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# Automated coaching to help parents increase their children's brushing frequency: an exploratory trial

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Advances in digital communication, such as the internet, now provide a cost effective channel to reach and help families struggling to establish good oral hygiene in their homes. This paper describes a novel internet based oral hygiene intervention whose design draws from advances in social cognitive models of behaviour change. Intervention components included role-modelling cartoons for children, a guide for parents on using rewards, a personalised plan with clear steps, tips to follow and a weekly 10-minute review of progress. ***Objective:*** To evaluate the efficacy of the online coaching programme; specifically we expected that those in the intervention group would brush their teeth more frequently during the intervention period than those in the control group. ***Basic research design:*** An exploratory trial using a randomised controlled parallel approach. ***Participants:*** Children aged 5 to 9 years from 44 families (23 control and 21 intervention). ***Main outcome measure:*** An objective monitoring of tooth brushing. ***Results*:** In the 3-week intervention period, children from families assigned to the coaching programme brushed their teeth 38% more often than those in the control group. ***Conclusions***: The programme was effective in a number of respects. Opportunities for further research are discussed, including the need to create a more engaging system and so increase compliance.

**Key words***: oral hygiene, internet, behavior, pilot projects, intervention studies, cellular phone, mobile phone*

## Introduction

Brushing twice a day with fluoridated toothpaste is recommended for good oral hygiene (Brothwell *et al*., 1998; Gregg, 1997; Marinho *et al.*, 2003) yet many people do not achieve this standard both in developing (Petersen, 2003) and developed countries (Eaton and Carlile, 2008). Ideally, parents should incorporate twice daily tooth brushing into their child's hygiene routine (Ramsay, 2000; Schou and Locker, 1994) but many struggle to do this, particularly those at lower socioeconomic levels, whose coping capacity may be taxed by other life stressors (Gratrix and Holloway, 1994). Knowledge from psychological sciences is central to the success of such interventions as it offers models and techniques aimed at modifying behaviour (Aunger, 2007; Claessen *et al*., 2008; Joffe, 2000; Schou, 2000), which have already been built into the design of successful school programmes (Pine, 2007) that engage children through personalised interaction, provide skills training and reinforce desired behaviours. Dental research might also gain from advances in other health domains, such as the promotion of healthier eating in children (Horne *et al*., 2004; Lowe *et al*., 2002), where medium term (e.g. 4 months) behaviour change has been generated after a relatively short (3-week) intervention. These healthy eating programmes combine a progressive ratio reward system with peer group modelling; deployed via videos of slightly older children gaining superhuman powers by eating fruit and vegetables in order to defeat an imaginary gang of 'nasty food junkies'.

These food-related interventions have been deployed through school programmes, primarily for ease of access to children and subsequent cost benefit (Jones and Furner, 1998). However, given that children's tooth brushing primarily occurs in the home and is related to parental beliefs and behaviours (Pine *et al*., 2000; Tolvanen *et al*., 2010), an intervention targeted through parents may prove cost effective if delivered through the internet and/or mobile phone. World internet penetration continues to grow rapidly and the the facility proves to be an effective medium for health interventions (Webb *et al*., 2010). Interventions designed with more extensive use of psychological theory and those with a greater degree of interactivity (e.g. text messaging) showed greater changes in behaviour. There have also been advances in the devices to objectively monitor oral hygiene behaviours. For example, a Sensor brush is a toothbrush with a compartment handle containing a triaxial accelerometer data logger. The validity and reliability of the Sensor brush for recording brushing events has been demonstrated in a number of studies (Zillmer, 2011).

This paper concerns a novel oral hygiene intervention that builds on the opportunities provided by advances in social cognitive models of behaviour change, increased capability of internet media and objective monitors of brushing. We have built an internet and mobile phone based intervention designed to help parents guide their children towards better tooth brushing behaviours. The intervention provides parents with a step-by-step approach and materials for them to deploy over 3 weeks in their own home. We first describe key characteristics of the intervention before reporting on an exploratory trial to evaluate its impact on a small group of parents and their children in preparation for a larger scale clinical study.

