

**The psychological determinants of engagement with an online cognitive health tool and its associated recommendations for protective cognitive health behaviours.**

Ms Megan Bird<sup>1</sup>, Prof Claudia Cooper<sup>1</sup>, Ms Ferzana Patel<sup>2</sup>, Mr Clive Copeman<sup>1</sup>, Dr Jacki L Stansfeld<sup>1,2</sup>, Dr Georgina Charlesworth<sup>2,3</sup>, Dr Elisa Aguirre<sup>2,3</sup>

<sup>1</sup>Division of Psychiatry, University College London

<sup>2</sup>Research and Development, North East London NHS Foundation Trust

<sup>3</sup>Department of Clinical, Education and Health Psychology, University College London

**Correspondence address:**

Dr Elisa Aguirre, North East London NHS Foundation Trust  
Research and Development, 1st Floor Maggie Lilley Suite  
Goodmayes Hospital  
Ilford  
Essex  
IG3 8XJ  
0300 555 1200 ext.64497  
elisa.aguirre@nelft.nhs.uk



## **Abstract**

**Background & Objectives:** The Covid-19 pandemic has revolutionised how we receive services, with a huge shift to online delivery. Online health promotion tools could be a cost-effective and safe way to improve population health. We used mixed methods to explore user responses to an online cognitive health tool.

**Methods:** 15-28 months after completing an online tool, comprising a cognitive test, lifestyle questionnaire; and dietary and lifestyle behaviour feedback, 4826 participants completed an online survey about their perceptions of it; and questions about their capability, opportunity and motivation for behavioural change developed using the COM-B behaviour change model. We reported how responses to the behaviour change questionnaire predicted decisions to make lifestyle and dietary changes. 24 participants attended focus groups to further explore their responses.

**Results:** Most users reported that the tool was useful (88%), with 37% reporting they made lifestyle or dietary changes after using it. More positive responses to questions regarding capability and motivation predicted making changes. Over a third (36%) felt more fearful after completing the tool. In qualitative findings, we identified barriers to engagement across the three COM-B domains: a sense that information was “nothing new” (so did not enhance capability); that “experts don’t agree” and that the tool may not be credible (influencing motivation), and a lack of support from peers and lower availability of healthy food (reducing opportunities for change).

**Conclusions:** Future e-health tools will be most effective if they have high credibility, demonstrate advice is evidence-based and provide opportunities for support and follow up.

**Keywords:** eHealth, behaviour change, cognition, dementia prevention, risk reduction



## **Introduction**

Lifestyle and environmental influences on brain health are increasingly recognised (1). The 2020 Lancet Commission on dementia prevention, intervention and care outlines twelve potentially modifiable risk factors for dementia, including: hypertension, smoking, obesity, depression, physical inactivity, diabetes, low social contact and excessive alcohol consumption (2). Protective effects for cognitive health have been found to be particularly high for physical activity, non-smoking behaviour and higher fish consumption (3). A systematic review of lifestyle and psychosocial interventions found good evidence that group interventions promoting regular activity, involving aerobic or resistance exercise, and cognitively demanding or creative tasks improved global cognition, memory and executive functioning (4). It has been estimated that if the main risk factors were addressed, up to a third of cases of Alzheimer's disease could be prevented (5,6).

Existing dementia prevention interventions, such as the multimodal intervention evaluated in the FINGER (Finnish Geriatric Intervention Study to Prevent Cognitive impairment and Disability) trial, can be expensive and time-consuming (7), thus cannot be widely implemented (8). Recent societal changes due to Covid-19 have revolutionised how we receive services, with a huge shift to online delivery. This brings challenges and opportunities for the development of existing and new interventions. Social distancing can limit opportunities to adopt key elements of dementia prevention, for example, for social and cognitive engagement and physical exercise. Online interventions (eHealth) are comparatively affordable and accessible (9,10), but to maximise their impact on public health, we need to understand what determines who engages with such tools and how.

Behaviour change interventions are effective (11,12) and enable long-term changes (13). The psychological COM-B behaviour change model (14) proposes that people need capability (C), opportunity (O) and motivation (M) to perform a behaviour (B). If a desired behaviour is not occurring (or an undesirable behaviour is occurring) then an analysis of the determinants of the behaviour will help to define what needs to shift in order for the desired behaviour to occur (or the unwanted behaviour to cease) (15). Previous studies have indicated that brief, computer-tailored advice can change dietary behaviours (Parekh et al., 2012). The current



study is, to our knowledge the first to use mixed methods to explore what determines whether and how such advice is adopted.

In an eHealth tool created by the not-for-profit organisation Food for the Brain, users undertook a validated online cognitive test (CFT) (16) and completed a questionnaire about dietary and lifestyle factors associated with cognitive health in areas related to the current evidence that Mediterranean dietary adherence and staying physically, mentally and socially active are associated with cognitive health (17): (1) consumption of fish and seeds, (2) consumption of antioxidants (3) minimising sugar and refined foods by eating a low GL (glycaemic load) diet, (4) taking vitamin B supplements, (5) moderating coffee consumption and (6) keeping physically, mentally and socially active. After the test, users received their cognitive test result and recommendations in the six areas of diet and lifestyle. In this mixed methods study we gathered quantitative and qualitative data 15-28 months after participants completed the CFT and associated lifestyle questionnaire. We used the quantitative data to explore the factors that influenced users' responses to the tailored lifestyle advice, and triangulate with qualitative data from four focus group interviews.

