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SmokefreeTXT Behaviour Change Technique Analysis

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Mobile text-messaging smoking cessation interventions have demonstrated their efficacy in increasing cessation rates. These interventions tend to be multifaceted and there is a need to specify their building blocks. The purpose of this study was to use the Behavioural Change Techniques Taxonomy V1 (BCTTv1) to systematically analyse the behaviour change techniques present in the SmokefreeTXT (SFTXT) adult programme. The entire SFTXT library was coded using the BCTTv1. Frequencies were calculated to assess the presence of BCT groups and unique BCTs in the entire programme. The mix of BCTs was also examined by programme week and during periods of high user dropout. Of the 16 groups of behavioural techniques, 14 were present in SFTXT. Of the 93 distinct BCTs, 41 were present in the full SFTXT message library. The most prevalent BCT groups were Feedback and Monitoring, Natural Consequences, Social Support, and Shaping Knowledge. There were differences in the mix of BCTs across the duration of the intervention. The results will enable us to test how changes in the use of specific BCTs and their frequency of use over time, impact (1) engagement with the programme (particularly during the days with high dropout rates), and (2) smoking cessation outcomes over time.

Introduction

Smoking remains the leading cause of preventable death in the United States, killing almost half a million adults every year (Centers for Disease Control and Prevention [CDC], 2014). Of the 40 million adult smokers in the United States, roughly 70% want to quit. However, less than 10% succeed (CDC, 2011; CDC, 2016). Amongst the newest approaches to improving quit rates are smoking cessation programmes that use mobile phone text messaging. Randomised controlled trials have demonstrated the efficacy of these interventions in increasing and, in some cases, even doubling cessation rates (Abroms, Boal, Simmens, Mendel, & Windsor, 2014; Bock et al., 2013; Free et al., 2009; Free et al., 2011; Rodgers et al., 2005; Squiers et al., 2016; Whittaker et al., 2012).

In 2013, more than 90% of American adults owned a cell phone (Rainie, 2013). Using text messaging to deliver an evidence-informed cessation intervention is a cost-effective way to reach a large number of smokers in a convenient and timely manner (Guerriero et al., 2013). Although smoking cessation text messaging programmes have been found to be effective, they are multifaceted, and the exact mechanisms by which they lead to behaviour change are not fully understood. A behaviour change technique (BCT) is 'a replicable component of an intervention designed to alter or redirect causal processes that regulate behaviour' (Michie et al., 2014, p. 9). Characterising and mapping the BCTs within mobile health (mHealth) cessation interventions is the first step towards being able to explore the role of specific components in facilitating behaviour change. It also enables a systematic adjustment of the intervention's elements, which can be evaluated to assess the extent to which these modifications increase efficacy over the baseline intervention.

Various behaviour change taxonomies have been used to identify components of behavioural interventions and health education programmes that are implemented in a face-to-face format or by using technology (Bishop, Fenge-Davies, Kirby, & Geraghty, 2015; Dale, Raftery, & Locke, 2014; Direito et al., 2014; Hynynen et al., 2014; Michie, Free, & West, 2012; Presseau et al., 2014; West, Walia, Hyder, Shahab, & Michie, 2010; Yang, Maher, & Conroy, 2015). Notably, Txt2Stop, a text messaging smoking cessation programme, was mapped to BCTs using an adapted version of a taxonomy designed for face-to-face smoking cessation interventions (Michie, Hyder, Walia,

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& West, 2011). The smoking-cessation-specific taxonomy included 43 BCTs organised into categories. Michie and colleagues found that seven BCTs represented 90% of the BCTs present in the Text2Stop intervention, i.e., provide information on the consequences of smoking and smoking cessation; boost motivation and self-efficacy; create or reinforce negative associations; promote use of relaxation techniques; promote behavioural substitution; provide behavioural substitution; and promote engagement with the programme (Michie et al., 2012). The authors concluded that text messaging programmes may also benefit from the inclusion of BCTs that were less frequently used in Text2Stop, such as strengthening ex-smoker identity, providing reassurance, and advising on the use of social support (Michie et al., 2012).

Whilst a variety of behaviour change taxonomies are available, behavioural interventions across domains must use a common taxonomy in order to support a common language of BCTs and compare programmes to each other. To facilitate the use of one taxonomy across behavioural domains, Michie and colleagues created a taxonomy that standardises the terms and definitions used to describe BCTs so that they can be applied consistently across behavioural interventions, namely the Behaviour Change Technique Taxonomy version 1 (BCTTv1).

The primary aim of this analysis was to apply the BCTTv1 to the SmokefreeTXT (SFTXT) adult text messaging programme in order to characterise the type and mix of BCTs in the programme over time, as well as highlight potential 'active ingredients'.

Methods

SFTXT is the U.S. National Cancer Institute's (NCI) 6–8 week text messaging smoking cessation programme. It was developed by a team of digital strategists, mobile technology specialists, and clinical psychologists specialising in smoking cessation. The programme provides emotional and educational support to smokers who are trying to quit. Users of SFTXT sign up for the programme either online or via SMS short code and choose a target quit date that is within 2 weeks of their signup date. They receive messages for up to 2 weeks prior to their quit date and 6 weeks following their quit date, for a total of as many as 166 messages. Messages provide general motivational support, tips on preparing to quit, advice on managing cravings, suggestions for smokefree activities, relevant smoking facts, and recognition of cessation milestones. Scheduled throughout the programme are interactive messages that prompt users to assess their mood, smoking status, and craving level. Depending on the user's response, a reply message is sent to them. Users can also send specific keywords (e.g., *crave, mood, slip*) to receive immediate support messages. Smoking status is assessed via text message on the quit date and weekly thereafter for the 6 weeks of the programme. Follow-up cessation assessments are sent 1, 3, and 6 months after the programme has ended.

