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Delivering Behaviour Change Techniques via Short Text Messages to Promote Active Travel

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Abstract

Active travel has many benefits for both individuals and societies. While the number of interventions aiming to promote active travel increases, it is usually not easy to deliver those interventions, identify 'active components' of them, and/or replicate them. The current paper reports two studies testing interventions that used SMS messages to deliver behaviour change techniques (BCTs) based on the Control Theory (i.e., goal-setting (behaviour), action planning, self-monitoring of behaviour). Study 1 sought to increase the use of a bike share scheme. Participants were randomly assigned to one of three experimental groups that received messages for three BCTs (n = 26), one BCT (n = 29), or no BCTs (n = 40) and were followed up one month later. The effect of intervention on bike use was significant when two intervention groups were combined and compared to the control group. Study 2 tested an intervention to decrease car use. Participants were randomly allocated to one of two experimental groups that receive three BCTs (n = 29) versus no BCTs (n = 32). The effect of the intervention on car use was marginally significant. The results of the two studies suggest that interventions delivering BCTs via SMS message may be used to promote active travel, although both studies were underpowered. Given the relative ease and low cost of delivering psychosocial interventions via SMS messages, the potential public health impact at a population level is, nonetheless, likely to be important.

Keywords: behaviour change techniques (BCTs), intervention, text message, active travel

Davranış Değiştirme Tekniklerini Kısa Mesajlarla İleterek Aktif Ulaşım Davranışının Arttırılması

Öz

Aktif ulaşımın hem bireyler hem de toplumlar için pek çok yararı vardır. Bu alanda yapılan müdahale çalışmalarının sayısı günden güne artsa da bu müdahaleleri uygulamak, 'aktif bileşenlerini' tespit etmek ve/veya tekrar uygulamak her zaman kolay olmamaktadır. Bu çalışma Kontrol Teorisi'ne dayanan davranış değiştirme tekniklerini (hedef koyma (davranış), eylem planlama, davranışın öz-izlenmesi) SMS mesajlarıyla ileterek aktif ulaşımı arttırmayı amaçlayan iki müdahale çalışmasını sunmaktadır. Çalışma 1 kiralanan bisikletlerin kullanımını arttırmayı amaçlamıştır. Katılımcılar kısa mesajlarla üç davranış değiştirme tekniğinin kısa uygulandığı (n = 26), 1 davranış değiştirme tekniğinin uygulandığı (n = 29), veya hiçbir davranış değiştirme tekniğinin uygulanmadığı (n = 40) gruplardan birine seçkisiz olarak atanmışlar ve ilk anketten bir ay sonra ikinci ankete katılmışlardır. İki müdahale grubu birleştirilerek kontrol grubuyla karşılaştırıldığında etkinin anlamlı olduğu görülmüştür. Çalışma 2 geliştirilen müdahalenin araba kullanma davranışını azaltıp azaltamayacağını test etmiştir. Katılımcılar 3 davranış değiştirme tekniğinin uygulandığı (n = 29), veya hiçbir davranış değiştirme tekniğinin uygulanmadığı (n = 32) gruplardan birine rastgele olarak atanmışlardır. İlk anketten bir ay sonra doldurulan ikinci ankette katılımcılara geçen süre boyunca kaç kez arabayla işe/okula gidip geldikleri sorulmuştur. Yapılan müdahale çalışmasının marjinal derecede anlamlı olduğu görülmüştür. Her ne kadar düşük katılımcı sayılarına sahip olsalar da yapılan bu iki müdahale çalışması göstermiştir ki kısa mesajlarla iletilerek uygulanan davranış değiştirme teknikleri aktif ulaşımın arttırılması için kullanılabilir. Psikososyal müdahale çalışmalarını kısa mesajlarla iletebilmenin uygulama kolaylığı ve ucuzluğu da göz önüne alındığında, bu tür müdahale çalışmalarının toplum sağlığına potansiyel etkileri oldukça yüksek olabilir.

Anahtar kelimeler: davranış değiştirme teknikleri, kısa mesaj, müdahale, aktif ulaşım

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Delivering Behaviour Change Techniques via Short Text Messages to Promote Active Travel

Active travel (i.e., walking and cycling) can be a viable solution to a number of contemporary problems including air pollution (Tainio et al., 2021), carbon emissions, traffic congestion (Rissel, 2009; Woodcock et al., 2009), sedentary lifestyle and health consequences such as heart disease, diabetes, hypertension, and osteoarthritis (Braun et al., 2016; Hartog, Boogard, Nijland, & Hoek, 2010; Oja et al., 2011; Pucher, Buehler, Bassett, & Dannenberg, 2010). Despite the known benefits, active travel is far from being the main travel mode across countries such as Turkey, US, the UK, Germany (Diniz, Duarte, Peres, Oliveira, & Berndt, 2015; Nehme, Perez, Ranjit, & Amick, 2016; Ünal Ankaya & Gülgün Aslan, 2020). Even for the trips between 1 to 2 miles, only 31% and 3% of those trips are made by walking and cycling in the UK, respectively (Department for Transport, 2020).

Factors associated with active travel include overall physical activity (Wanner, Gotschi, Martin-Diener, Kahlmeier & Martin, 2012), past behaviour and habits (Bruijn & Gardner, 2010; Lanzini & Khan, 2017), attributes of the social (Panter, Jones, & Van Sluijs, 2008) and physical environment (Davison & Lawson, 2006; de Vries, Hopman-Rock, Bakker, Hirasing, & Mechelen, 2010), perceptions about the social (e.g. what others do/approve) and physical (e.g. is it safe to walk/cycle) environment (Liao, 2016), distance (Panter et al., 2008), and intention (Bruijn et al., 2005) among others. These factors are consistent over genders (Pollard & Wagnild, 2017), age groups (Cerin, Nathan, van Cauwenberg, Barnett, & Barnett, 2017; Panter et al., 2008), and countries (Cheng et al., 2019; Ikeda et al., 2018; Rothman, Macpherson, Ross, & Buliung, 2018). However, the proliferation of efforts to understand and promote active travel is relatively recent, with most of the interventions reported in the last decade (Bird et al., 2013; Doğru, Webb, & Norman, 2021; Larouche, Mammen, Rowe, & Faulkner, 2018), and previous research on promoting active travel has two common shortcomings; namely, they are too expensive and hard to implement.