## **Material and methods**

### **Recruitment**

Individuals were eligible to participate in the anonymous online survey if they had completed the eCFT (online Cognitive Function Test and associated lifestyle questionnaire <https://cft.foodforthebrain.org/>) between January 2014 and January 2015 and were aged between 50 and 65 at the time of completion. The charity who own and manage the eHealth intervention (Food for the Brain) emailed eligible participants details of the study and a survey link. Two reminder emails were sent. The survey was open for five weeks (28th April 2016 to 2nd June 2016). A sub-sample of eCFT users took part in focus groups. We directed those who, as an addendum to the survey, agreed to participate in a follow up study to a doodle poll to indicate their contact details and availability. From these respondents we selected participants from North and South areas of England, to whom we sent invitations together with a participant information sheet, consent form, and participation letter. We compensated participants with a £20 voucher.

Ethical approval was obtained through the University College London ethics committee; reference CEHP/2016/550. Informed consent was obtained.



## Procedure

*Focus groups.* Two facilitators ran the focus groups, which lasted one hour, using semi-structured questions. Focus groups were audio recorded and transcribed verbatim. Observational notes were taken during the session, including verbatim quotes.

## Measures

*Online survey.* The online survey was hosted on Survey Monkey (<http://www.surveymonkey.com>). It included a consent form and the following questions:

- (1) *Sociodemographic:* we asked their age, gender, nationality, ethnicity, highest level of education, employment status and family history of dementia.
- (2) *Utility and impact of the eHealth Intervention:* We presented participants with statements, requiring yes/no responses, on the utility of the tool and its impact on their subsequent behaviours (see Table 1 for statements presented).
- (3) *Questionnaire based on the COM-B model.* We developed questions to explore how capability, opportunity, and motivation for change influenced users' response to health promotion advice. The COM-B behaviour change model [14, 15] is subdivided into three primary elements:
  - (i) Capability. Comprised of two domains: psychological and physical. Within each, knowledge and skills are identified as areas for potential intervention.
  - (ii) Opportunity. Includes five areas as potential facilitators or barriers to behaviour change: presence or absence of disability/illness, financial constraints, social factors, individual hobbies and interests, and access to healthcare.
  - (iii) Motivation. Comprised of five areas: goals, conscious decision making, habitual processes, emotional responding, analytical decision making.

One researcher developed the initial cohort of questions to assess each of these elements. To establish consensus, a second researcher reviewed the questions and noted which of the elements they judged it to be investigating. The matrices were compared and any discrepancies were removed. A second draft of questions was produced and the process repeated until consensus was attained. The final questions are shown in Table 2 and further details of survey development are available from the authors.



*Focus group questions.* We developed semi-structured questions using the theoretical framework of the COM-B behaviour change model (Table 3). We used these questions to explore barriers and enablers to participants' capability, opportunity and motivation to engage with the lifestyle and dietary recommendations.

## **Analysis**

*Quantitative.* We used SPSS version 25. We described the data using standard summary statistics. Our main outcome was whether or not participants reported making lifestyle or dietary changes after engaging with the eHealth tool. In an exploratory analysis, we investigated how responses on the COM-B questionnaire predicted this main outcome. First, we examined univariate relationships with the questions in the COM-B questionnaire. Then we used multiple logistic regression, with our main outcome as the dependent variable and all the COM-B questions, age and gender, as independent variables. Correlations among these variables were investigated and no multi-collinearity was identified (defined as  $r < 0.7$ ). Due to multiple testing we set the level of significance as  $p < 0.01$ .

*Qualitative.* We used NVivo software (QSR International Pty Ltd. Version 10) to support the coding process. Two independent researchers analysed the transcripts. Thematic analysis was conducted based on the methodology outlined by Braun & Clarke (18).

## **Results**

*Participant characteristics.* Of 33,000 eCFT users who were sent the survey link, 4826 (14.6%) responded. Most respondents were female (73%), white (83%) and from the UK (68%) (see Table 4 for further demographic information).

In the focus groups we included 24 participants across four focus groups: comprising 9, 4, 5 and 6 people (mean age = 59; 19 female). All participants were white British, spoke English as their first language and were UK residents. 65% of participants had an immediate family member who had been diagnosed with dementia.

## **Quantitative measures**

### **User perceptions (Table 1)**



Of those who responded, 88.2% reported that the eHealth intervention was useful. 79.2% perceived the information as novel; 87.3% found it useful in understanding how to be proactive in maintaining healthy cognitive function; 81.2% reported that it increased their awareness of risk factors associated with Alzheimer's (Table 1).

### **Reported responses to cognitive, dietary and lifestyle feedback**

3901/4826 (81%) of respondents gave some information regarding their responses to the feedback they received. Over a third of respondents (37%; 1248/3353) reported making changes to their lifestyle or diet. Few people visited a health professional (5%; 192/3886); while 36% (1199/3382) reported feeling more fearful about their own risk of cognitive decline, and 38% (1265/3355) reported that it had prompted them to undertake their own research into the risk factors associated with dementia and Alzheimer's.