BCTTv1 is an internationally validated tool for mapping BCTs within interventions across behavioural domains. The tool was developed using an iterative process that included input from 54 experts in behavioural change interventions. The process included multiple rounds of feedback and reliability testing. The final version consists of 93 distinct BCTs hierarchically clustered into 16 groups (Michie et al., 2013). The BCT clusters represent groups of BCTs that share a common function in how they facilitate behaviour change (e.g., shaping knowledge, feedback & monitoring). The hierarchy was deemed to be important to help organise the tool conceptually and simplify its use.

The SFTXT programme was coded using the BCTTv1 by three members of the Smokefree.gov team. Coders 1 and 2 (Author 1 and Author 3) a health communication specialist and a digital strategist, have been directly involved in the development and evaluation of Smokefree's cessation programmes. The third coder, Author 6, was the research manager for Smokefree.gov. In addition to their respective expertise, all three coders reviewed the materials at the online BCTTv1 training website before the coding process began (http://www.bct-taxonomy.com includes the full list of BCTs and definitions). The coding guidelines were based on the definitions and examples in BCTTv1 (Michie et al., 2013).

After a review of several SFTXT messages and documentation of lessons learned from a similar project (Michie et al., 2012), the coders applied a maximum of three BCTs per message. After this decision was made, Author 1 and Author 3 independently coded 25 randomly selected messages to assess the level of inter-rater reliability. Initial agreement was at 45%. Next, Author 1, Author 3, and Author 6 discussed disagreements and concluded that the majority of discrepancies came from ambiguities arising from the brevity of the messages, an inability to assess users' perceptions of the content of the messages, and difficulty in distinguishing subtle differences amongst BCTs with similar functions. These findings are similar to the conclusions of a previous analysis using an older version of the taxonomy (specific to smoking cessation) to analyse the text messaging programme Txt2Stop (Michie et al., 2012).

Given that the BCTTv1 was developed primarily to code face-to-face intervention manuals and reports, which contain more details about the nature of the interaction and the context in which it was delivered, we found it necessary to revise some definitions to reflect BCTs in text-based interactions more accurately. A full list of the modified BCTs, along with their original definitions, can be found in Table 1.

After discrepancies were resolved, Author 1 and Author 3 independently coded both the general library as well as the keyword and status response library. The general library includes all possible messages ($N = 128$) that may be sent to users depending on their choice of quit day. The messages are grouped into the following types: (1) *14-day*

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Table 1

Additional definitions and clarifications used in the coding process of the analysis (notes and multiple examples from the original definitions were omitted)

BCT		Original definitions	Additional definitions specific to SFTXT
1.1	Goal setting (behaviour)	Set or agree on a goal defined in terms of the behaviour to be achieved. **Example:** Agree on a daily walking goal (e.g., 3 miles) with the person and reach agreement about the goal.	We reiterate the quit date, user-selected during sign-up, multiple times in the messages designed for the 2 weeks preparation before quit date. This is not additional goal setting, but a reminder of an already set goal. **Example:** 10 days until your quit day. Value your future. Quitting at any age adds years to your life. You are not going to regret this. Text STOP to end.
1.2	Problem solving	Analyse, or prompt the person to analyse, factors influencing the behaviour and generate or select strategies that include overcoming barriers and/or increasing facilitators (includes "Relapse Prevention" and "Coping Planning"). **Example:** Identify specific triggers (e.g., being in a pub, feeling anxious) that generate the urge/want/need to drink and develop strategies for avoiding environmental triggers or for managing negative emotions, such as anxiety, that motivate drinking.	Given that we cannot identify specific triggers for each SFTXT user, we coded problem solving for any message that implied potential common barriers to quitting, and gave examples on how to overcome them. **Example:** Don't let boredom get you down. Finish a project you have been putting off, like a photo album or home improvement project.
2.3	Self-monitoring of behaviour	Establish a method for the person to monitor and record their behaviour(s) as part of a behaviour change strategy. **Example:** Ask the person to record daily, in a diary, whether they have brushed their teeth for at least 2 minutes before going to bed.	The method of self-monitoring we provide our users with is weekly check-ins on their smoking status. We defined *behaviour* as smoking. 2.2 was also coded when the message included potential feedback on the behaviour. **Example:** "Hi there. Are you still smokefree? Reply: YES or NO" **If user responds Yes, THEN**: "Awesome! Keep staying strong & smokefree. We know it's not easy but it's totally worth it."
2.4	Self-monitoring of outcome(s) of behaviour	Establish a method for the person to monitor and record the outcome(s) of their behaviour as part of a behaviour change strategy. **Example:** Ask the person to weigh themselves at the end of each day, over a 2-week period, and record their daily weight on a graph to increase exercise behaviours.	We defined outcomes of behaviour as the outcomes from not smoking, such as mood changes, cravings, and slipping. For the mood assessments, we also coded 5.4. **Example:** "You are well on your way to being smokefree for good & nearing the end of the SmokefreeTXT program. How is your mood today? Text: GOOD, OK, or BAD"
2.7	Feedback on outcome(s) of behaviour	Monitor and provide feedback on the outcome of performance of the behaviour. **Example:** Inform the person how much weight they have lost following the implementation of a new exercise regime.	We only coded for explicit feedback on reaching a milestone as outcome of not smokng. Ambiguous statements like "well done" and "wow" were not coded as feedback on being smokefree. **Example:** "Congratulations - 1 month smokefree! That is a major milestone. Tell us about it on Twitter @SmokefreeGov or https://www.facebook.com/SmokefreeTXT"
3.1	Social support (unspecified)	Advise on, arrange, or provide social support (e.g., from friends, relatives, colleagues, buddies or staff) or non-contingent praise or reward for performance of the behaviour. It includes encouragement and counseling, but only when it is directed at the behaviour. **Example:** Give information about a self-help group that offers support for the behaviour.	In addition to the original definition, we coded messages that were intended for rapport building and checking in with the user as social support. **Example:** "You may be tempted to have just 1 puff. Don't. It'll only feed your craving & make it stronger. What's your craving level? Reply: HI, MED, or LOW"

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Table 1
Continued.