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## Methods

No prior information was available to quantitatively estimate sample size due to the lack of studies deploying objective measures of tooth brushing frequency in this age group when using an automated coaching system. Given the exploratory nature of the study we used a sample size (30 per group) similar to that reported by Horne *et al* (2004) for the dietary intervention programme upon which we based the design of our coaching system. Fifty-seven families living near Liverpool (UK) with a child aged between 5 and 9 and who reported an average brushing frequency of once a day or less were recruited by a market research agency to take part in the study. Families were either single (female only) parent or a two-parent family, with the female parent responsible for their child's oral health, having declared an interest in increasing their brushing frequency and prepared to use an internet based coaching programme to help them improve. The parent was able to read and write English and the child was able to understand spoken English and use the study toothbrush (judged by a dentist at screening). All adult participants reported being computer literate (e.g. able to use simple search engines), had a broadband connected home personal computer with Windows XP or a higher operating system and a working printer. Parents were also required to have a mobile phone and email account and be willing to receive at least two text messages and three emails per week as part of the programme. Parents worked less than 16 hours a week – making attendance at the initial screening session easier and increasing their availability for toothbrush collection and delivery at home. Households were excluded if any family member was currently participating in another research study, or there was a planned holiday or other absence from the house for three or more consecutive days during the study. Households were also excluded if the mother was pregnant or breast feeding, or the children had a dental or medical condition that prevented normal tooth brushing twice per day. Children were excluded if they resided in more than one household for the duration of the study. The total maximum incentive for taking part in the study was £70, given as a high street shop voucher. Families were free to withdraw at any time during the study with full compensation. Families who did not meet the inclusion criteria were paid £20 for completing the initial screening visit.

## Materials

Brushing frequency was monitored using a Sensor toothbrush (Claessen *et al.,* 2008) with a time based triaxial accelerometer data logger in the handle, which was triggered by movement and so captured brushing events per day. The validity and reliability of the sensor brush for capturing brushing events has been established in a range of studies (Zillmer, 2011).. The battery life of the sensor brush was just over three weeks and so, in this study, the batteries were replaced between the two-week baseline and three-week intervention phases. The online coaching was a three-week programme (www.coachingkidsprogram.com) providing parents with materials and advice on how to encourage their children to brush their teeth more frequently and with less fuss. Programme development was fully funded by Unilever (www.unilever.com) and based on the underlying principles of the Food Dudes approach (www.fooddudes.co.uk; Horne *et al*., 2004), which were converted to the oral care domain and delivered via an automated online coaching system. The programme included six 5-minute cartoons for the parent to show their children, a guide for parents on how to use rewards, a personalised plan with clear steps and tips to follow and a weekly review of progress that took about 10 minutes to complete. The parent first answered a few questions in a series of screens about how their child currently brushed. These questions included how often their child brushed twice a day, how much help they needed when brushing, how much they enjoyed brushing and how much they liked the toothpaste they used. Parents also chose a time and event (e.g. after breakfast or just before a bedtime story) to remind them when their child would brush in the morning and evening. Parents chose rewards to give their children as part of a reinforcement schedule, where each reward required the child to achieve a step towards attaining their goal of brushing twice a day. So, for example, the parent would choose a reward (such as a small toy or trip to a park) to give their child when they first brushed twice in a day. The next reward chosen by the parent would be for when their child brushed twice a day for two days in a row and the next reward would be for brushing twice a day for three days in a row. After answering the questions, the parent printed a summary plan, which showed what they needed to do each day to help their child and when to give rewards. They also printed a three-week chart, with the child's name on it, to put up in the bathroom so their child could add a sticker each morning and evening when they brushed their teeth. The parent reviewed their child's progress at the end of each week. For children who had done well, the plan for the next week included a more difficult goal, e.g. brushing teeth for longer and around more of the mouth. For children who had not done so well, the goal remained the same and the reward ratio was increased so that they received rewards for fewer days of success, to boost their motivation. In the last week of the programme, the reward schedule was changed so that children had to achieve even more of the goal of brushing twice a day before they got a reward. The reward schedule was designed so that children moved from the extrinsic motivation of gifts in the first two weeks to a more intrinsic motivation (being part of a cool group) for brushing in the last week.

