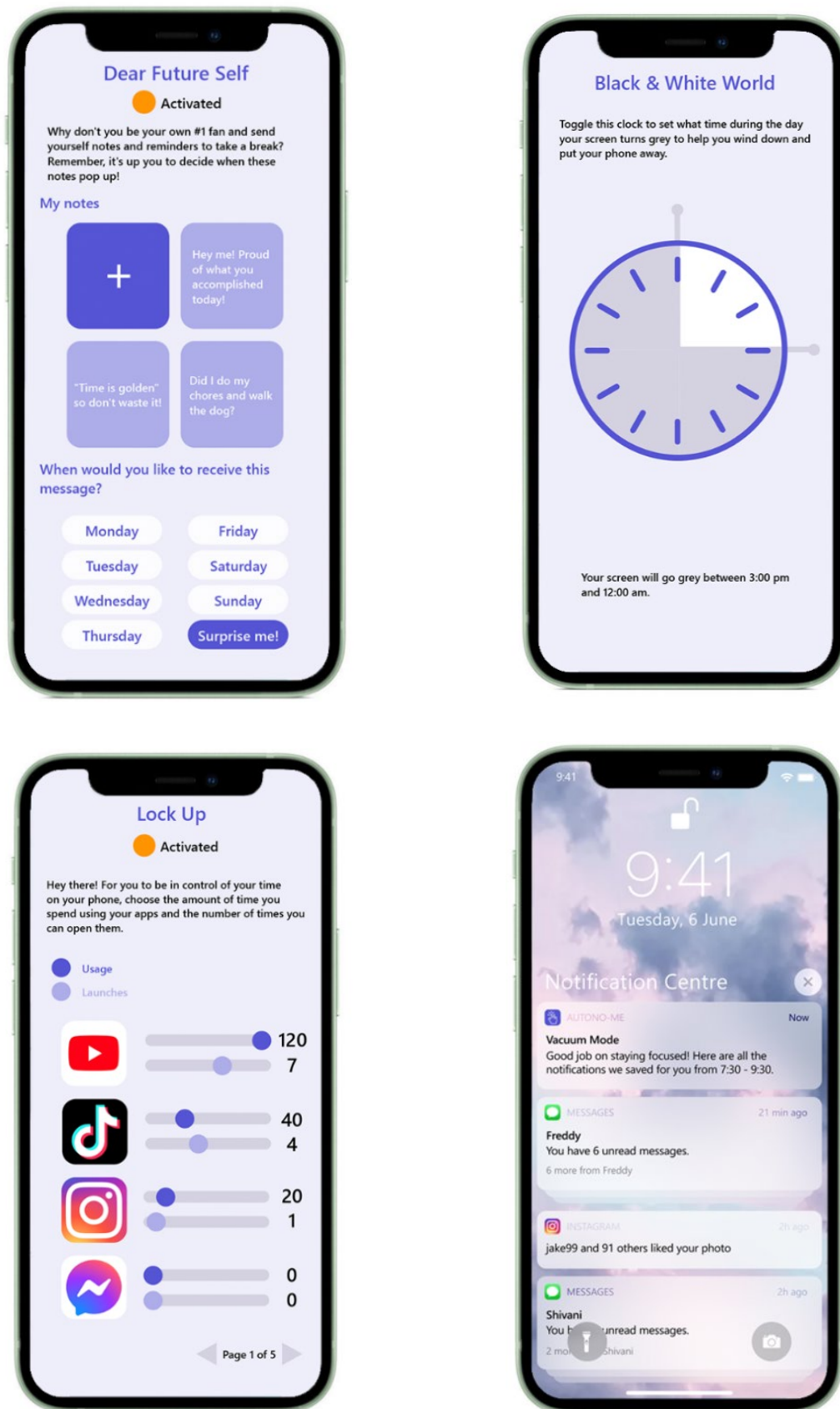


Figure 1. User interface design of the AutonoMe app's Encouragement Tools.