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ORIGINAL ARTICLE

The psychological determinants of making lifestyle and dietary behaviours after using an online cognitive health tool and its associated recommendations for protective cognitive health behaviours

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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).

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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.

Introduction

Lifestyle and environmental influences on brain health are increasingly recognized.[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.[16] The current study is, to our knowledge the first to use mixed methods to explore what determines whether and how such advice is adopted.

Our study objective was to explore how users of an online ehealth tool responded to and engaged with the advice they received. In an eHealth tool created by the not-for-profit organisation Food for the Brain, users undertook a validated online cognitive test (CFT)[17] 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[18]: (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

Participants who completed the Cognitive Function test and associated lifestyle questionnaire were invited to take part on this study.

Focus groups

Two facilitators ran the focus groups, which lasted one hour, using semi-structured questions. These involved questionaos in relation to the Cognitive Function Test and the Lifestyle questionanaire.

The Cognitive Function Test (CFT) is a self-administered online test designed to assess various cognitive domains; executive function, episodic memory and processing speed.[17] The CFT has been validated in a pilot study against pen and paper tests used in memory clinics nationally. Strong correlations ($r = .75$) between pen and paper tests and the CFT show concurrent validity and the four subtests and total CFT show good internal consistency (Cronbach's Alpha = 0.73).[17]

The CFT produces a composite score of these domains at the end of the test and this score was provided to the participant. This is considered in relation to one's age and classified into one of three categories: (1) Green: Little or no cognitive impairment (CFT score range: 110—43), (2) Amber: Potential risk for cognitive impairment (CFT score range: 42—38), (3) Red: Mild Cognitive Impairment (CFT score range: $\leq$37). Participants were informed that an amber and red rating indicates an individual is performing below the expected cognitive functioning for their age and that a green rating indicates an individual is performing as expected for their age. A series of recommendations followed the test results based on the scores and areas highlighted in the lifestyle questionnaire.

A questionnaire investigating lifestyle behaviours followed the CFT. It is a self-reported questionnaire identifying the frequency of various lifestyle habits identified as potential risk factors for AD.[2] At the end of the CFT, tailored lifestyle advice is provided online, covering six prevention areas: physical, social and mental activity, B vitamins, caffeine, antioxidant, sugar and fish and seeds intake. In addition to a CFT RAG rating, individuals also receive a Red, Amber, or Green (RAG) rating for each domain for their lifestyle habits and a personalised lifestyle prevention plan highlighting their weakest area in relation to prevention steps which they were emailed. This was calculated based on a weighted score for each individual, generated within the FFB online test. However, the computation of the weighted score is the intellectual property of FFB and was not available for this project. As there was limited publicly available information to determine how or why specific weightings were used, the CHEB RAG rating was not utilised for this project. Instead, the raw score for each question was used and a total score was calculated. The higher the score, the better an individual has performed on the given lifestyle behaviour. The range of scores for each lifestyle category were: sugar (4–20), fish (4–20), antioxidants (6–30), caffeine (5–25), B vitamins (6–30), social stimulation (4–20) and exercise (3–15). Psychometric properties were not available for this scale as it has not been previously validated.

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:

"02" *Sociodemographic:* we asked their age, gender, nationality, ethnicity, highest level of education, employment status and family history of dementia.

"02" *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).

"02" *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

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

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 Lts. 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, $p = 0.007$). Of the 21 areas entered into our regression, 9 were included in the final model model that predicted making lifestyle changes (see also Table 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[a]					Chi2 (p)
			1	2	3	4	5	
	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)
Capability		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	
	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	
Opportunity	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)
Motivation		No	0.3	0.6	9.7	60.8	28.5	

Table 2 (*Continued*)

	Made changes	% Giving response[a]					Chi2 (p)
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	

[a] 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?

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.

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

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.

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)**

* $p < 0.01$.
** $p < 0.001$.

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 is 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 break 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. This concurs with findings from a previous study indicating that people at risk of dementia are willing to adopt tailed, lifestyle advice.[1] This is, to our knowledge the first mixed methods study to explore the impact of advice from an online ehealth tool. 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.[20,21] We found that perceptions of achievability are important for user engagement with the protective cognitive health behaviours.[22,23] Long and short term goals have different motivational potentials, focusing on mastery and performance, respectively.[24] 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.[25]

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[26] and have been shown to override intention,[27] 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,[28] an ongoing support mechanism supporting behavioural regulation, delivered via social media or mobile application, could enhance engagement.[29]

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 in order to address a perceived current problem. This may also reflect a growing concern around the positioning of individuals as responsible for the management of risk factors and the prevention of illness through participation in practices of self-care. In other words, the potential stress that may be caused when dementia is presented as a problem for individuals to solve.[2]"

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',[30] 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.[31] 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.[32]

A meta-analysis of interactive health communication applications showed they improved users' knowledge, social supports, health behaviours and clinical outcomes.[33] 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.

Future e-health tools will be most effective if they have high credibility (linking to trusted information sources); demonstrate advice is evidence based; and provide ongoing support and feedback; and consider and mitigate as far as possible for the potential for increased anxiety through engaging with a dementia prevention tool.

This study presents some limitations. As the participants completed questionnaires and took part in focus groups 15–28 months after taking the test, recall bias is a significant limitation. On the other hand it is also worth noting that 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,[34] in the case of an external survey such as this it can be considered an acceptable rate of response.[35] Qualitative sampling strategies should be designed to be purposive rather than representative that is to encompass a broad range of perspectives; while we sought to recruit from diverse geographical areas, we were not able to explicitly purposively recruit to ensure different sociodemographic groups and other diversity were represented in our sample.

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.

Conflict of interest

The authors have no conflict of interest to declare.

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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.

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