The series of cartoons were also designed to increase intrinsic motivation. There were six cartoon stories, each about 5 minutes long and carefully designed to role model the behaviour of cleaning teeth more often. Two new cartoons were made available in each week of the three-week programme. The key characters in the cartoons were called the 'Teeth Chiefs' (Oliver, Minty, Mo and Fang) who developed superhuman powers by brushing their teeth. Oliver had a dazzling smile. Minty had super fresh breath. Mo had a tooth-shaped shield and Fang had 'bluetooth' vision. The Teeth Chiefs had a series of adventures with nasty germ-like monsters, called the 'Plackos', that rot children's teeth. Design of the cartoons was guided by a set of behaviour change

principles. Specifically, the single most important message running through all six cartoons was that brushing your teeth twice a day makes you a cool kid who can be part of a gang admired by all other kids. The dangers of not cleaning your teeth were represented by the evil army of monsters (the Plackos) who were designed to look disgusting; with pale unattractive colours and limited character development. The cartoons made it clear that the Teeth Chiefs might lose their powers if they did not clean their teeth properly and that the first sign of this was a change in the sensory status of their teeth, e.g. feeling unclean or looking darker. Whereas cleaning their teeth regularly could lead to extra powers, also forecasted by sensory markers, e.g. fresh breath and clean feeling teeth. In the cartoons, the bathroom was treated as a very safe zone, where the Plackos did not appear, to avoid children becoming frightened of the bathroom. The cartoons reinforced the parent's use of rewards, by showing the Teeth Chiefs using a similar chart to monitor their brushing and receiving gifts for cleaning their teeth well. In the last few cartoons the Teeth Chiefs talked more about being part of a cool gang and less about receiving extrinsic gifts; so that they were role modelling tooth brushing as a behaviour characteristic of the group (an intrinsic reward) rather than for gifts (extrinsic rewards).

Two cartoons were made available to the parent each week, which they could access via the website to show their children. At the end of each week there was also a certificate for the parent to print off and give their child, congratulating them for their most positive achievement that week.

The parent received a personalised plan for each child that they could print. The plan summarised each step they needed to follow each day (e.g. when to show the videos), the times they had chosen for their child to brush teeth each morning and night, the reward schedule and a tip on how to help their child. Examples of tips included: "Use some stuffed animals or action figures to make the teeth cleaning experience more fun" and "Make up a special short story that you tell only during tooth brushing time. Try to keep it short and targeted on teeth."

Parents could opt for mobile phone text messages to remind them when to show the cartoons, to remind them of the morning and evening brushing times and when to log back into the coaching programme to review progress each week.

The study ran from the end of October 2010 to mid-December 2010 and had three key phases: recruitment and screening, baseline measurement (two weeks) and intervention (three weeks). The 163 families recruited were given an appointment to attend a Consumer Studies Centre (CSC) near Liverpool, bringing their child with them. On arrival at the study site, each family was allocated a unique identifier number for the study. Families read an Information Sheet describing the study, were given time to ask any questions and, if they wanted to take part, signed an Informed Consent Form. Although the children were too young to give informed consent they were asked to provide their assent after having seen a cartoon strip outlining what would happen during the study (Hurley and Underwood, 2002). Children were then screened by a dentist for any medical conditions that would prevent them from increasing their brushing frequency, for the presence of loose deciduous teeth and their capability of using the study toothbrush unaided. Fifty seven families who successfully passed screening were then randomised into the intervention (n=28) and control (n=29) groups. Randomisation was by alternate allocation to intervention or control based on appointment time assigned by the recruitment agency.

A further appointment was made for an agency member to visit their home, confirm the computer was capable of downloading the online programme and deliver the study toothbrush for the child to use with their usual toothpaste. The child's current toothbrush was removed to avoid any confusion about which brush they should use during the study period. At the end of the two-week baseline phase, the participants were visited at home again to collect the baseline study toothbrush, be given a new toothbrush for the three-week intervention period, and instructed to download the online coaching system from a web link. At the end of the intervention period the participants were again visited at home to collect the second study toothbrush and return their child's original toothbrush or receive a new one. Participants were then fully briefed on the study purpose and design, including the presence of data loggers in the toothbrushes, asked for re-consent for the logger data to be used, thanked for their participation and given their reward. All contact with the families was through a recruitment agency independent of the team that designed the coaching system.

Participants allocated to the control group followed the same procedure as the intervention group except they were not instructed to download the online coaching programme.

A protocol fully describing the study processes and materials was approved by Unilever's Research Ethics Committee before the start of screening of participants for the study. The research approach was conducted in full accordance with the Declaration of Helsinki ethical guidance (World Medical Association, 2011).