### **Behavioural determinants of engagement with the recommendations**

We report how participants' responses on the COM-B questionnaire related to their likelihood of making lifestyle or behavioural changes in Table 2. In our multiple logistic regression model (Nagelkerke  $R^2 = .226$ ), women were more likely to make changes to their behaviour (OR = 1.35, 95% CI = 1.09, 1.69,  $p=0.007$ ). Nine areas were identified as being significant behavioural change predictors of engagement with recommendations (see also Table 5).

*Capability.* Perceiving the protective cognitive health behaviours as achievable (OR= 1.54, 95% CI= 1.30, 1.82,  $p<0.001$ ) predicted increased odds of behaviour change whereas perceiving them as not making any difference in reducing risk of dementia (OR= 0.76, 95% CI= 0.68, 0.85,  $p<0.001$ ) predicted diminished odds.

*Opportunity.* Counterintuitively, those who indicated they had a disability which prevented them from engaging with the recommended behaviours showed *increased* odds of behaviour change (OR= 1.18, 95% CI= 1.05, 1.30,  $p=0.003$ ).

*Motivation.* Those who answered positively to the statement 'I'm fixed in my ways and don't like changing my habits' showed diminished odds of engaging with the protective cognitive health behaviours (OR= 0.86, 95% CI= 0.78, 0.95,  $p=0.005$ ). Trusting the eCFT result as being a good indicator of memory status (OR= 1.39, 95% CI= 1.20, 1.59,  $p<0.001$ ), seeing headlines about dementia and being concerned about their risk (OR= 1.35, 95% CI = 1.22, 1.49,  $p<0.001$ ), and seeing the changes as goals in managing risk factors (OR=1.85, 95% CI=



1.56, 2.17,  $p < 0.001$ ) all predicted increased odds of behaviour change. Two elements within motivation, wanting to make provisions for the future and making a concerted effort to be physically and mentally healthy, were not predictive of behaviour change.

### **Thematic analysis.**

We identified barriers to engagement in all three COM-B domains: 1. A feeling that information was “nothing new” (capability), 2. A sense that “experts don’t agree” (motivation), 3. Concerns that the tool may not be credible (motivation), 4. Users wanting support (capability), 5. Availability of food (opportunity).

#### *1. A feeling that knowledge presented was “nothing new”*

This acted as a barrier to engagement with the tool as participants did not perceive the information to be new or specifically tailored to preventing Alzheimer’s disease. It was deemed too commonplace and similar to any other diet and lifestyle advice.

P1: “I mean that’s not necessarily to do with Alzheimer’s or anything else, that’s...

P2: “That’s on every diet sheet”

P1: (Laughs) “Yeah...”

P3: “I mean, if it were a project about cancer prevention it would have very similar and we all know about this...”

P2 & P4: “Yes, yeah.”

#### *2. A sense that “experts don’t agree” about how best to promote cognitive health*

Users reported that in recent years there has been an increase in the number of news articles relating to dementia risk and prevention, which has exacerbated their awareness and driven their motivation to do something about it. However, this wealth of information has also led to uncertainty in relation to what recommendations and advice to follow. Users reported that due to this overabundance and contradictory information, they were very uncertain of who or what to believe.

P2: “It’s confusing, it’s very confusing... it depends on what piece of research, or the latest research...”



There was also a sense that amongst such a wealth of experts there was no consensus of how to address the best way to offset dementia. The resultant feeling of helplessness was seen to affect people's levels of motivation to engage with any recommendations.

P20: "I think... right now... a lot of people are at the stage where they think... They can't agree... how am I supposed to know if... if the experts can't agree..."

### *3. Concerns that the tool, may not be credible*

Users also felt unsure in relation to the evidence behind each of the recommended suggestions and real consequences of some of them, for example those related to B vitamins. There was also a sense that the tool may not be credible.

P12: "It made me think the whole questionnaire was made to be a means of seeking a drug... that's where my... I felt... less inclined to take it all (laughs)..."

P7: "I am now taking erm... lots of vitamins, B6, B12, folic acid and so on in the hope that this might have something to do with it but... what do I know?"

### *4. Users wanting support.*

Users felt that support following completion of the online cognitive health tool would have been helpful.

P9: "After receiving the recommendation, there is nothing to track how well you are doing, only doing the test after a year, I was very frustrated as test after a year was worse but I really tried to follow the recommendations but nothing helps you to track that."

Participants also felt that having other people sharing how to incorporate the protective behaviours in their life could save them time in planning and it would guide them to make engagement more realistic.

P10: "I didn't have any support from others after the recommendations,... it would be beneficial to have... that conversation with others following test because you can have your eyes opened because... And that is an eye-opener for me."

### *5. Availability of food*



Across the four focus groups, users consistently discussed perceived barriers to particular types of foods, which are available for ready consumption. Participants reported that food readily available is often high in sugars and made from highly refined ingredients. This was perceived as reducing their control over personal choices, which in turn influenced patterns of food purchase and consumption. Users felt that the availability of high quality and reasonably priced 'healthy' food is constrained by external factors out of their control and much more limited for those who live in low-income salaries and guided by a tight budget and that this constraint may be presented as an obstacle for following the recommended behaviours.