BCT		Original definitions	Additional definitions specific to SFTXT
4.2	Information about antecedents	Provide information about antecedents (e.g., social and environmental situations and events, emotions, cognitions) that reliably predict performance of the behaviour. **Example:** Advise keeping a record of snacking and of situations or events occurring prior to snacking.	In addition to the original definition, we also coded messages that included information about, or set up expectations for, cravings and withdrawal. **Example:** "Feelings can be a smoking trigger. If you feel cranky or grouchy, it is only temporary, so stay strong. How is your mood? Reply: GOOD, OK, or BAD."
5.1	Information about health consequences	Provide information (e.g., written, verbal, visual) about health consequences of performing the behaviour. **Example:** Explain that not finishing a course of antibiotics can increase susceptibility to future infection.	5.1 was only coded when the health consequence information was related to the negative effects of smoking. When positive health consequences of replacement behaviours (such as eating healthy) were provided, those messages were either coded as problem solving (1.2), or help with behavioural substitution (8.2). **Example:** "Smoking makes your breath, clothes, & hands stink. It can also cause you to age more quickly. Learn the benefits of quitting: http://lil.ms/gur"
5.4	Monitoring of emotional consequences	Prompt assessment of feelings after attempts at performing the behaviour. **Example:** Agree that the person will record how they feel after taking their daily walk.	Discussed in 2.4
8.2	Behaviour substitution	Prompt substitution of the unwanted behaviour with a wanted or neutral behaviour. **Example:** Suggest that the person goes for a walk rather than watches television.	In addition to the original definition, we also considered support messages with keyword prompts (*crave, mood, slip*) to fall under this BCT, as these messages serve as a substitute/distraction when a person is experiencing difficulty staying smokefree. **Example:** "You can get extra help any time you need it. Text one of these keywords at any time & you will receive a special message: CRAVE, MOOD, or SLIP)."
10.2	Material reward (behaviour)	Arrange for delivery of money vouchers or other valued objects if and only if there has been effort and/or progress in performing behaviour. **Example:** Arrange for the person to receive money that would have been spent on cigarettes if and only if the smoker has not smoked for one month.	Given that we could not arrange a delivery of any monetary/valued rewards, we coded every message that suggested rewarding oneself with gifts. It was assumed that if a user is in the program, he or she is putting effort into quitting. **Example:** "Wow, 3 weeks smokefree. Treat yourself to something new as a reward, like new shoes. Just don't light up to celebrate; that is a slippery slope."

pre-quit countdown, or messages sent for the 2 weeks leading up to one's quit date to provide support in preparing to quit; (2) *core intervention*, or all the messages sent during the 6-week post-quit intervention period (including quit day) except for status assessments; and (3) *status assessments*, or messages asking users to provide a response about their smoking status, craving level, or mood. The status and keyword response library ($N = 38$) includes messages the programme sends in response to the user's answer to an assessment question or if the user initiates an interaction through a keyword. This library was coded and reported on separately.

The percent agreement for the general library was 65%. The status and keyword response library contained more homogenous BCTs meant to provide support when the users respond to assessment status messages or voluntarily seek support by texting one of the keywords. There was 87% agreement for the status and keyword response library. All remaining discrepancies were resolved by Author 6.

Frequencies were calculated to assess the presence of BCT groups and distinct BCTs in the programme as a whole, as well as within particular content groups of the two libraries designed to perform different functions (Table 2). We also assessed the frequencies of BCTs by important temporal markers within the programme. Specifically, we assessed the distribution of distinct BCTs across each week after quit day and explored variations over time.

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Table 2
Library and message types definitions

Message Library	Definition
General Library	All possible messages, excluding status and keyword response messages
Message Types	**Definition**
14 Day Pre-Quit Countdown	All possible messages sent to the user prior to quit date.
Core Intervention	All possible messages sent to user after, and including, quit date. These messages exclude Status Assessment Messages.
Status Assessment Messages	All possible messages meant to assess the user's craving, mood, and smoking status.
	Examples
	14 Days Countdown: "3 days left until quit day! Eat healthy and exercise. It will reduce stress, boost confidence, & help you feel better overall."
	Core Intervention: "If friends and family smoke, ask them not to smoke or leave their cigs near you. Change the scenery. Go for a bike ride to ride out the craving."
	Status Assessment: "Try this trick to deal w/ cravings. Breathe in. Hold for 5 seconds. Breathe out. Repeat. What's your craving level? Reply: HI, MED, or LOW."
Message Library	**Definition**
Status and Keyword Response Library	All available messages sent to users based on their response to assessment messages, as well as all messages in response to specific keywords sent by the user (*crave, slip, mood*).
Message Types	**Definition**
Status Assessment Response Messages	All messages sent after a user responds to one of the smoking, craving, or mood status assessment messages.
	Examples
	Mood Status Response (if Mood = Good): "Glad to hear you are feeling good! Keep up that positive attitude and keep staying strong."
	Crave Status Response (if Status = High): "Wait it out. Even the strongest cravings will go away after a few minutes. Focus on something else and remind yourself why you are smokefree."
	Smoking Status Response (if Status = Yes): "Awesome! Keep staying strong & smokefree. We know it's not easy but it's totally worth it."
Keyword Response Messages	All messages sent in response to a user's use of one of the keywords *crave, slip* or *mood.*
	Examples
	Crave Keyword Response: "Cravings got u down? Call 1-877-44U-QUIT & talk to a quit coach. Its free & anonymous! Or chat online using LiveHelp: https://livehelp.cancer.gov
	Slip Keyword Response: "Slips happen. Don't beat yourself up over it. Like anything tough, you learn as you go. Use right now as a time to restart & get back on track."
	Mood Keyword Response: "Feeling cranky is normal, & some days will be hard. You got this! We know you have lots going on but take a time out & blow off tension w/o cigs."

We also profiled messages sent on the day before the quit date, during the quit date, and during the two days following the quit date. This allowed for a detailed assessment of distinct BCTs being delivered during the time when programme dropout rates are the highest (Cole-Lewis, et al., 2016).

Results

Of the 16 hierarchically clustered groups of BCTs, 14 were present in SFTXT (general content library and status and keyword response library). Of the 93 distinct BCTs, 41 were present across the SFTXT messages (Tables 3 and 4).