Our primary analysis objective was to evaluate the efficacy of the online coaching programme. Specifically, we expected those in the intervention group, using the coaching system, would brush their teeth more frequently during the intervention period than those in the control group. We also expected the intervention group brushing frequency to increase from baseline to intervention phase, whereas we expected the control group would remain unchanged. Given the exploratory nature of the study, we did not follow a full intention-to-treat analysis, as although all families with available data were included in the analysis regardless of their protocol compliance, we did not make assumptions about the possible trajectory of families where data were unavailable. This analysis approach best fitted the objective to explore rather than formally test the programme's efficacy. A larger scale follow-up study could deploy a full intention-to-treat analysis, where families with no data available would be assumed not to have changed in the key outcome variables. Therefore, in this study, data were excluded from the analysis if the data logger failed at any point during the study or if the family withdrew from the study. Data were not excluded for families in the intervention group who failed to log on as required. Paired t-tests were

used to examine differences between the baseline and intervention brushing frequency for the control and test groups. The intervention phase values for the intervention and control groups were also compared by analysis of covariance (ANCOVA) using baseline values as covariates. All analyses were conducted using JMP v8 with the significance threshold set at α=0.05. The statistician was not involved in the study management and was blind to treatment allocation. Figure 1 shows participant numbers at enrolment, allocation, follow-up and analysis. There were no adverse events.

## Results

Two families withdrew from the study (refusing entry to the house at the baseline visit) and eleven data loggers failed, leaving 44 families (23 control and 21 intervention) for analysis. The age of children in the intervention group (mean 7.23 years, range 5.2 to 8.9) did not significantly differ from that of the control group (mean 7.18 years, range 5.1 to 8.8). The proportion of males was balanced between the control group (44%, 10/23) and intervention group (43%, 9/21). Ten of the 21 intervention participants completed a predefined minimum level engagement with the programme by logging in at least once during each of the three weeks. The number of participants watching each cartoon video at least once fell from 19 for the first video through 17, 15, 10 and 9 to 4 for the sixth video. During the two-week baseline phase, the mean brushing events per day did not significantly differ between control (0.94, SE=0.08) and intervention groups (0.90, SE=0.10).

There was a significant difference between control and intervention group with regard to change from baseline, $F(1, 42)=7.21$, $p=0.01$, with the mean number of brushings in the intervention group increasing from 0.90 per day (SE=0.10) to 1.07 per day (SE=0.12), whilst the control group decreased from 0.94 per day (SE=0.8) to 0.77 per day (SE=0.08). The intervention group increase ($\Delta=+0.17$) was not significant whereas the control group decrease ($\Delta= -0.17$) was significant ($t(22)=2.93$, $p=0.008$).

To explore the proportion of people increasing or decreasing their brushing behaviour we conducted a *post-hoc* analysis. Categorical positive and negative changes in brushing behaviour were defined as a greater than 10% change in mean brushings per day, i.e. intervention phase brushing levels being either more than 10% higher ('positive change') or 10% lower ('negative change') than baseline. A 10% level was arbitrarily chosen to represent a minimal level of change of clinical importance. This categorical analysis found 12 intervention participants (of 21) with positive change from baseline compared with 3 (of 23) in the control group ($\chi^2$ $\chi^2$ (1, $n$=55) =7.95, $p=0.005$).

## Discussion

We expected that those in the intervention group, using the coaching system, would brush their teeth more frequently during the intervention period than those in the control group, and the results do indicate some efficacy