P18: "Every snack you get is b... is based around bread or wrapped as a sandwich or a wrap or it's a pitta bread... you know, it's a... bread bread bread bread bread.."

## **Discussion**

Most users perceived the online cognitive health tool to be useful and over a third reported making a lifestyle or dietary change because of the feedback they received. The COM-B model is part of the Behaviour Change Wheel (BCW) (14,15), designed to help intervention developers move from a behavioural analysis of the problem to intervention design using the evidence base. We identified several potential areas within the COM-B model that could be incorporated with the existing eHealth intervention to maximise engagement and bring about change; this linking of theory with intervention design is consistent with MRC guidance (19, 20). We found that perceptions of achievability are important for user engagement with the protective cognitive health behaviours (21, 22). Long and short term goals have different motivational potentials, focusing on mastery and performance, respectively (23). Whilst maintaining cognitive function is the optimum outcome, mastery of shorter-term performance goals might be more tangible in people's minds. As e-Health tools have the potential to provide tailored interventions, it may help to consider how to address these two differing motivations to better foster behaviour change (24).

Perhaps counterintuitively, those who indicated they had a disability which prevented them from engaging with the recommended behaviours showed increased odds of behaviour change. This could indicate that the intervention was helpful in engendering a sense of achievability of change and cognitive wellbeing among people with pre-existing health conditions, which they might have been more likely to perceive as precluding cognitive health before using the tool. It is also possible that this finding is an artefact of how we



phrased the question, as in retrospect we acknowledge there was room for confusion about whether we were, in the question 'I have a disability which prevents me from adopting the suggested diet and lifestyle changes' asking about presence of a disability as opposed to whether disability was a barrier to change.

While 37% of participants made changes following receipt of the tailored recommendations, the majority did not. Insights from the focus groups highlighted the need for ongoing validation and reminders, and follow up techniques to maximise engagement from the eHealth intervention. Our findings confirm that habits are important factors to consider to maximise engagement: those who answered positively to 'I'm fixed in my ways and don't like changing my habits' showed diminished odds of engaging with the protective cognitive health behaviours. As habits are automatic responses to specific cues (25) and have been shown to override intention (26), the mere proposal of a behaviour may not be enough to ensure change. As the median time for formulation of new habits is 66 days (27), an ongoing support mechanism supporting behavioural regulation, delivered via social media or mobile application, could enhance engagement (28).

Awareness of dementia (from headlines or family experience) increased the likelihood of behavioural change: our findings suggest that changes were also facilitated when the tool was perceived as credible, evidence-based and recommended changes were considered to be important. Although a high percentage of survey participants perceived the information to be novel and useful, qualitative respondents described feeling uncertain of who or what to believe. Trust of a source might be influenced in various ways, such as 'Information Overload' (29), whereby a large proliferation of information causes people to feel a diminished sense of trust in any individual source. Users reported a sense of helplessness influenced by the abundance of conflicting information readily available. The advice given by the host charity broadly aligns with current UK government guidelines, though there is one notable discrepancy: current recommendations do not advise that everyone takes B vitamin supplements (30). The advice may have been perceived as more credible if it had been endorsed by a national organisation such as the NHS; and this may have increased uptake of the advice. Qualitative findings also revealed the type of food readily available as a barrier to engagement with the suggested dietary and lifestyle changes. This study was undertaken prior to the introduction of the 'sugar tax' in the UK (April 2018) which has had an influence on the content of 'grab and go' food stands; this resulted in at least 50% of beverage manufacturers reducing the sugar content of their products (31).



A meta-analysis of interactive health communication applications showed they improved users' knowledge, social supports, health behaviours and clinical outcomes (32). The risks associated with the burgeoning availability of internet health tools must be acknowledged. Even though the advice presented was standard and in-line with most other sources of health advice in the area of cognitive health, over a third of users reported feeling more fearful after the intervention, highlighting the importance of planning after-care.

This study presents some limitations. The sample was not designed to be, and was not, representative of the general population. While the survey response rate (14.6%) is low compared to more traditional mail-out techniques (33), in the case of an external survey such as this it can be considered an acceptable rate of response (34).

## **Conclusion**

We need to understand the most effective ways to engage users with online health promotion tools (eHealth) in order to maximise their impact on public health. The COM-B model of behaviour change has been a useful framework for understanding users' perceptions of, and the psychological determinants influencing engagement with, the eHealth intervention. Interventions should focus on incorporating intervention functions that focus on increasing feelings of capability and motivation within users. Future e-health tools will be most effective if they have high credibility; demonstrate advice is evidence based; and provide ongoing support and feedback.

## **Ethics approval and consent to participate**

Ethical approval was granted by the University College London ethics committee, reference CEHP/2016/550.

Written informed consent to participate in the study was obtained for all participants.

## **Consent for publication**

Not applicable.

## **Availability of data and materials**

The data generated and analysed during the current study has been anonymised and it is available contacting the authors.



**Competing interests**

The authors declare that they have no competing interests.

**Funding**

Funding for the research costs of this study was provided by Food for the Brain research award. Food for the Brain was completely independent and was not involved in the design of the study, data collection, analysis, and interpretation of data or in writing the manuscript.