1.1. Interventions to Promote Active Travel

As active travel is closely related to the environment it takes place, interventions aiming to promote active travel usually target the physical environment, which are expensive (Pucher, Dill, & Handy, 2010). Building new paths to segregate motorized travel and active travel, building end-trip facilities (e.g., showers, lockers, bike parking decks) to common destination points such as metro stations or workplaces, landscaping walking/cycling paths and crosswalks, improving traffic signs and regulations are all common and usually successful methods to promote active travel (de Nazelle et al., 2011; Larouche et al., 2018). Moreover, many of those efforts were eclectic, i.e., they were governmental policies, programs, or city-wide projects with multiple areas of intervention. For instance, one of the biggest projects to promote active travel is the "Safe Routes to School" program initiated in the US to promote active travel among the youth (Chillon, Evenson, Vaughn, & Ward, 2011; Pucher, Dill, & Handy, 2010). This program consists of interventions on five E's; (1) Education, e.g., pedestrian safety rules, cycling training; (2) Enforcement, e.g., changing and reframing traffic rules, especially around schools; (3) Encouragement, e.g., Walking School Bus Projects, walking and cycling contests, (4) Evaluation, e.g., student travel tallies, parent surveys, and (5) Engineering, e.g., restructuring the sidewalks, crosswalks, and bicycle lanes (McDonald, Yang, Abbott, & Bullock, 2013). However, US federal government have spent over $1.1 billion on this program between 2005 and 2013. Furthermore, similar eclectic projects have also been implemented in the Netherlands for €1.8 billion a year, in Germany for €1.1 billion in total, and in the UK for £1.2 billion in total (Pucher, & Buehler, 2008; Department for Transport; 2018). Efforts to build new bicycle lanes are being made in many cities across Turkey such as Ankara, İstanbul, Eskişehir, and

İzmir (Balcı, Özbek, Koçak, & Çeyiz, 2018; Ünal Ankaya & Gülgün Aslan, 2020). These efforts also result in relatively small increases in cycling rates over the recent years. Even though most of these efforts are effective in promoting active travel, the money spent does not guarantee improved active travel rates (Doğru et al., 2021).

There are also studies to promote active travel that use psychosocial interventions which are inherently "cheaper". Interventions that have targeted psychological aspects to promote active travel have mostly used face-to-face communication (such as education in a classroom or workshop setting), counseling, incentives, etc. (Bird, et al., 2013). Other psychosocial efforts to promote active travel include educational activities about maintaining safety, choosing routes, or shower and storage information (Mutrie et al., 2002), promotional campaigns such as publishing posters or leaflets to encourage active travel, marketing activities through media, or incentivising active travel (Norwood, Eberth, Farrar, Anable, & Ludbrook, 2014; Petrunoff, Rissel, Wen, & Martin, 2015), raising awareness, encouragement or suggestions for active travel directly from medical professionals (Hemmingson, Udden, Neovius, Ekelund, & Rossner, 2009), or social events such as walking to school together, cycle to work days, etc. (Merom, Miller, Lymer, & Bauman, 2005; Pucher, Buehler, & Seinen., 2011; Yang, Sahlqvist, McMinn, Griffin, & Ogilvie, 2010). To the best of our knowledge, there are no psychosocial interventions conducted in Turkey to promote cycling or active travel in general. However, these methods may be difficult and costly to implement in larger populations. The shortcoming of these interventions is that they require extended periods and effort from experts, researchers, or medical professionals. Either one by one or via group meetings, they need to allocate their labour into the intervention and perform at the same level for each session. It can be suggested that being labour intensive makes it hard for psychosocial interventions to be implemented and replicated. Also, the effects of intervention methods that can reach larger populations easily such as media and social marketing are not clearly explored yet, as they are typically used along with other methods such as organised walking or cycling events, cycling skills courses, infrastructure changes, etc. (Rissel et al., 2010; Verhoeven et al., 2016). Hence, it can be suggested that literature on promoting active travel is lacking a structured method that can reach larger populations easily.

1.2. Mode of Delivery

It is possible to counter these inconveniences or hardships in the previous interventions (e.g., being expensive, being time-consuming) via the use of technology. However, research on the use of technology to promote active travel is relatively scarce. Among those, the use of accelerometers to monitor activity is a common method, especially with the developments in the smartphone technology (Coombes & Jones, 2016; Piwek, Joinson, & Morvan, 2015). Regular accelerometers and smartphone apps can be used to monitor one's own travel behaviour and serve as a travel diary. There are also interventions that utilize the internet to convey their intervention components to promote active travel (Gilson, McKenna, Cooke, & Brown, 2007; Napolitano et al., 2003). It is also suggested that the effectiveness of internet-based health behaviour change interventions increase with additional modes of delivery such as text messages, or telephone calls (Webb, Joseph, Yardley, & Michie, 2010). Yet, we do not know what the outcome would be if these methods are utilized to promote active travel.