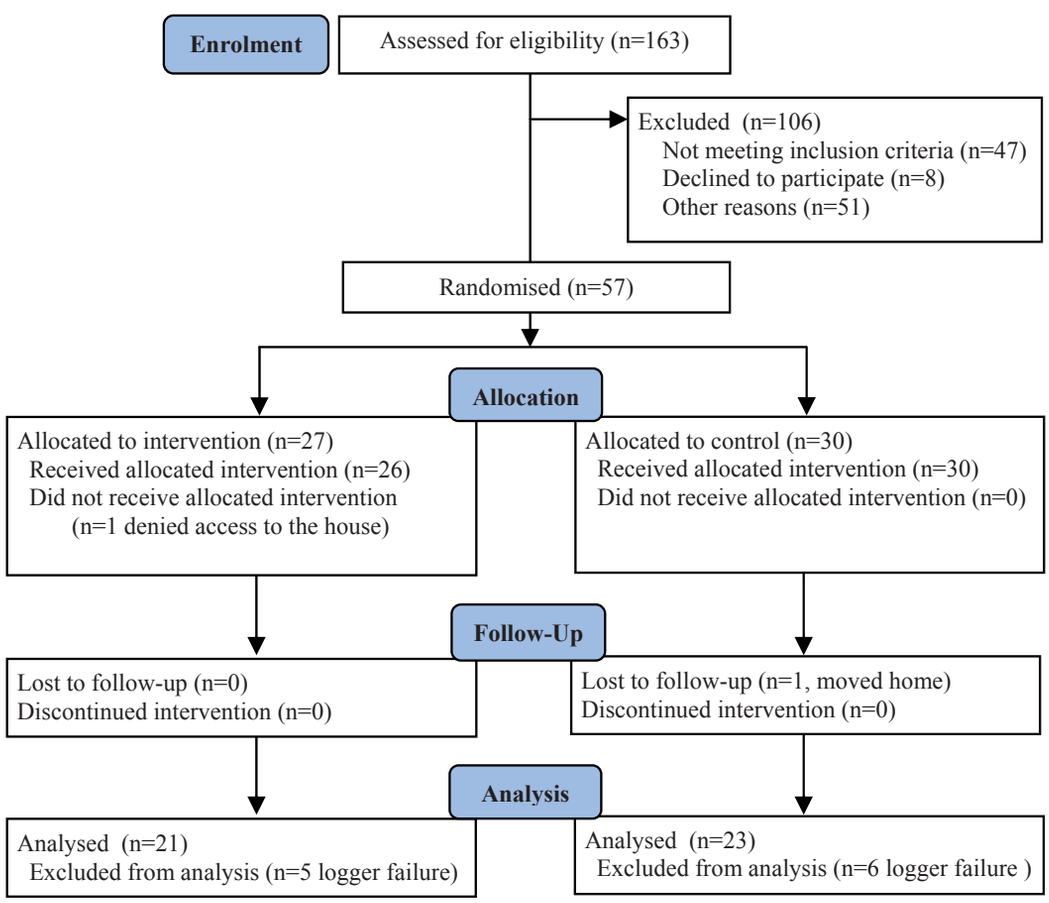


**Figure 1.** *Participant Flow Diagram*

for the intervention; with children from those families assigned to the coaching programme brushing their teeth 38% more often than those in the control group; 1.07 vs 0.77 mean brushing events per day. This increase did not reach the goal of 2 brushes per day (mean) but nevertheless indicates the approach is worthy of further development. There is also clearly room for the programme to be more engaging, with only 48% (10/21) of intervention families logging on at least once a week for the three week intervention period. Indeed, if a higher proportion of participants had logged on frequently there may have been a greater increase in mean brushing events per day. Poor compliance and dropout is common in person-to-person behaviour change programmes (Evers *et al*., 2003) and even more problematic with internet programmes, perhaps because of the lower levels of supervision (Ritterband *et al*., 2003). Unfortunately, research on internet interventions is at an early stage, with limited frameworks to guide their design (Kraft *et al*., 2008) and few meta-analyses exploring the influence of different intervention components (Webb *et al.,* 2010). However, experimental approaches to evaluate health interventions are developing, with objective monitors of behaviour revealing design factors to be considered. Our data indicate, in line with findings from other health intervention research designs (Hurling *et al*., 2007), that issuing participants with new devices or monitors can temporarily stimulate behaviour and so may generate artificially high baseline levels. One interpretation of our data is that the control group baseline brushing level in our study (0.94) was artificially high due to the novelty of having just received the sensor brushes. The lower control group brushing levels observed during the intervention phase (0.77) may be more representative of their usual behaviour. If this lower level was the 'true' baseline then our study population represented a challenging group to change, as on average they were usually brushing less than once a day. We also have no information on the longer term impact of the intervention as our exploratory study focused on the immediate impact over just three weeks.

There are therefore three main improvement opportunities in moving from this exploratory study to a more definitive randomised controlled trial (RCT) to establish intervention efficacy. First, the programme itself should be improved to increase participant engagement and compliance, perhaps by considering alternative digital media formats such as smart phones that are more integrated with people's lives. Secondly, the target group should be initially screened to confirm they are at least brushing once a day on average, with a desire to brush twice a day, so that they are better matched to the programme content. Finally, although the behaviour change techniques used in this programme have proven potency over the longer term in face-to-face interventions for other health domains (Horne *et al*., 2004), their efficacy in an automated internet based oral care programme is yet to be established and so future studies should include at least a few months follow-up.

In summary, we have built a novel internet and mobile phone based intervention designed to help parents guide their children towards better tooth brushing behaviours. An exploratory study indicated some potential efficacy for the intervention along with a need to improve participant engagement. These initial results warrant further development of the programme for a more comprehensive RCT evaluation of its efficacy over the longer term.

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