**Authors' contributions**

EA and CC collected and analysed the data, and wrote the manuscript. JS revised the topic guides and the manuscript. EA and GC conceived and designed the study. EA gained funding for the study from Food for the Brain, supervised the entire process of conducting the study, and also reviewed and approved the final manuscript. FP was involved in the process of data cleaning and statistical analysis. CC, FP, CCoo and MB were also involved in drafting the manuscript. All authors commented on the manuscript, revised it critically for intellectual input and took part in the design and delivery of the study.

**Acknowledgements**

The authors would like to express gratitude to Food for the Brain for their engagement in this project and for providing access to their participant research database. Also the North East London NHS Foundation Trust (NELFT) for the use of their Survey Monkey account and facilities and finally to all participants.



## References

1. Hughes TF, Andel R, Small BJ, Borenstein AR, Mortimer JA, Wolk A, et al. Midlife fruit and vegetable consumption and risk of dementia in later life in Swedish twins. *The American journal of geriatric psychiatry* [Internet]. 2010 May 1;18(5):413-20. Available from: doi:10.1097/jgp.0b013e3181c65250
2. Livingston G, Huntley J, Sommerlad A, Ames D, Ballard C, Banerjee S, et al. Dementia prevention, intervention, and care: 2020 report of the Lancet Commission. *The Lancet* [Internet]. 2020 Aug 8;396(10248):413-46. Available from: doi:10.1016/s0140-6736(20)30367-6
3. Beydoun MA, Beydoun HA, Gamaldo AA, Teel A, Zonderman AB, Wang Y. Epidemiologic studies of modifiable factors associated with cognition and dementia: systematic review and meta-analysis. *BMC public health* [Internet]. 2014 Dec 1;14(1):643. Available from: doi:10.1186/1471-2458-14-643
4. Whitty E, Mansour H, Aguirre E, Palomo M, Charlesworth G, Ramjee S, et al. Efficacy of lifestyle and psychosocial interventions in reducing cognitive decline in older people: systematic review. *Ageing Research Reviews* [Internet]. 2020 Jun 10;101113. Available from: doi:10.1016/j.arr.2020.101113
5. Barnes DE, Yaffe K. The projected effect of risk factor reduction on Alzheimer's disease prevalence. *The Lancet Neurology* [Internet]. 2011 Sep 1;10(9):819-28. Available from: doi:10.1016/s1474-4422(11)70072-2
6. Fratiglioni L, Qiu C. Prevention of cognitive decline in ageing: dementia as the target, delayed onset as the goal. *The Lancet Neurology* [Internet]. 2011;9(10):778-9. Available from: doi:10.1016/s1474-4422(11)70145-4
7. Ngandu T, Lehtisalo J, Solomon A, Levälähti E, Ahtiluoto S, Antikainen R, et al. A 2 year multidomain intervention of diet, exercise, cognitive training, and vascular risk monitoring versus control to prevent cognitive decline in at-risk elderly people (FINGER): a randomised controlled trial. *The Lancet* [Internet]. 2015 Jun 6;385(9984):2255-63. Available from: doi:10.1016/s0140-6736(15)60461-5
8. Kivipelto M, Solomon A, Ahtiluoto S, Ngandu T, Lehtisalo J, Antikainen R, et al. The Finnish geriatric intervention study to prevent cognitive impairment and disability (FINGER): study design and progress. *Alzheimer's & Dementia* [Internet]. 2013 Nov 1;9(6):657-65. Available from: doi:10.1016/j.jalz.2012.09.012
9. Ahern DK. Challenges and opportunities of eHealth research. *American journal of preventive medicine* [Internet]. 2007 May 1;32(5):S75-82. Available from: doi:10.1016/j.amepre.2007.01.016
10. Schoffman DE, Turner-McGrievy G, Jones SJ, Wilcox S. Mobile apps for pediatric obesity prevention and treatment, healthy eating, and physical activity promotion: just fun and games?. *Translational behavioral medicine* [Internet]. 2013 Sep 1;3(3):320-5. Available from: doi:10.1007/s13142-013-0206-3