Using digital technology for promoting health-related behaviours has been proliferated in the last decade, such as SMS text messages (Gerber, Stolley, Thompson, Sharp, & Fitzgibbon, 2009; Militello, Kelly, & Melnyk, 2012), social media such as Facebook or Twitter (Turner-McGrievy, & Tate, 2011; Wojcicki, Grigsby-Toussaint, Hillman, Huhman, & McAuley, 2014), smartphone applications (Carter, Burley, Nykjaer, & Cade, 2013; Stephens, & Allen, 2013; Turner-McGrievy, & Tate, 2011), or biofeedback devices such as pedometers (Griffin et al.,

2018; Newton, Wiltshire, & Elley, 2009). These studies show the usefulness of digital technology to increase self-regulation directed at physical activity and other health-related behaviours of a larger number of people with convenience, and at little or no cost (Hall, Cole-Lewis, & Bernhardt, 2015; McKay et al., 2018; Webb et al., 2010). However, to date, interventions specific to active travel have been lacking.

1.3. Current Research

We conducted the current interventions in order to develop a replicable, easy, and cheap intervention to promote active travel. For our intervention, we aimed to use structured intervention components. For this, we adopted behaviour change techniques (BCTs) defined by Michie et al. (2013). BCTs are "observable, replicable, and irreducible component(s) of an intervention designed to alter or redirect causal processes that regulate behaviour" (Michie et al., 2013, p. 82). The resultant BCT taxonomy specifies 93 techniques that reflect unique 'active ingredients' of interventions. Reviews and meta-analyses indicate that the most effective and most frequently used BCTs to promote physical activity are self-monitoring, intention formation, feedback on performance, and goal setting (Bird et al., 2013; Michie, Abraham, Whittington, McAteer, & Gupta, 2009; O'Brian et al., 2015; Rose et al., 2017), with self-monitoring being the most frequently used and most effective technique. Three of these techniques are also the core tenets of the Control Theory (Carver, & Scheier, 1982; 2002) which suggests that setting goals, monitoring progress, and taking action when needed (termed goal operating), are central to achieving desired outcomes (e.g., cycling rather than taking the car). The current intervention uses the three techniques related to Control Theory to promote cycling as a form of active travel and to reduce car use for commuting to work. The effectiveness of these techniques, when delivered via short text messages, has been reported in an intervention by Griffin et al. (2018) related to physical activity and dietary behaviour. Specifically, they prepared text messages for BCTs such as "goal setting", "self-monitoring", or "instructions on how to perform the behaviour" and sent 2 or 3 messages per day. They found that participants receiving the text messages had improved dietary and physical activity behaviour at 12 weeks follow-up.

In the current paper, we aimed to utilize the usage of mobile phones and convey BCTs specific to Control Theory to the participants via SMS text messages (Carver, & Scheier, 2002; Michie et al., 2013). This would also help us expand the current scope of digital interventions to cycling behaviour and active travel in general. A series of interventions was conducted in order to test whether BCTs (from Control Theory) that are delivered by SMS messages can promote cycling (as assessed by use of bike share schemes) and reduce car use (as assessed by car parking).

It was hypothesised that participants who receive short text messages about three BCTs based on control theory will increase their active travel more than the participants who receive no text messages.

2. Study 1 – The Use of BCTs from Control Theory to Promote Cycling

Study 1 sought to promote cycling via a city-wide dockless bike share scheme. Promoting cycling in a general population might fail because not everyone would have access to a bicycle, and convincing people to obtain a bike would be subject to other barriers than convincing people to cycle. For this reason, bike share schemes were used which have been growing in number around the world and have the potential to help increase cycling and decrease car use (Braun et al., 2016). It is easy to start using such bikes as it only needs a smartphone to unlock the bikes and begin riding. Hence, the current study aims to use digital technology (smartphone apps for tracking cycling and SMS for applying BCTs) to promote cycling as a form of active travel.

The primary aim of the present study was to test whether BCTs targeting the self-regulatory processes described by the Control Theory are effective in promoting the use of a bike share scheme when delivered via short messages. Specifically, we sent text messages about BCTs from Control Theory (i.e., goal setting, goal operating, and self-monitoring) to the first intervention group and we sent text messages only about self-monitoring (as this was the most frequently used technique in effective interventions; Bird et al., 2013) to the second intervention group over three weeks (see Supplementary file for messages and the schedule). Self-monitoring was used in isolation because, although this technique was frequently used in effective interventions, it was always tested along with some other techniques so, it is still not known if this technique is effective by itself or if it is only effective when combined with other techniques. Meanwhile, the control group received no messages during the intervention period. It was hypothesized that participants in the first intervention group would increase their usage of the bike share scheme more than participants in the second intervention group and that participants in the second intervention group would increase their usage more than participants in the control group.

2.1. Method

2.1.1. Bike Share Scheme.

Study 1 focused on the use of the OFO Bikes dockless bike share scheme in a large city in England. OFO Bikes can be used by downloading a smartphone app and registering with an online payment method. At the time of the data collection (April to June 2018), OFO bikes charged £0.50 for every half an hour that the bicycles were used. After the transaction is made, one can unlock the bikes using the app and start cycling. When the trip is over, the bikes can be left at any public place in the operating area marked as GeoFence which covers a large proportion of the city in which the study was conducted.

2.1.2. Participants.

An a priori power analysis indicated that the required sample size for detecting medium effect size (f = 0.25) for this study with three groups and with high statistical power ($1 - \beta$ = .95) was 189 participants. A medium-sized effect was anticipated on the basis of the effects observed in a recent meta-analysis on interventions to promote active travel (Doğru et al., 2021). Specifically, for interventions that include self-monitoring of behaviour (BCT 2.3), the average effect size was d = 0.48 (95% CI [0.36, 0.59]), which equals to f = 0.24 (Lenhard & Lenhard, 2016). Participants were recruited from the volunteers email list of *Redacted for review* staff and students. The study ran from mid-April 2018 until the end of June 2018. It was only possible to collect baseline data from 131 participants as the OFO bikes company withdrew from the city at the beginning of July. Data collection was, therefore, ended at this point, as there were no other bike share schemes present in the city at that time.