General Library

In the general library (Table 3), there was a varied mix of BCT groups, with instances of *Feedback and Monitoring* ($N = 43$), *Natural Consequences* ($N = 36$), *Social Support* ($N = 31$), and *Shaping Knowledge* ($N = 28$) being the most common clusters. The most common distinct BCTs

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Table 3

BCTs and BCT groups within the general library for smokefree.gov adult, where N refers to number of messages

Distinct BCTs	14-Day pre-quit countdown $N = 29$	Core intervention messages $N = 75$	Smoking status assessment questions $N = 10$	Craving status assessment questions $N = 8$	Mood status assessment questions $N = 6$	Total instances
1.1 Goal setting (behaviour)	6	1				**7**
1.2 Problem solving	5	5	1			**11**
1.3 Goal setting (outcome)	1					**1**
1.4 Action planning	2	1				**3**
1.9 Commitment		2				**2**
Total 1. *Goals and planning*	**14**	**9**	**1**	**0**	**0**	**24**
2.2 Feedback on behaviour		10	1	1	1	**13**
2.3 Self-monitoring of behaviour		1	10			**11**
2.4 Self-monitoring of outcomes(s) of behaviour				8	6	**14**
2.7 Feedback on outcome(s) of behaviour		1	4			**5**
Total 2. *Feedback and monitoring*	**0**	**12**	**15**	**9**	**7**	**43**
3.1 Social support (unspecified)	5	22		1	1	**29**
3.3 Social support (emotional)	1	1				**2**
Total 3. *Social support*	**6**	**23**	**0**	**1**	**1**	**31**
4.1 Instruction on how to perform the behaviour	1	4		1		**6**
4.2 Information about antecedents	6	12		3	1	**22**
Total 4. *Shaping knowledge*	**7**	**16**	**0**	**4**	**1**	**28**
5.1 Information about health consequences	8	14				**22**
5.2 Salience of consequences	1	1				**2**
5.3 Information about social and environmental consequences		3				**3**
5.4 Monitoring of emotional consequences					6	**6**
5.6 Information about emotional consequences	1	2				**3**
Total 5. *Natural consequences*	**10**	**20**	**0**	**0**	**6**	**36**
Total 6. 6.2 Social comparison	**0**	**1**	**0**	**0**	**0**	**1**
Total 7. 7.1 Prompts/cues	**1**	**0**	**0**	**0**	**0**	**1**
8.1 Behavioural practice/rehearsal	2					**2**
8.2 Behaviour substitution	3	9		2		**14**
8.4 Habit reversal		1				**1**
Total 8. *Repetition and substitution*	**5**	**10**	**0**	**2**	**0**	**17**
10.2 Material reward (behaviour)		2				**2**
10.4 Social reward		7	1			**8**
10.7 Self-incentive		1				**1**
10.9 Self-reward		6				**6**
Total 10. *Reward and threat*	**0**	**16**	**1**	**0**	**0**	**17**

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Table 3
Continued.

Distinct BCTs	14-Day pre-quit countdown $N = 29$	Core intervention messages $N = 75$	Smoking status assessment questions $N = 10$	Craving status assessment questions $N = 8$	Mood status assessment questions $N = 6$	Total instances
11.1 Pharmacological support	1	1				**2**
11.2 Reduce negative emotions	2	10				**12**
Total 11. *Regulation*	**3**	**11**	**0**	**0**	**0**	**14**
12.1 Restructuring the physical environment	2	2				**4**
12.2 Restructuring the social environment		3				**3**
12.3 Avoidance/reducing exposure to cues for the behaviour	2	4				**6**
12.4 Distraction		3		2		**5**
Total 12. *Antecedents*	**4**	**12**	**0**	**2**	**0**	**18**
13.1 Identification of self as role model	1	1				**2**
13.2 Framing/reframing		2				**2**
13.5 Identity associated with changed behaviour		3			1	**4**
Total 13. *Identity*	**1**	**6**	**0**	**0**	**1**	**8**
15.1 Verbal persuasion about capability	1	9				**10**
15.2 Mental rehearsal of successful performance	1	1				**2**
15.3 Focus on past success		4				**4**
15.4 Self-talk		1				**1**
Total 15. *Self-belief*	**2**	**15**	**0**	**0**	**0**	**17**
Total	**53**	**151**	**17**	**18**	**16**	**255**

present were social support (unspecified) ($N = 29$), information about antecedents ($N = 22$), information about health consequences ($N = 22$), behavioural substitution ($N = 14$), self-monitoring of outcome(s) of behavior ($N = 14$), and feedback on behaviour ($N = 13$).

The 14-day pre-quit countdown messages and core intervention messages had a greater mix of BCT groups than the status assessment messages (Table 3). *Goals and Planning* ($N = 14$) and *Natural Consequences* ($N = 10$) were the most frequently represented distinct BCTs in the 14-day pre-quit countdown messages. The mix of BCT groups for core intervention messages was more evenly distributed, with *Social Support* ($N = 23$), *Natural Consequences* ($N = 20$), and *Shaping Knowledge* ($N = 16$), and *Reward and Threat* ($N = 16$) being the most common ones. The BCT groups within the assessment messages were more homogeneous, with *Feedback and Monitoring* ($N = 31$) being the most prevalent group. However, smoking assessment messages included additional *Goals and Planning* ($N = 1$) technique, craving assessment messages included *Shaping Knowledge* ($N = 4$) BCTs, and mood assessments often included *Natural Consequences* ($N = 6$) BCTs as well.

Status and Keyword Response Library

Amongst the status and keyword response messages, there were 12 BCT groups and 17 distinct BCTs (Table 4). *Social Support* ($N = 11$) was the most common BCT group, followed by *Shaping Knowledge* ($N = 10$) and *Self-Belief* ($N = 9$). Amongst the *crave* keyword response messages, *Shaping Knowledge* ($N = 6$) (information about antecedents in particular) was the most common BCT group. Amongst the *slip* keyword response messages, there was not a most common group, as the results were split evenly between *Goals and Planning* ($N = 4$), *Social Support* ($N = 4$), and *Self-Belief* ($N = 4$). In the *mood* keyword response messages, *Regulation* ($N = 4$) was the most common BCT group, represented by only one distinct BCT (reduce negative emotions).