11. Abraham C, Kelly MP, West R, Michie S. The UK National Institute for Health and Clinical Excellence public health guidance on behaviour change: a brief introduction. *Psychology, health & medicine* [Internet]. 2009 Jan 1;14(1):1-8. Available from: doi:10.1080/13548500802537903
12. Nigg CR, Allegrante JP, Ory M. Theory-comparison and multiple-behavior research: common themes advancing health behavior research. *Health Education Research* [Internet]. 2002 Oct 1;17(5):670-9. Available from: doi:10.1093/her/17.5.670
13. Michie S, Abraham C. Interventions to change health behaviours: evidence-based or evidence-inspired?. *Psychology & Health* [Internet]. 2004 Feb 1;19(1):29-49. Available from: doi:10.1080/0887044031000141199
14. Michie S, Atkins L, West R. The behaviour change wheel: a guide to designing interventions. 2014. Great Britain: Silverback Publishing. 2015.
15. Michie S, Van Stralen MM, West R. The behaviour change wheel: a new method for characterising and designing behaviour change interventions. *Implementation science* [Internet]. 2011 Dec 1;6(1):42. Available from: doi:10.1186/1748-5908-6-42
16. Trustram Eve C, de Jager CA. Piloting and validation of a novel self-administered online cognitive screening tool in normal older persons: the Cognitive Function Test. *International journal of geriatric psychiatry* [Internet]. 2014 Feb;29(2):198-206. Available from: doi:10.1002/gps.3993
17. Cooper C, Sommerlad A, Lyketsos CG, Livingston G. Modifiable predictors of dementia in mild cognitive impairment: a systematic review and meta-analysis. *American Journal of Psychiatry* [Internet]. 2015 Apr 1;172(4):323-34. Available from: doi:10.1176/appi.ajp.2014.14070878
18. Braun V, Clarke V. Using thematic analysis in psychology. *Qualitative research in Psychology* [Internet]. 2006 Jan 1;3(2):77-101. Available from: doi:10.1191/1478088706qp063oa
19. Campbell M, Fitzpatrick R, Haines A, Kinmonth AL, Sandercock P, Spiegelhalter D, et al. Framework for design and evaluation of complex interventions to improve health. *Bmj* [Internet]. 2000 Sep 16;321(7262):694-6. Available from: doi:10.1136/bmj.321.7262.694
20. Craig P, Dieppe P, Macintyre S, Michie S, Nazareth I, Petticrew M. Developing and evaluating complex interventions: the new Medical Research Council guidance. *Bmj* [Internet]. 2008 Sep 29;337. Available from: doi:10.1136/bmj.a1655
21. Butler CC, Simpson SA, Dunstan F, Rollnick S, Cohen D, Gillespie D, et al. Effectiveness of multifaceted educational programme to reduce antibiotic dispensing in primary care: practice based randomised controlled trial. *Bmj* [Internet]. 2012 Feb 2;344:d8173. Available from: doi:10.1136/bmj.d8173
22. Klasnja AV, Popadic Gacesa J, Barak O, Karan V. Peak cardiac power output and cardiac reserve in sedentary men and women. *Periodicum biologorum*. 2014 Mar 31;116(1):59-63.



23. Dweck CS. Motivational processes affecting learning. *American psychologist* [Internet]. 1986 Oct;41(10):1040. Available from: doi:10.1037/0003-066x.41.10.1040
24. Noar SM, Benac CN, Harris MS. Does tailoring matter? Meta-analytic review of tailored print health behavior change interventions. *Psychological bulletin* [Internet]. 2007 Jul;133(4):673. Available from: doi:10.1037/0033-2909.133.4.673
25. Verplanken B, Aarts H. Habit, attitude, and planned behaviour: is habit an empty construct or an interesting case of goal-directed automaticity?. *European review of social psychology* [Internet]. 1999 Jan 1;10(1):101-34. Available from: doi:10.1080/14792779943000035
26. de Bruijn GJ, Kremers SP, Singh A, Van den Putte B, Van Mechelen W. Adult active transportation: adding habit strength to the theory of planned behavior. *American journal of preventive medicine* [Internet]. 2009 Mar 1;36(3):189-94. Available from: doi:10.1016/j.amepre.2008.10.019
27. Lally P, Van Jaarsveld CH, Potts HW, Wardle J. How are habits formed: Modelling habit formation in the real world. *European journal of social psychology* [Internet]. 2010 Oct;40(6):998-1009. Available from: doi:10.1002/ejsp.674
28. Wasson JH, Forsberg HH, Lindblad S, Mazowita G, McQuillen K, Nelson EC. The medium is the (health) measure: patient engagement using personal technologies. *The Journal of ambulatory care management* [Internet]. 2012 Apr 1;35(2):109-17. Available from: doi:10.1097/jac.0b013e31824a235e
29. Klerings I, Weinhandl AS, Thaler KJ. Information overload in healthcare: too much of a good thing?. *Zeitschrift für Evidenz, Fortbildung und Qualität im Gesundheitswesen* [Internet]. 2015 Jan 1;109(4-5):285-90. Available from: doi:10.1016/j.zefq.2015.06.005
30. National Health Service. B vitamins and folic acid. [Internet]. 2010 [cited 2020 August 14]. Available from: <https://www.nhs.uk/conditions/vitamins-and-minerals/vitamin-b/>.
31. Treasury HM. The soft drinks industry levy. [Policy paper on the internet]. 2016 [cited 2020 September 15]. Available from: [www.gov.uk/government/publications/soft-drinks-industry-levy/soft-drinks-industry-levy](http://www.gov.uk/government/publications/soft-drinks-industry-levy/soft-drinks-industry-levy)
32. Murray E, Burns J, Tai SS, Lai R, Nazareth I. Interactive Health Communication Applications for people with chronic disease. *Cochrane database of systematic reviews* [Internet]. 2005(4). Available from: doi:10.1002/14651858.cd004274.pub3
33. Henry RC, Zivick JD. Principles of survey research. *Family practice research journal*. 1986;5(3):145.
34. Fan W, Yan Z. Factors affecting response rates of the web survey: A systematic review. *Computers in human behaviour* [Internet]. 2010 Mar 1;26(2):132-9. Available from: doi:10.1016/j.chb.2009.10.015



Table 1. Summary of user perceptions of the online cognitive health tool, and reported responses to the recommended dietary and lifestyle changes.