The baseline sample comprised 59 females (45%) and 72 males (55%) with a mean age of 29.07 (SD = 10.07). Of these participants, 92 (70%) were White-Caucasian, 27 (21%) were Asian, and 12 (9%) were from other ethnicities (none reported Black ethnicity). Participants were asked if they already had the OFO bike application on their smartphones before the study; 106 (81%) did and the remaining were instructed to download the app for the study. Participation was incentivised with a chance to win one of three £25 vouchers for those completing both baseline and follow-up questionnaires. Ninety-nine (76%) of the participants also completed the one-month follow-up survey (see Figure 1).

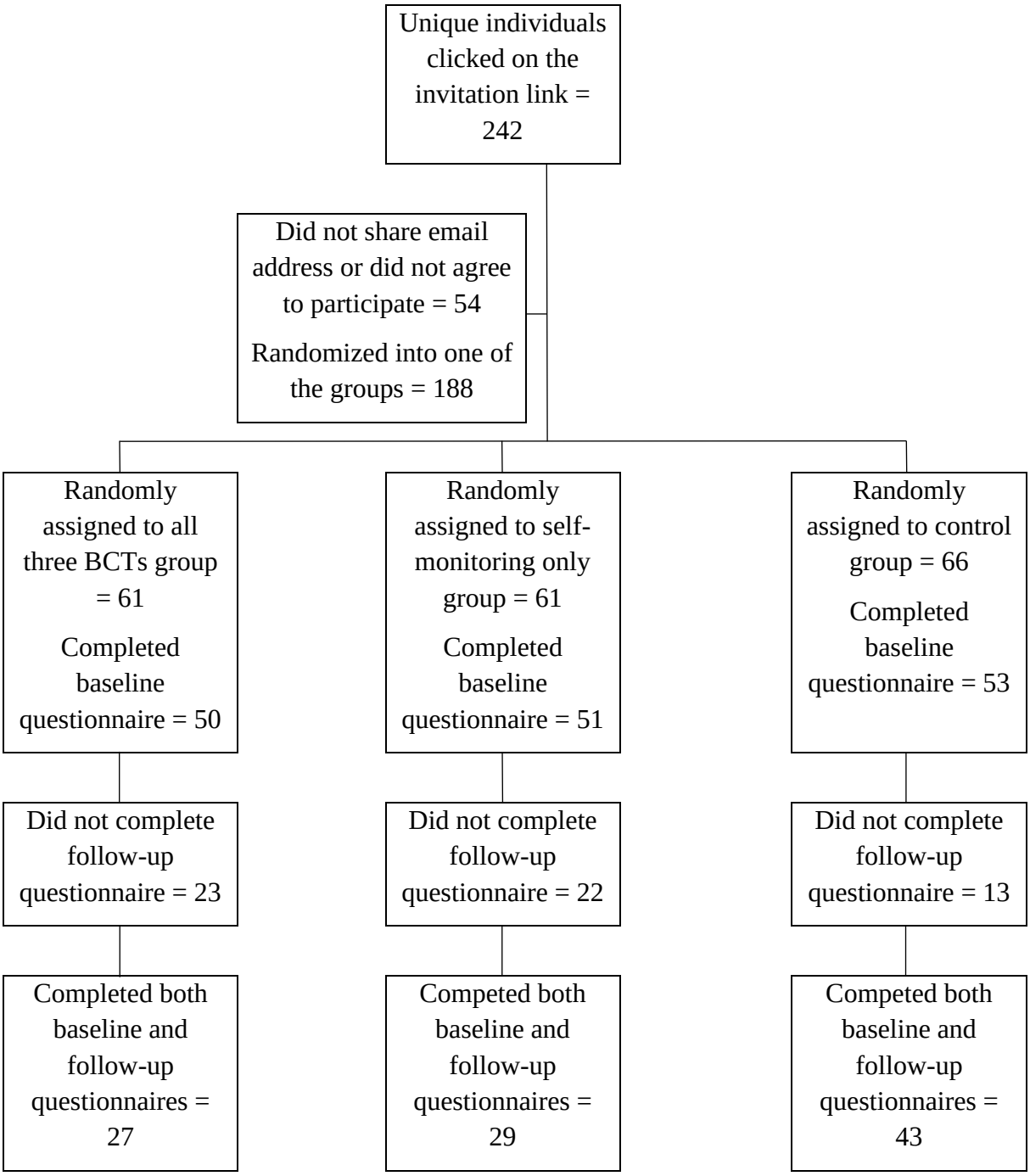

Figure 1. Participant Flow-Through Experiment

2.1.3. Measures.

Demographics (e.g., age, gender, ethnicity, the first part of post codes, etc.), and cycling behaviour were collected in a self-report online questionnaire at the beginning of the study. In order to have an objective measure of cycling, participants were asked to report the number of times they used the OFO bikes in the past month, which is recorded in the app, in both the baseline and follow-up questionnaires. In order to control for overall cycling, participants were also asked if they cycled with any bike other than OFO in the last week, i.e., "*Have you cycled with any other bike than OFO bikes in the past 7 days? Yes/No*" in the follow-up questionnaire

and if they respond "Yes", they were further asked to type how many times they used other bikes.

2.1.4. BCT Messages.

Short messages were designed to target the three central processes specified by control theory (Carver, & Scheier, 1982); namely, behavioural goal-setting (BCT 1.1), action planning (BCT 1.4), and self-monitoring of behaviour (BCT 2.3). To target these processes, 15 text messages were prepared by the authors (three for behavioural goal-setting, three for action planning, and nine for self-monitoring of behaviour; so that both intervention groups could receive nine text messages in total). The text messages were prepared to have 160 or fewer characters each. Thus, the short text messages targeted three specific BCTs from the Behaviour Change Techniques Taxonomy (v1) (Michie et al., 2013): (i) behavioural goal-setting (e.g., "*How many times can you ride OFO bikes over the next week? Set yourself a goal and challenge yourself!*"), (ii) action planning (e.g., "*Make plans about when you could use an OFO bike, such as at particular times or for particular journeys next week.*"), and (iii) self-monitoring of behaviour (e.g., "*Studies show that keeping track of progress can help people to achieve their goals. This is what the OFO app can do for you!")*. (See Supplementary file for the full list of text messages and the schedule for the messages sent).