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Table 4
Distinct BCTs and BCT groups within the status and keyword response library

Distinct BCTs	Status response text ($N = 8$)	Crave keyword response ($N = 10$)	Slip keyword response ($N = 10$)	Mood keyword response ($N = 10$)	Total instances
1.1 Goal setting (behaviour)	1				**1**
1.2 Problem solving		2	4		**6**
Total 1. *Goals and planning*	**1**	**2**	**4**	**0**	**7**
Total 2. 2.2	**3**				**3**
Feedback on behaviour					
3.1 Social support (unspecified)	1	2	4	1	**8**
3.3 Social support (emotional)	1			2	**3**
Total 3. *Social support*	**2**	**2**	**4**	**3**	**11**
4.1 Instruction on how to perform thebehaviour			1	2	**3**
4.2 Information about antecedents		6		1	**7**
Total 4. *Shaping knowledge*	**0**	**6**	**1**	**3**	**10**
Total 5. 5.1	**0**	**0**	**0**	**2**	**2**
Information about health consequences					
Total 8. 8.2	**0**	**2**	**0**	**1**	**3**
Behavioural substitution					
Total 9. 9.3	**0**	**0**	**0**	**1**	**1**
Comparative imagining of future outcomes					
Total 10. 10.4	3	0	0	0	**3**
Social reward					
Total 11. 11.2	**0**	**0**	**0**	**4**	**4**
Reduce negative emotions					
Total 12. 12.4	**1**	**1**	**0**	**2**	**4**
Distraction					
Total 13. 13. 5	**1**	**0**	**0**	**0**	**1**
Identity associated with changed behaviour					
15.1 Verbal persuasion about capability	1	1	3	2	**7**
15.2 Mental rehearsal of successful performance	1				**1**
15.3 Focus on past success			1		**1**
Total 15. *Self-belief*	**2**	**1**	**4**	**2**	**9**
Total	**13**	**14**	**13**	**18**	**58**

Note: The core Intervention category includes quit day.

BCT Groups and Distinct BCTs Within the Programme as They Relate to Key Temporal Markers

Mapping the presence of BCT groups within each of the 6 weeks of the core intervention (post-quit date) helped elucidate the distribution of BCTs throughout the programme over time (Table 5). *Feedback and Monitoring* ($N = 35$), *Natural Consequences* ($n = 26$) and *Social Support* ($N = 24$) were the most predominant BCT groups across the 6 weeks of the post-quit date intervention. There were temporal differences in the presence of all BCT groups. Specifically, in the first half of the intervention (weeks 1–3), *Feedback and Monitoring* ($N = 22$), *Social Support* ($N = 16$), *Shaping Knowledge* ($N = 14$), *Reward and Threat* ($N = 12$), *Repetition and Substitution* ($N = 11$), *Antecedents* ($N = 11$), and *Regulation* ($N = 9$) were more common. In the second half (weeks 4–6), *Self-Belief* ($N = 10$) and *Identity* ($N = 5$) BCTs were more noticeable.

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Table 5

Distinct BCTs and BCT groups within each week of SFTXT, excluding quit day, including assessment questions

Distinct BCTs	Week 1 ($N = 24$)	Week 2 ($N = 21$)	Week 3 ($N = 15$)	Week 4 ($N = 12$)	Week 5 ($N = 10$)	Week 6 ($N = 10$)	Total instances
1.2 Problem solving	2		1		1	1	**5**
1.4 Action planning					1		**1**
1.9 Commitment	1						**1**
Total 1. *Goals and planning*	**3**	**0**	**1**	**0**	**2**	**1**	**7**
2.2 Feedback on behaviour	6	3	2	1			**12**
2.3 Self-monitoring of behaviour	1	1	1	1	1	2	**7**
2.4 Self-monitoring of outcome(s) of behaviour	4	2	2	2	2	2	**14**
2.7 Feedback on outcome(s) of behaviour				1		1	**2**
Total 2. *Feedback and monitoring*	**11**	**6**	**5**	**5**	**3**	**5**	**35**
3.1 Social support (unspecified)	7	5	3	3	3	2	**23**
3.3 Social support (emotional)			1				**1**
Total 3. *Social support*	**7**	**5**	**4**	**3**	**3**	**2**	**24**
4.1 Instructions on how to perform a behaviour		4				1	**5**
4.2 Information about antecedents	5	1	4	1	3	1	**15**
Total 4. *Shaping knowledge*	**5**	**5**	**4**	**1**	**3**	**2**	**20**
5.1 Information about health consequences	1	4	3	2	3	1	**14**
5.2 Salience of consequences						1	**1**
5.3 Information about social and environmental consequences		1	1			1	**3**
5.4 Monitoring of emotional consequences	1	1	1	1	1	1	**6**
5.6 Information about emotional consequences		2					**2**
Total 5. *Natural consequences*	**2**	**8**	**5**	**3**	**4**	**4**	**26**
Total 6. 6.2 Social comparison	**0**	**0**	**0**	**1**	**0**	**0**	**1**
8.2 Behavioural substitution	4	6					**10**
8.4 Habit reversal		1					**1**
Total 8. *Repetition and substitution*	**4**	**7**	**0**	**0**	**0**	**0**	**11**
10.2 Material reward (behavior)			2				**2**
10.4 Social reward	1	2	1	1		3	**8**
10.7 Self-incentive				1			**1**
10.9 Self-reward	3	1	2				**6**
Total 10. *Reward and threat*	**4**	**3**	**5**	**2**	**0**	**3**	**17**
11.1 Pharmacological support	1						**1**
11.2 Reduce negative emotions	3	2	3		1	1	**10**
Total 11. *Regulation*	**4**	**2**	**3**	**0**	**1**	**1**	**11**
12.1 Restructuring the physical environment	1						**1**
12.2 Restructuring the social environment	2	1					**3**
12.3 Avoidance/reducing exposure to cues for the behaviour	2	1					**3**
12.4 Distraction	2	2			1		**5**
Total 12. *Antecedents*	**7**	**4**	**0**	**0**	**1**	**0**	**12**
13.1 Identification of self as role model						1	**1**

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Table 5
Continued.