		Responding to question N (%)	Responding yes N (%)
<b>Test utility</b>	<i>I found the Cognitive Function Test useful</i>	3873/4826 (80.3)	3416/3873 (88.2%)
	<i>The information provided on the test was new to me</i>	3878/4826 (80.4)	3072/3878 (79.2%)
	<i>Taking the test increased my awareness of the risk factors associated with Alzheimer's</i>	3870/4826 (80.2)	3143/3870(81.2%)
	<i>Taking the test helped me understand that I can be proactive in reducing my risk of developing Alzheimer's</i>	3849/4826 (79.8)	3360/3849 (87.3%)
<b>Test effects/ Repercussions</b>	<i>After taking the test I visited a health professional to discuss my cognitive score</i>	3886/4826 (80.5)	192/3886 (4.9%)
	<i>After taking the test I made changes to my diet and lifestyle</i>	3353/4826 (69.5)	1248/3353 (37.2%)
	<i>After taking the test I undertook my own research into risk factors associated with Alzheimer's</i>	3355/4826 (69.5)	1265/3355 (37.7%)
	<i>Taking the test made me more fearful about my own risk of cognitive decline</i>	3382/4826 (63.7)	1199/3382 (35.5%)



Table 2. Univariate relationships between COM-B survey results and reporting making dietary or lifestyle changes following receipt of tailored dietary and lifestyle advice.

	Made changes	% giving response <sup>a</sup>					Chi2 (p)	
		1	2	3	4	5		
CAPABILITY	I felt the suggested diet and life style changes were achievable	Yes	0.6	0.8	10	70.6	18	298.3 (p<0.001)
		No	0.7	2.4	37.4	49.8	9.7	
	I could easily incorporate the suggested diet and lifestyle changes into my daily routine	Yes	0.5	3.9	14.9	65.3	15.4	191.9 (p<0.001)
		No	0.8	5.3	37.1	48.2	8.6	
	I am capable of making changes in my life	Yes	0.6	0.8	3.5	67.2	28	76.3 (p<0.001)
		No	1.1	1.8	11.7	64.1	21.3	
	I understood what actions would be required to achieve the suggested diet and lifestyle changes	Yes	0.8	1.1	7.2	69.8	21.1	155.7 (p<0.001)
		No	1.2	2.9	23.1	60.1	12.8	
	I thought adopting the suggested diet and lifestyle changes would create physical problems for me	Yes	24.8	48.1	16.7	8.5	1.9	98.7 (p<0.001)
		No	16.7	42.1	32.5	6.7	1.9	
	I feel I am capable of reducing my risk of dementia	Yes	1.0	5.2	25.8	56.8	11.1	62.9 (p<0.001)
		No	2.4	7.7	36.5	44.8	8.6	
OPPORTUNITY	I did not feel that the suggested diet and lifestyle changes would make any difference in reducing my risk of dementia	Yes	18.7	45.7	28.4	6.3	0.9	175.0 (p<0.001)
		No	9.2	30.7	47.2	10.8	2.1	
	I have a disability which prevents me from adopting the suggested diet and lifestyle changes	Yes	50.0	35.8	8.4	4.4	1.3	8.9 (p=0.06)
		No	48.8	33.5	11.6	5.1	1.0	
	Adopting the suggested diet and lifestyle changes would have been too expensive	Yes	22	42.9	26.6	7.4	1.2	43.6 (p<0.001)
		No	17.3	36.1	38.3	7.3	1.0	
	I felt I had sufficient social support to make the recommended diet and lifestyle changes	Yes	3.3	10.5	34.3	42.9	9.0	79.9 (p<0.001)
		No	3.5	11.7	49.4	29.9	5.5	
	I felt unsure whether adopting the suggested diet and lifestyle changes would be possible, given my hobbies and interests	Yes	16.6	48.8	26.4	7.7	0.5	124.4 (p<0.001)
		No	12.1	32.4	46.0	8.8	0.7	
	I don't like going to the doctor	Yes	9.4	21.3	28.3	29.1	11.8	0.994 (p=0.91)
		No	8.6	21.6	28.0	30.4	11.4	