2.1.5. Procedure.

After receiving ethics approval from the University's Research Ethics Committee (application #018732), invitation emails were sent to university staff and students who were members of a volunteers list. Volunteers who agreed to participate in the study continued to the online baseline questionnaire by following a link in the invitation email. At the beginning of the questionnaire, participants were randomly allocated into one of three conditions, comprising two intervention groups and one control group, in a factorial design using the randomisation function within Qualtrics. Hence, different levels of the intervention were tested separately (i.e., all three BCTs, self-monitoring technique in isolation, and no BCTs condition). However, a full factorial design could not be utilized due to the large sample size requirement of this design. Participants were blinded to the conditions as neither the information sheet nor the consent form mentioned that there were different experimental conditions. The experimenter was not blinded in the study as the data files included details of which experimental condition participants had been allocated to. This information was also used by the experimenter to send out the correct text messages to each participant (by condition).

Participants in the intervention groups were sent nine messages over the next three weeks via an online SMS broadcasting service. The order of the messages was arranged for the first intervention group so that participants would receive text messages for the constructs of the Control Theory respectively (i.e., goal-setting, action planning, and self-monitoring). Participants in the first intervention group received messages designed to promote goal setting in the first week, messages designed to promote goal operating in the second week, and messages designed to promote self-monitoring messages in the third week (three messages per BCT and three messages per week). Participants in the second intervention group only received messages designed to promote self-monitoring for three weeks (nine messages for the same BCT and three messages per week). Frequency of thrice per week was selected because more than once a week and less than once a day is reported to be the optimum frequency for the effectiveness of physical activity interventions that use text messages (Armanasco, Miller, Fjeldsoe, & Marshall, 2017; Hall et al., 2015; Rose et al., 2017). Participants in the control group received no text messages over the intervention period. One month after completing

baseline surveys, all participants received another email asking them to fill out the follow-up survey about their use of OFO bikes in the past month.

2.1.6. Data Analytic Strategy.

Outliers (scores that were more than three standard deviations away from the group mean) were removed from the data set (5 removed in total). Then, a 3 (group: all 3 messages, self-monitoring only, control) x 2 (time: baseline vs. follow-up) mixed measures ANOVA was conducted to test for differences in OFO bike use between the groups to test the hypothesis.

2.2. Results

2.2.1. Effects of Intervention Group Membership and Time on the Use of OFO Bikes.

A 3 (group: all three constructs, self-monitoring only, control) x 2 (time: baseline vs. follow-up) mixed-measures ANOVA showed that the main effects of time, $F(1, 92) = 1.73$, $p = .189$, and group, $F(2, 92) = 0.45$, $p = .636$ were non-significant. Thus, participants' levels of OFO bike use did not differ from baseline to follow-up, and there were no between-group differences in OFO bike use. The interaction between group and time, however, approached significance, $F(2, 92) = 2.74$, $p = .070$ (see Table 1 for means and SDs for three groups).

Table 1. ***Group Means (and Standard Deviations) for OFO Bike Use by the Time***

	All three BCTs group (*n* = 26)	**Self-monitoring only group (*n* = 29)**	**Control group (*n* = 40)**
Baseline	1.20 (2.29)	1.82 (3.00)	2.35 (3.59)
Follow-up	1.96 (2.66)	2.14 (2.91)	1.90 (2.70)

Given that the relatively small sample may have led the primary analyses to be underpowered the hypothesis was tested again by nesting two intervention groups into one. In this analysis, the main effect of time remained non-significant, $F(1, 93) = 0.30$, $p = .588$, as did the main effect of group, $F(1, 93) = 0.69$, $p = .409$ (see Table 2 for means and SDs for two groups). However, the interaction between group and time was significant, $F(1, 93) = 5.32$, $p = .023$. Repeated measures t-test indicated a significant increase for combined intervention group, $t(54) = 2.26$, $p = .028$, and non-significant decrease for the control group, $t(39) = 1.12$, $p = .27$. These results indicated that the change in the use of OFO bikes from baseline to follow-up for participants of intervention groups (combined) was significantly different from the change in the participants of the control group.

Table 2. ***Group Means (and Standard Deviations) with Combined Intervention Groups for OFO Bike Use by the Time***

	Combined intervention group (*N* = 55)	**Control group (*N* = 40)**
Baseline	1.33 (2.19)	2.04 (3.31)
Follow-up	2.05 (2.77)	1.90 (2.70)

2.3. Discussion

Study 1 tested if sending short text messages based on BCTs related to the processes specified by Control Theory can promote cycling. The results were promising; the analysis with three groups indicated that interaction of time and group approached significance (p = .070) and analysis with combined intervention groups yielded a significant interaction between time and group (p = .023), despite the relatively small sample size. This significant interaction of time and group membership indicated that the increase in the number of times the participants used OFO bikes was greater in the intervention groups than in the control group (which showed a slight reduction in use over time). The current findings, therefore, provide the basis for testing whether SMS interventions might be used to promote cycling or active travel in general. The use of bike share schemes represents a promising solution to many problems participants may encounter, such as owning, maintaining, and safekeeping bicycles, as well as recalling the number of trips they had in the last 30 days. However, we were unable to recruit a sufficient number of participants to test the effectiveness of the intervention to increase the usage of the bikes. Given the difficulties experienced recruiting participants to the studies on bike share scheme usage, Study 2 tested the intervention in another (similar) behaviour. This would also allow us to test the intervention developed on a different behaviour, which would improve the generalisability of the findings. Specifically, the intervention was directed to decrease car use, another aspect of active travel.