Distinct BCTs	Week 1 ($N = 24$)	Week 2 ($N = 21$)	Week 3 ($N = 15$)	Week 4 ($N = 12$)	Week 5 ($N = 10$)	Week 6 ($N = 10$)	Total instances
13.2 Framing/reframing		1				1	**2**
13.5 Identity associated with changed behaviour		1				3	**4**
Total 13. *Identity*	**0**	**2**	**0**	**0**	**0**	**5**	**7**
15.1 Verbal persuasion about capacity	2		1	1	1	3	**8**
15.2 Mental rehearsal of successful performance				1			**1**
15.3 Focus on past success				2		2	**4**
15.4 Self-talk	1						**1**
Total 15. *Self-belief*	**3**	**0**	**1**	**4**	**1**	**5**	**14**
Total	**50**	**42**	**28**	**19**	**18**	**28**	**185**

Note: The 6-week period does not include the quit date or the last three assessment messages at 1, 3, and 6 months.

Natural Consequences was one of the most prevalent BCT groups and was also one of the most evenly distributed across the 6 weeks (first 3 weeks $N = 15$; second 3 weeks $N = 11$).

During the most vulnerable 4-day period for user dropout from the intervention (the day before quit day through day 2), *Goals and Planning* ($N = 7$) was the most common BCT group, followed by *Feedback and Monitoring* ($N = 5$), *Repetition and Substitution* ($N = 4$), and *Shaping Knowledge* ($N = 4$) (Table 6).

Discussion

The SFTXT programme is composed of 14 BCT clusters and 41 distinct BCTs distributed with different frequencies. Some BCTs are more present than others, with *Feedback and Monitoring*, *Natural Consequences*, *Social Support*, and *Shaping Knowledge* being the most prevalent BCT clusters.

In our analysis of BCTs present in SFTXT for each week of the intervention (post-quit date), we found differences in the mix of BCTs over time, which may reflect the changing needs of individuals trying to quit. Quitting smoking is a process that consists of several phases, including preparation, quit day, sustained quitting, and potential slips or relapses. These phases require different mixes of BCTs.

There are some BCTs that are consistent throughout, such as *Natural Consequences* (which includes emotional, social, environmental, and health consequences, as well as anticipated regret), *Feedback and Monitoring*, and *Social Support*. However, there are others that are used more frequently at different points. For example, *Goals and Planning* and *Natural Consequences* BCTs have strong presence in the 14-day pre-quit messages when individuals are preparing to quit. After the quit date, in the first half of the intervention, *Shaping Knowledge* is an important part because it allows users to better understand the process they are going through and receive practical tips, such as understanding *Antecedents* (e.g., restricting the environment, reducing cues) as well as learning about *Repetition & Substitution* (e.g., behavioural substitution). *Natural Consequences* are important during this time as well, because they reinforce all the reasons for quitting. During the latter half, the emphasis shifts towards promoting a new *Identity* as a non-smoker and reinforcing *Self-Belief* by highlighting users' success and confirming their ability to stay smoke-free. These BCTs help participants internalise their new identity and realise their success at accomplishing a difficult achievement such as quitting smoking.

Some techniques were underrepresented in the programme; specifically, distinct aspects of *Identity* (identification of self as model and incompatible beliefs) as well as *Covert Learning* (imaginary punishment and imaginary reward). Future mobile text messaging programmes should consider developing content that reflects these techniques as they can be well suited for text delivery.

Whilst we cannot make a direct comparison to the Text2Stop analysis because of the use of different BCT taxonomies, there were some similarities in terms of the BCTs that were most prevalent. For example, information about health consequences and behavioural substitution were some of the more prevalent techniques used in both interventions. Furthermore, use of social support, which was less prevalent in Text2Stop but highlighted as a technique that should be used more, was frequently present in the SFTXT programme.

In order to highlight potential active ingredients amongst all the BCTs in the programme, we compared techniques found in the SFTXT programme to an evidence-based resource, namely the recommendations for treatment of tobacco use and dependence for patients

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Table 6
Distinct BCTs and BCT groups within day -1, quit day (0), day 1, and day 2 of SFTXT

Distinct BCTs ($N = 16$)	Day -1 ($N = 2$)	Day 0 (quit date) ($N = 4$)	Day 1 ($N = 4$)	Day 2 ($N = 3$)	Total Instances ($N = 31$)
1.1 Goal setting (behaviour)	1	1			2
1.2 Problem solving	1	1	1		3
1.9 Commitment		1	1		2
Total 1. *Goals and planning*	**2**	**3**	**2**	**0**	**7**
2.2 Feedback on behaviour		1	1		2
2.3 Self-monitoring of behaviour		1			1
2.4 Self-monitoring of outcomes(s) of behaviour			1	1	2
Total 2. *Feedback and monitoring*	**0**	**2**	**2**	**1**	**5**
Total 3. 3.1 Social support (unspecified)	0	1		2	3
Total 4. 4.2 Information about antecedents	1	1	1	1	4
Total 5. 5.4 Monitoring of emotional *consequences*	0	0	0	1	1
Total 8. 8.2 Behaviour substitution	2	1	0	1	4
10.4 social reward			1		1
10.9 Self-reward			1		1
Total 10. *Reward and threat*	**0**	**0**	**2**	**0**	**2**
12.1 Restructuring the physical environment	1	1			2
12.3 Avoidance/reducing exposure to cues for the behaviour		1			1
Total 12. *Antecedents*	**1**	**2**	**0**	**0**	**3**
15.1 Verbal persuasion about capability		1			1
15.4 Self-talk			1		1
Total 15. *Self-belief*	**0**	**1**	**1**	**0**	**2**
Total	**6**	**11**	**8**	**6**	**31**

willing to quit (Fiore et al., 2008). Some of the clinical practices aimed at assisting individuals when quitting that directly tie into the BCT clusters present in SFTXT are as follows:

1. Help the participant to set a quit date (BCTs – *Goals and Planning*; message example: 'The countdown begins! 2 weeks until you quit smoking. We are here to help you prepare & follow through. Visit http://lil.ms/gw1 to get more info').
2. Encourage the participant to tell family and friends about his or her attempt (BCTs – *Social Support*; message example: 'Tell your friends how they can help. They may not know how unless you tell them. For more info on social support: http://lil.ms/gw2').
3. Help the participant to anticipate challenges to the upcoming quit attempt (BCTs – *Shaping Knowledge;* message example: 'You may feel strange when you quit—this is withdrawal. You are addicted to nicotine & your body is used to smoking. These feelings will go away').
4. Help the participant understand the importance of removing tobacco products from his or her environment (BCTs – *Antecedents*; message example: 'Take everything that reminds you of smoking out of your home, car, and office. This includes your lighters, ashtrays, and matches. Everything!').
5. Provide the participant with practical counseling (BCTs – *Shaping Knowledge/Goals and Planning;* message example: 'Move your body. Exercise is good for you & can help you beat cravings. Walking up stairs burns 7 to 10 calories per minute. Take the stairs today!').
6. Provide the participant with opportunities to seek social support delivered as part of the treatment (BCTs – *Social Support;* message example: 'It's hard to fail, but worse to never have tried to succeed. If you need motivation, visit us on Facebook. https://www.facebook.com/SmokefreeUS').

Characterising SFTXT by using the BCTTv1 enabled us to systematically assess the frequency and type of specific BCTs and BCT groups that make up the SFTXT intervention. Furthermore, mapping the frequency and type of BCT groups and distinct BCTs based on different temporal dimensions helped us better understand how we are addressing smokers' needs over time, and in particular, key

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time points in which they might be most vulnerable (e.g., the first 24 hours or first 2 weeks). Having these insights, in addition to the individual-level performance metrics available through mHealth programmes like SFTXT, provides an opportunity to test important research questions such as 'What are the optimal methods to decrease barriers and increase appeal and use of treatment?'; 'How effective is tailoring of content to cessation?' (Fiore et al., 2008).

Fractional factorial experiments can be conducted to identify the BCTs that play an active role in increasing engagement and cessation rates (Chakraborty, Collins, Strecher, & Murphy, 2009; Collins, Murphy, & Strecher, 2007). Factorial experiments are well-suited for developing and evaluating multicomponent interventions because each component is a separate factor (e.g., in this case BCTs), and participants in the experiment are randomised to receive unique combinations of the factors so that the unique effects of each can be established. Candidate BCTs can be hypothesised using existing evidence, such as the clinical practice guidelines for treating tobacco use and dependence (Fiore et.al., 2008) and research examining how text messaging interventions facilitate behaviour change (Hall, Cole-Lewis, & Bernhardt, 2015). We can then make evidence-informed decisions on how to optimise future iterations of the SFTXT programme. Overall, mapping the baseline intervention to BCTTv1 will enable us to test how changes in the use of specific BCTs, BCT groups, mix of BCTs per message, as well as their frequency of use over time, will impact (1) engagement with the programme (particularly during the days with high dropout rates), and (2) smoking cessation outcomes over time.

In this analysis, we applied the BCT taxonomy to SFTXT in a post-hoc analysis after it was developed and disseminated. Future programmes could benefit from using BCTs to guide the development of their intervention. Existing research can be used to help select BCTs that are likely to be effective in facilitating behaviour change. As the Number of interventions that specify their components using a BCT taxonomy grows, there will be opportunities to conduct meta-analyses to better understand the active ingredients of multifaceted behavioural interventions.

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Conflict of Interest

The authors declare no conflict of interest.

Ethical Standards

Not applicable.

References

Abroms, L. C., Boal, A. L., Simmens, S. J., Mendel, J. A., & Windsor, R. A. (2014). A randomized trial of Text2Quit: A text messaging program for smoking cessation. *American Journal of Preventive Medicine*, *47*(3), 242–250. doi:10.1016/j.amepre.2014.04.010.

Bishop, F. L., Fenge-Davies, A. L., Kirby, S., & Geraghty, A. W. (2015). Context effects and behaviour change techniques in randomised trials: A systematic review using the example of trials to increase adherence to physical activity in musculoskeletal pain. *Psychology & Health*, *30*(1), 104–121. doi:10.1080/08870446.2014.953529.

Bock, B., Heron, K., Jennings, E., Morrow, K., Cobb, V., Magee, J. et al. (2013). A text message delivered smoking cessation intervention: The initial trial of TXT-2-Quit: Randomized controlled trial. *JMIR mHealth and uHealth*, *1*(2), e17. doi:10.2196/mhealth.2522.

Centers for Disease Control and Prevention. (2011, November 11). Quitting smoking among adults: United States, 2001–2010. *Morbidity and Mortality Weekly Report, 60*(44), 1513–1519. Retrieved from http://www.cdc.gov/MMWr/preview/mmwrhtml/mm6044a2.htm.

Centers for Disease Control and Prevention. (2014, February 6). *Tobacco-related mortality* [Fact sheet]. Retrieved from http://www.cdc.gov/tobacco/data_statistics/fact_sheets/health_effects/tobacco_related_mortality/index.htm.

Centers for Disease Control and Prevention. (2016, March 14). *Current cigarette smoking among adults in the United States* [Fact sheet]. Retrieved from http://www.cdc.gov/tobacco/data_statistics/fact_sheets/adult_data/cig_smoking/.

Chakraborty, B., Collins, L. M., Strecher, V. J., & Murphy, S. A. (2009). Developing multicomponent interventions using fractional factorial designs. *Statistics in Medicine, 28*(21), 2687–2708. doi:10.1002/sim.3643.

Cole-Lewis, H., Augustson, E., Sanders, A., Schwarz, M., Geng, Y., Coa, K., & Hunt, Y. (2016). Analysing user-reported data for enhancement of SmokefreeTXT: a national text message smoking cessation intervention. Tobacco Control, tobaccocontrol-2016.