I make a concentrated effort to be physically and mentally healthy	Yes	0.4	1.9	9.2	61.5	27.1	41.810 (p<0.001)
	No	0.6	5.3	14.5	53.7	26.0	
I want to reduce my risk of Alzheimer's as I don't want to be a burden to my family	Yes	0.5	0.6	4.6	45.8	48.4	66.696 (p<0.001)
	No	0.6	1.2	12.3	49.2	36.7	
I want to manage the risk factors associated with Alzheimer's	Yes	0.4	0.2	1.7	57.6	40.1	94.385 (p<0.001)
	No	0.3	0.6	9.7	60.8	28.5	
I like the suggested diet and lifestyle changes as they gave me something to aim for in managing risk factors associated with Alzheimer's	Yes	0.3	1.5	16.0	62.4	19.8	354.1 (p<0.001)
	No	0.6	4.6	48.2	37.8	8.8	
Someone in my family had dementia so I wanted to know my own level of risk	Yes	14.0	20.7	10.4	30.8	24.2	45.989 (p<0.001)
	No	16.6	25.5	15.3	26.1	16.4	
I'm fixed in my ways and don't like changing my habits	Yes	24	45.2	20.6	8.8	1.5	67.764 (p<0.001)
	No	17.5	36.9	26.7	16.8	2.1	
I've been seeing headlines about dementia which made me concerned about my own risk	Yes	2.2	11.8	27.8	48.1	10.1	73.857 (p<0.001)
	No	5.6	16.5	34.9	37.5	5.5	
I want to make provisions for my future as I get older	Yes	0.5	1.0	11.1	63.0	24.4	45.732 (p<0.001)
	No	0.8	2.9	18.3	59.3	18.6	
I trusted the CFT result as being a good indicator of my memory status	Yes	0.5	1.7	22.2	62.5	13.0	128.4 (p<0.001)
	No	1.2	4.9	39.1	47.6	7.2	

<sup>a</sup> Participants scored their agreement with statements on a Likert scale (1=Strongly disagree, 2=Disagree, 3=Neither agree nor disagree, 4=Agree, 5=Strongly agree).



Table 3. Topic guide used in the focus groups.

	COM-B model domain	Question
Pre-test	Capability	What was your personal impression of what could be done about Alzheimer's Disease/dementia prior to taking the test?
	Opportunity	What were your thoughts at that time about who or what might affect your ability to reduce your risk of cognitive decline?
	Motivation	How would you describe what drove you to take a cognitive test in the first instance?
Test	Capability	Did you feel you knew what you had to do in the test, and that you would be able to do it? Was the information clear, was there enough or too much? Was the terminology simple enough, or not complex enough?
	Opportunity	Was there anything which made doing the test easy/difficult?
	Motivation	How did you find doing the test? What would make the test more appealing?
Post-test	Capability	After the test, did you feel any differently about what you could do to influence your risk of cognitive decline? Which of the 6 steps did you find most surprising and which do you feel warranted the most attention?
	Opportunity	Following the test, what factors do you feel are most influential in your adoption or non-adoption of the suggested diet and lifestyle changes?
	Motivation	After the test, did you feel any differently about what you could do to influence your risk of cognitive decline?



Table 4. Sociodemographic data of participants in the online survey.

		Frequency	
		N	%
Age	50 - 55	1627	33.7
	56 - 60	1560	32.3
	61 – 65	1391	28.8
	Missing	248	5.1
Gender	Female	3525	73.0
	Male	1046	21.7
	Missing	255	5.3
Place of birth	UK	3262	67.6
	Europe	170	2.5
	USA	510	10.57
	Other	587	12.2
	Missing	297	6.2
Ethnicity	White	4185	86.7
	Asian	55	1.1
	African	21	0.4
	Other	287	6.0
	Missing	278	5.8
Education level	Undergraduate degree	1265	26.2
	Postgraduate degree	1094	22.7
	Diploma	789	16.4
	A-level (or equivalent)	498	10.3
	GCSE (or equivalent)	604	12.5
	Trade certificate/Apprenticeship	280	5.8
	Other	59	1.2
	Missing	237	4.9
Employment status	Full-time	1564	34.3
	Part-time	939	19.5
	Retired	1160	24.0
	Student	19	0.4
	Unemployed	132	2.7
	Other	686	14.2
	Missing	236	4.9
Family history of dementia	No	2438	50.5
	Yes	2086	43.2
	Missing	302	6.3



Table 5. Results of logistic regression showing predictors of making dietary or lifestyle change following tailored recommendations.

		Unadjusted OR (95% CI)
	Female gender	1.35 (1.09, 1.69)*
Capability	I felt that the suggested diet and lifestyle changes were achievable	1.54 (1.30, 1.82)**
	I did not feel that the suggested diet and lifestyle changes would make any difference in reducing my risk of dementia	0.76 (0.68, 0.85)**
Opportunity	I have a disability which prevents me from adopting the suggested diet and lifestyle changes	1.18 (1.05, 1.30)*
Motivation	I make a concerted effort to be physically and mentally healthy	1.15 (1.01, 1.32)
	I like the suggested diet and lifestyle changes as they gave me something to aim for in managing risk factors associated with Alzheimer's	1.85 (1.56, 2.17)**
	Someone in my family had dementia so I wanted to know my own level of risk	1.10 (1.03, 1.18)*
	I'm fixed in my ways and don't like changing my habits	0.86 (0.78, 0.95)*
	I've been seeing headlines about dementia which made me concerned about my own risk	1.35 (1.22, 1.49)**
	I want to make provisions for my future as I get older	1.18 (1.02, 1.36)
	I trusted the CFT result as being a good indicator of my memory status	1.39 (1.20, 1.59)**

\* $p < 0.01$

\*\* $p < 0.001$

Parekh, S., Vandelanotte, C., King, D., & Boyle, F. M. (2012, Sep 11). Improving diet, physical activity and other lifestyle behaviours using computer-tailored advice in general practice: a randomised controlled trial. *Int J Behav Nutr Phys Act*, 9, 108. <https://doi.org/10.1186/1479-5868-9-108>