3. Study 2 – Using BCTs from Control Theory to Decrease Car Use

Private car use is the main mode of transport across the world since the proliferation of car production and roads made for motorized transport (Anable, 2005; DfT, 2018a). In the UK, 76% of all households own at least one car (DfT, 2018b) and 75% of all trips (78% for urban areas only) are made by private cars, while just 8% are made by walking, 7% by bus, and 2% by bicycle (DfT, 2018a). About half of all car trips are shorter than five miles, and about one-third are shorter than two miles in the UK (Jones, 2012). Targeting those trips could be a good way to decrease car use. However, car travel is seen as a more positive mode of travel. For instance, participants report that car travel offers more privacy, protection, autonomy, freedom, and control over other travel modes (Woods & Masthoff, 2017).

Reducing car use is somewhat similar to promoting cycling as, mainly, both of them are about promoting sustainable (or active) travel. Both behaviours are studied by the same fields (e.g. public health, city and regional planning, civil engineering, etc.), targeted to decrease carbon emissions and improve public health (de Nazelle et al., 2011; Graham-Rowe, Skippon, Gardner, & Abraham, 2011), and affected by the infrastructure (Pucher, Dill, & Handy, 2010; Schoner, Cao, & Levinson, 2015), habits (Heinen & Ogilvie, 2016; Mantzari et al., 2015) and weather (Schmiedeskamp & Zhao, 2016). Hence, it can be hypothesised that using the previously prepared text messages to decrease car use would yield similar effects to using these messages to promote cycling.

As a measure of car use, the primary outcome for this second intervention study was the number of parking scratch cards used during the intervention period by students and staff at the *Redacted for review*. To be able to use parking spots, either an annual permit card (£41 per month) or scratch cards (books of 20 scratch cards costing £41 in total) need to be acquired. *Redacted for review* staff and students can buy these cards in books from Estates Facilities Management helpdesk, and Students Union Welcome desk. These cards do not guarantee a parking space and are valid for one day only.

In short, the current intervention aimed to decrease car use (measured by the use of scratch cards) for commuting by delivering BCTs taken from the Control Theory (i.e., goal setting,

action planning, and self-monitoring) via short text messages. It was hypothesized that the participants who receive text messages would use fewer scratch cards than the participants who do not receive text messages.

3.1. Method

3.1.1. Procedure and Data Collection.

Ethical approval was obtained from the university ethics committee (application #027511) and permission to contact university staff and students for the intervention from the university transport manager. Then invitation emails were sent to the university volunteers list. In addition, leaflets were distributed with a short explanation, a written link, and a QR code to the study in parking lots and desks where these cards are sold from June 2019 to February 2020, until the COVID-19 pandemic started. Participants who followed the link to the study (either via the invitation email or via the leaflets) were directed to a Qualtrics survey with the informed consent form on the first page. Those who agreed to participate were then randomly assigned either to the intervention or the control group. The participants who were assigned to the intervention group were sent three SMS messages per week for three weeks (nine messages in total). Each participant received the follow-up survey 30 days after they completed the baseline survey. Those who did not complete the follow-up surveys were sent two reminder emails after a week.

3.1.2. BCT Text Messages.

Text messages sent to decrease car use were adopted from the Study 1 intervention. Only the wordings were changed to target decreasing car use, instead of promoting cycling. Example text messages are as follows: (i) behavioural goal-setting (e.g., "*How many times can you skip using your car to commute to the university over the next week? Set yourself a goal and challenge yourself!*"), (ii) action planning (e.g., "*Make plans about when you could not use your car to commute to the university next week - such as a particular day next week.*"), and (iii) self-monitoring of behaviour (e.g., "*Studies show that keeping track of progress can help people to achieve their goals. You can use your scratch cards to keep track of your car use!")*. (See Supplementary file for the full list of text messages and the schedule for the messages sent).

3.1.3. Participants and Measures.

The effect size from Study 1 was calculated from the means and standard deviations (Cohen's d = 0.23) and the power analysis estimated that 248 participants were required. In total, 134 people clicked on the link to the study information and 83 participants (62%) completed the baseline survey (66 females, mean age = 40.58 (SD = 10.89), 90% white ethnicity), of whom 34 were randomly allocated to the intervention group and 49 to the control group. Sixty-one participants (46%) completed both baseline and follow-up surveys (47 females, mean age = 41.10, SD = 10.64), 91% white ethnicity), of whom 29 were in the intervention group and 32 in the control group. In addition to the demographics, participants were asked how many scratch cards they had at the time of baseline as well as at follow-up data collection, which was sent 30 days exactly after the baseline survey. Then, the number of scratch cards used between two time points was calculated. Measuring the number of days that participants commuted by car via asking participants the number of scratch cards they had at the beginning and at the end of the data collection did not require participants to remember how many journeys they had made by car and allowed us to have an objective measure.

3.1.4. Data Analytic Strategy.

Independent samples t-test was conducted with two groups to test the hypothesis that participants in the intervention group would use fewer scratch cards than the participants in the

control group. Specifically, the number of scratch cards used was calculated for each participant between the baseline and follow-up surveys. As the use of scratch cards before the intervention period was not controlled for in this study, the analysis was run with only the number of scratch cards during the intervention period. Weekends and holidays were assumed to be equally distributed between the participants as they were randomly assigned to intervention and control groups. Outliers were cleared by excluding the scores more than three standard deviations from the mean.

3.2. Results

3.2.1. Effect of the Interventions on Car Use.

It was tested whether participants in the intervention group used fewer scratch cards than participants in the control group over the course of our intervention. An independent samples t-test indicated that the difference in the number of scratch cards used by the intervention (M = 31.03, SD = 12.16) and control (M = 36.64, SD = 12.54) groups approached significance, $t(59) = 1.78$, $p = .080$.