Collins, L. M., Murphy, S. A., & Strecher, V. (2007). The multiphase optimization strategy (MOST) and the sequential multiple assignment randomized trial (SMART). New methods for more potent eHealth interventions. *American Journal of Preventive Medicine, 32*(Suppl. 5), S112–S118. doi:10.1016/j.amepre.2007.01.022.

Dale, H., Raftery, B., & Locke, H. (2014). Behaviour change and sexual health; SHARE programme evaluation. *Health Education, 114*(1), 2–19. doi:10.1108/HE-12-2012-0056.

Direito, A., Dale, L. P., Shields, E., Dobson, R., Whittaker, R., & Maddison, R. (2014). Do physical activity and dietary

https://doi.org/10.1017/jsc.2016.24 Published online by Cambridge University Press

smartphone applications incorporate evidence-based behaviour change techniques? *BMC Public Health*, *14*(1), 646. doi:10.1186/1471-2458-14-646.

Fiore, M. C., Jaén, C. R., Baker, T. B., Bailey, W. C., Benowitz, N. L., Curry, S. J. et al. (2008). *Treating tobacco use and dependence: 2008 update (Clinical Practice Guideline)*. Rockville, MD: U.S. Department of Health and Human Services.

Free, C., Whittaker, R., Knight, R., Abramsky, T., Rodgers, A., & Roberts, I. G. (2009). Txt2stop: a pilot randomised controlled trial of mobile phone-based smoking cessation support. Tobacco control, *18*(2), 88–91. doi:10.1136/tc.2008.026146

Free, C., Knight, R., Robertson, S., Whittaker, R., Edwards, P., Zhou, W. et al. (2011). Smoking cessation support delivered via mobile phone text messaging (txt2stop): A single-blind, randomised trial. *Lancet, 378*(9785), 49–55. doi:10.1016/S0140-6736(11)60701-0.

Guerriero, C., Cairns, J., Roberts, I., Rodgers, A., Whittaker, R., & Free, C. (2013). The cost-effectiveness of smoking cessation support delivered by mobile phone text messaging: Txt2stop. *The European Journal of Health Economics, 14*(5), 789–797. doi:10.1007/s10198-012-0424-5.

Hall, A. K., Cole-Lewis, H., & Bernhardt, J. M. (2015). Mobile text messaging for health: A systematic review of reviews. *Annual Review of Public Health*, *36*, 393–415. doi:10.1146/annurev-publhealth-031914-122855.

Hynynen, S.-T., van Stralen, M. M., Sniehotta, F. F., Araújo-Soares, V., Hardeman, W., Chinapaw, M. J. M. et al. (2014). A systematic review of school-based physical activity and sedentary behaviour interventions among older adolescents. *European Health Psychologist*, *16*(Suppl.), 496.

Michie, S., Free, C., & West, R. (2012). Characterising the 'Txt2Stop'smoking cessation text messaging intervention in terms of behaviour change techniques. *Journal of Smoking Cessation, 7*(1), 55–60. doi:10.1017/jsc.2012.12.

Michie, S., Hyder, N., Walia, A., & West, R. (2011). Development of a taxonomy of behaviour change techniques used in individual behavioural support for smoking cessation. *Addictive Behaviours, 36*(4), 315–319. doi:10.1016/j.addbeh.2010.11.016.

Michie, S., Johnston, M., Abraham, C., Francis, J., Hardeman, W., & Eccles, M. (2014). *BCT taxonomy, version 1: Starter pack for trainees*. Retrieved from http://www.bct-taxonomy.com/pdf/StarterPack.pdf.

Michie, S., Richardson, M., Johnston, M., Abraham, C., Francis, J., Hardeman, W. et al. (2013). The behavior change technique taxonomy (v1) of 93 hierarchically clustered techniques: Building an international consensus for the reporting of behavior change interventions. *Annals of Behavioral Medicine, 46*(1), 81–95. doi:10.1007/s12160-013-9486-6.

Presseau, J., Knittle, K., Newham, J., Grimshaw, J. M., Danko, K., & Ivers, N. M. (2014). Behaviour change techniques used in diabetes quality improvement interventions: Secondary analysis of a systematic review. *European Health Psychologist*, *16*(Suppl.), 581.

Rainie, L., (2013, June 6). *Cell Phone ownership hits 91% of adults*. Retrieved from http://www.pewresearch.org/fact-tank/2013/06/06/cell-phone-ownership-hits-91-of-adults/.

Rodgers, A., Corbett, T., Bramley, D., Riddell, T., Wills, M., Lin, R. B., & Jones, M. (2005). Do u smoke after txt? Results of a randomised trial of smoking cessation using mobile phone text messaging. *Tobacco Control*, *14*(4), 255–261. doi:10.1136/tc.2005.011577.

Squiers, L. B., Augustson, E., Brown, D., Kelly, B., Southwell, B., Dever, J., … & Sanders, A. (2016). An experimental comparison of mobile texting programs to help young adults quit smoking. *Health Systems*, 1–14. doi:10.1057/s41306-016-0014-3.

West, R., Walia, A., Hyder, N., Shahab, L., & Michie, S. (2010). Behavior change techniques used by the English Stop Smoking Services and their associations with short-term quit outcomes. *Nicotine & Tobacco Research*, *12*(7), 742–747. doi:10.1093/ntr/ntq074.

Whittaker, R., McRobbie, H., Bullen, C., Borland, R., Rodgers, A., & Gu, Y. (2012). Mobile phone-based interventions for smoking cessation. *Cochrane Database of Systematic Reviews*, *11*, CD006611. doi:10.1002/14651858.CD006611.pub3.

Yang, C. H., Maher, J. P., & Conroy, D. E. (2015). Implementation of behavior change techniques in mobile applications for physical activity. *American Journal of Preventive Medicine*, *48*(4), 452–455. doi:10.1016/j.amepre.2014.10.010.

https://doi.org/10.1017/jsc.2016.24 Published online by Cambridge University Press