3.3. Discussion

Study 2 indicated that the current intervention to decrease car use was non-significant. There are no prior meta-analysis studies that report average effect size for interventions to reduce car use. Graham-Rowe et al. (2011) suggest in their review that the effects of interventions to reduce car use are inconsistently significant. Similar to the Study 1, Study 2 was also not able to collect data from a sample large enough to reach enough statistical power and the effect size of Study 2 was also small and non-significant. Taken together, the findings of the interventions yielded similar effect sizes both for promoting cycling and for reducing car use, suggesting that the findings might be generalizable across different target behaviours.

4. General Discussion

The interventions designed in the current study were the first interventions to deliver three BCTs specific to Control Theory via short text messages to promote cycling and to decrease car use. Results indicated that the first intervention conducted with OFO bikes was effective in promoting cycling when two intervention groups were combined and compared to the control group ($p = .028$). The second intervention conducted to decrease car use also lacked adequate statistical power but approached significance ($p = .080$).

The interventions reported in this study have a number of strengths. First, a key strength is that they provide an easily replicable intervention method for future studies. While the intervention was not effective in reducing car use, it approached significance and Study 1 was significant, and future studies could easily use other and/or new combinations of BCTs to promote active travel. It would take only a couple of hours for a single interventionist to apply the same or a similar intervention on a million participants that have access to a bike share scheme or use scratch cards in their work or school area. This is important as the relatively small effect of the current interventions could, nonetheless, have a large public health impact on a population level (West, 2007). The interventions designed in the current study used a structured approach by using three specific BCTs and conveyed them via short text messages, which can easily be converted for promoting other health-related behaviours. Second, the focus on bike share schemes as a means to promote cycling is a strength of Study 1. As mentioned before, cycling is distinct from walking as a form of active travel because it requires more preparation, e.g., having a bicycle. The use of bike share schemes resolves this problem, as people can easily and cheaply access dockless shared bikes. These bikes also remove the barrier of having a safe storage space at destination points such as home, work, or school. As found in a recent meta-

analysis, adding objects to the environment (making bicycles available, in this case) is a useful method to promote cycling (Doğru et al., 2021). But, given that the shared bikes were added to the environment for all the groups, this BCT was not different for intervention and control groups. Third, objective measures of behaviour were used in both interventions. In Study 1, smartphone apps kept the record of bicycle use automatically. In Study 2, scratch card use could be tracked by simply counting the missing pieces, instead of recalling the scratch card use over the intervention period. Objective measures of physical activity tend to be more reliable than self-report measures (Doğru et al., 2021; Milton, Clemes, & Bull, 2013).

It should be noted that the current interventions could also be delivered through different mediums such as social media, emails, and smartphone app notifications, in addition to SMS messages. Because we targeted the shortest form of digital mediums (i.e., SMS) to convey the BCTs, the messages were limited to 160 characters. Other digital mediums allow more characters; for example, Twitter allows 280 characters and other mainstream social media websites, smartphone app notifications, or email services do not have character limits. As a result, the current messages could easily be incorporated into other digital interventions using other modes of delivery. The wording of the text messages used is also quite simple and straightforward. So, the current intervention is still easily replicable across countries and digital mediums.

There are also a number of shortcomings of the studies reported in this chapter. First, the follow-up periods for the intervention effect were relatively short, as baseline and follow-up data were only collected one month apart. In addition, the follow-ups occurred only about 10 days after the last text messages were sent. Future studies need to include longer follow-up periods. Second, due to the circumstances beyond our control (i.e., OFO bikes were withdrawn from our city before the end of our data collection, and the COVID-19 pandemic started during the data collection of the second study and commuting trips stopped or decreased significantly), it was not possible to recruit sufficient participants in each study to reach adequate statistical power. Nonetheless, a significant result was found in Study 1, albeit when examining the effect of the combined intervention groups, and a marginally significant effect was found in Study 2. Future replication would benefit from recruiting larger samples. Third, due to the hardships in participant recruitment, it was not possible to test the effect of receiving text messages independent of BCTs, which would require an extra experimental group and more participants. Yet, it would be beneficial to test the unique effect of receiving messages to detect true effectiveness of applying BCTs via short text messages. Lastly, the experimenter was not blind to the condition, which could introduce biases. Experimenter effects are typically minimized by hiding participant identities and condition membership from researchers (Holman, Head, Lanfear, & Jennions, 2015; Schulz, Altman, & Moher, 2010). The current research sought to minimize any experimenter effects through participants providing data on cycling behaviour through Qualtrics and participants reporting objective information from their smartphone apps. In addition, the data were handled according to certain rules explained above (e.g., outliers were selected as cases with three or more standard deviations above or below the mean, and removed regardless of their group membership).

The current research developed a digital intervention that can be easily and cheaply applied on larger groups, yielding significant and marginally significant results albeit on relatively low sample sizes. Three BCTs suggested by Control Theory (Carver, & Scheier, 1982; 2002) – i.e., behavioural goal-setting, action planning, and self-monitoring of behaviour – were conveyed to participants in the intervention group by SMS messages. However, the findings of the two studies might not be enough to support the idea that conveying these three BCTs via short text messages was effective in promoting active travel in the short term. Given the small sample sizes, this conclusion should be treated with some caution. Given the above limitations, it is

clear that the effectiveness of the current interventions should be tested with longer intervention and follow-up periods, as well as with larger sample sizes. However, the studies presented in this study still represent a promising contribution to the growing literature of digital behaviour change interventions (Thomas Craig et al., 2020; Hedin, Katzeff, Eriksson, & Pargman, 2019).

Ethics Committee Approval Statement

Ethics committee approval of the study 1 and study 2 were obtained from University Research Ethics Committee (UREC) of Sheffield University (Date 17/04/2018 and Application Number: 018732).

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Appendix 1

List of text messages that were sent in Study 1 to the participants in the intervention groups

Prompt Goal-Setting (1.1)

1) Setting realistic but challenging goals can help you to progress. So, set yourself the goal to use an OFO bike tomorrow!
2) Set yourself the goal to use OFO bikes in the next two days.
3) How many times can you use OFO bikes over the next week? Set yourself a goal and challenge yourself!

Prompt Goal-Operating (1.4)

1) Make a plan detailing when and where you will use OFO bikes – e.g., next Wednesday to get to work.
2) Make plans about when you could use OFO bikes, such as at particular times or for particular journeys next week.
3) Make a plan to use OFO bikes this weekend.

Prompt Self-Monitoring (2.3)

1) Studies show that keeping track of progress can help people to achieve their goals. This is what the OFO app can do for you!
2) Monitoring your behaviour can help you to achieve your goals. Check your OFO app to see how often or how far you cycle.
3) Look at the "My Trips" section of the OFO app to see how often you have used OFO bikes.
4) Compare the number of times that you used OFO bikes this week with the number of times that you used them last week. How are you doing?
5) Did you check your trip records today on the OFO app?
6) Use the OFO app to look at the distance that you have cycled this week.
7) Your OFO app can help you to keep track of progress and therefore help you to achieve your goals.
8) Check your OFO app to see how often or how far you cycle. This information can help you to achieve your goals.
9) See how often you have used OFO bikes by looking at the "My Trips" section of the OFO app.

The schedule of the text messages sent

Times of messages	All three constructs	Self-monitoring only
1st week		
Tuesday, 9 am	Set yourself the goal to use OFO bikes in the next two days.	Studies show that keeping track of progress can help people to achieve their goals. This is what the OFO app can do for you!
Thursday, 6 pm	Setting realistic but challenging goals can help you to progress. So, set yourself the goal to use an OFO bike tomorrow!	Look at the "My Trips" section of the OFO app to see how often you have used OFO bikes
Sunday, 5 pm	How many times can you use OFO bikes over the next week? Set yourself a goal and challenge yourself!	Monitoring your behaviour can help you to achieve your goals. Check your OFO app to see how often or how far you cycle.
2nd week		
Tuesday, 6 pm	Make a plan detailing when and where you will use OFO bikes – e.g., next Wednesday to get to work	Did you check your trip records today on the OFO app?
Friday, 4 pm	Make a plan to use OFO bikes this weekend.	Use the OFO app to look at the distance that you have cycled this week.
Sunday, 6 pm	Make plans about when you could use OFO bikes, such as at particular times or for particular journeys next week.	Compare the number of times that you used OFO bikes this week with the number of times that you used them last week. How are you doing?
3rd week		
Tuesday, 9 am	Studies show that keeping track of progress can help people to achieve their goals. This is what the OFO app can do for you!	Your OFO app can help you to keep track of progress and therefore help you to achieve your goals.
Wednesday, 11 am	Look at the "My Trips" section of the OFO app to see how often you have used OFO bikes	See how often you have used OFO bikes by looking at the "My Trips" section of the OFO app.
Saturday, 3 pm	Monitoring your behaviour can help you to achieve your goals. Check your OFO app to see how often or how far you cycle.	Check your OFO app to see how often or how far you cycle. This information can help you to achieve your goals.

Appendix 2

List of text messages sent in Study 2 to deliver BCTs to decrease car use

Prompt Goal Setting

1) Set yourself the goal to cycle, walk, or use public transport instead of using your car to get to University one day next week!
2) Setting realistic but challenging goals can help you to progress. So, set yourself the goal to reduce the number of times you commute by car this week!
3) How many times can you skip using your car to commute to the university over the next week? Set yourself a goal and challenge yourself!

Action Planning

4) Make plans about when you could not use your car to commute to the university next week - such as a particular day next week.
5) Plan when and how you will commute to the university next week without using your car – e.g. next Wednesday by catching the bus.
6) Make a plan detailing how to commute without your car next week, such as getting up earlier to walk or looking up for times for public transport.

Prompt Self-Monitoring

7) Keep your old scratch cards to see how many times you have commuted to the university by car.
8) Studies show that keeping track of progress can help people to achieve their goals. You can use your scratch cards to keep track of your car use!
9) Monitoring your behaviour can help you to achieve your goals. Check your scratch card book to see how many times you commuted by car this week.

Schedule of the Text Messages

Times of messages	**Three different BCTs in each week**
1st week	
Monday, 9 am	Setting realistic but challenging goals can help you to progress. So, set yourself the goal to reduce the number of times you commute by car this week.
Thursday, 6 pm	Plan when and how you commute to the university next week without using your car – e.g. next Wednesday by catching the bus.
Sunday, 5 pm	Studies show that keeping track of progress can help people to achieve their goals. You can use your scratch cards to keep track of your car use!
2nd week	
Tuesday, 6 pm	Set yourself the goal to cycle, walk, or use public transport instead of using your car to get to University one day next week!
Friday, 4 pm	Make plans about when you could skip using your car to commute to the university next week - such as at a particular time or day next week.

Schedule of the Text Messages – *continued.*

Times of messages	**Three different BCTs in each week**
Sunday, 6 pm	Monitoring your behaviour can help you to achieve your goals. Check your scratch card book to see how many times you commuted by car this week.
3rd week	
Tuesday, 9 am	How many times can you skip using your car to commute to the university over the next week? Set yourself a goal and challenge yourself!
Wednesday, 11 am	Make a plan detailing how to commute without your car next week, such as getting up earlier to walk or looking up for times for public transport.
Saturday, 3 pm	Keep your old scratch cards to see how many times you have commuted to the university by car.