Routledge
Taylor & Francis Group

RESEARCH ARTICLE

Supporting eating behaviour of community-dwelling older adults: co-design of an embodied conversational agent

Lean L. Kramer[a] , Marije Blok[b,c] , Lex van Velsen[d,e] , Bob C. Mulder[f] and Emely de Vet[a]

[a]Consumption and Healthy Lifestyles group, Wageningen University & Research, Wageningen, The Netherlands; [b]Department of Sociology, VU Amsterdam, Amsterdam, The Netherlands; [c]National Foundation for the Elderly, Amersfoort, The Netherlands; [d]Roessingh Research and Development, eHealth cluster, Enschede, The Netherlands; [e]Biomedical Signals and Systems Group, University of Twente, Enschede, The Netherlands; [f]Strategic Communication group, Wageningen University & Research, Wageningen, The Netherlands

ABSTRACT

In order to support community-dwelling older adults with healthy eating behaviours, Embodied Conversational Agents (ECAs) may be an effective and engaging medium. However, ECAs have not yet been found to be capable of engendering behaviour change, which is partly attributed to the absence of a match with users' practices, needs and preferences. Hence, we describe a co-design process with older adults that informs both the content and the appearance of an ECA. Data was gathered through three consecutive iterations of co-design sessions with two groups of community-dwelling older adults in the Netherlands. Prior to the first session, participants completed a seven-day lifestyle diary. This study adds knowledge on the meaning of healthy eating, as well as on specific barriers to, and opportunities for, giving advice using an ECA in this target group. Furthermore, we translate this knowledge into general advice for designing an ECA in the context of health behaviour change, while reflecting on a co-design process with older adults.

Introduction

To help prevent or reduce the risk of chronic disease, support a healthy body weight, and enhance quality of life, community-dwelling older adults are recommended healthy eating patterns (DeSalvo, Olson, and Casavale 2016; Govindaraju et al. 2018). In the Netherlands the National Health Council

summarizes scientific evidence into the guidelines for a healthy diet. These guidelines are communicated by nutrition agencies to general populations and specific groups (e.g. through the Wheel of Five from the Netherlands Nutrition Center). A recent review suggest that factors influencing eating behaviours among this group interact across three domains: physiological changes associated with ageing (e.g. taste, loss of appetite, and mobility limitations); psychosocial aspects (e.g. living alone, self-perceptions of health, and a desire to maintain independence), and personal resources (e.g. mobility and health literacy and skills) (Host et al. 2016). It is essential that interventions targeting eating behaviours of community-dwelling older adults consider these factors.

The use of digital technologies to improve health bears the potential to achieve this aim, and is gaining interest as a way to address health behaviour change. As such, in recent years, several eHealth interventions improving eating behaviour have seen the light of day (Gasser et al. 2006; Rabbi et al. 2015; Robinson et al. 2013). One specific type of eHealth technology are Embodied Conversational Agents (ECAs). ECAs can be defined as 'more or less autonomous and intelligent software entities with an embodiment used to communicate with the user' (Ruttkay and Pelachaud 2004). Because establishing and maintaining an empathic relationship is the most crucial factor for successful lifestyle coaching (Brandt et al. 2018), ECAs present a promising health coaching tool (Bickmore, Caruso, Clough-Gorr, and Heeren 2005; Provoost et al. 2017). In addition, compared to real-life coaches, ECAs are always available and can offer support when it matters most: immediately before or after specific behaviour (Brinkman 2016). ECAs have great potential among our target group as well, as earlier studies show high ratings of acceptance, enjoyment and usability of ECAs among older adults (Bickmore, Caruso, and Clough-Gorr 2005; Bickmore, Caruso, and Clough-Gorr 2005; Bickmore et al. 2013; Ponathil et al. 2020; ter Stal et al. 2020). An example is 'Sylvia', which can be seen in Figure 1 (ter Stal et al. 2020). Sylvia is part of a frailty assessment web app, and aims to counter frailty by offering older adults training modules in the domains of healthy nutrition and physical and cognitive training. However, although a recent review including 20 intervention studies shows that ECAs in the health context are more engaging then interventions without an ECA, they are not always successful in engendering an actual change in behaviour, knowledge or motivation (Kramer et al. 2020).

Despite the positive reactions from the target group towards ECAs, the technology is not yet successful in creating actual change. A recent review (Kramer et al. 2020) suggests that target groups own views are usually not sought to inform the design process of ECAs in the field of health behaviour change. This could result in a mismatch between the actual design and users' practices, needs and preferences, and therefore lower uptake and impact (van Gemert-Pijnen et al. 2011). Human-centred design (HCD) aims to diminish this mismatch
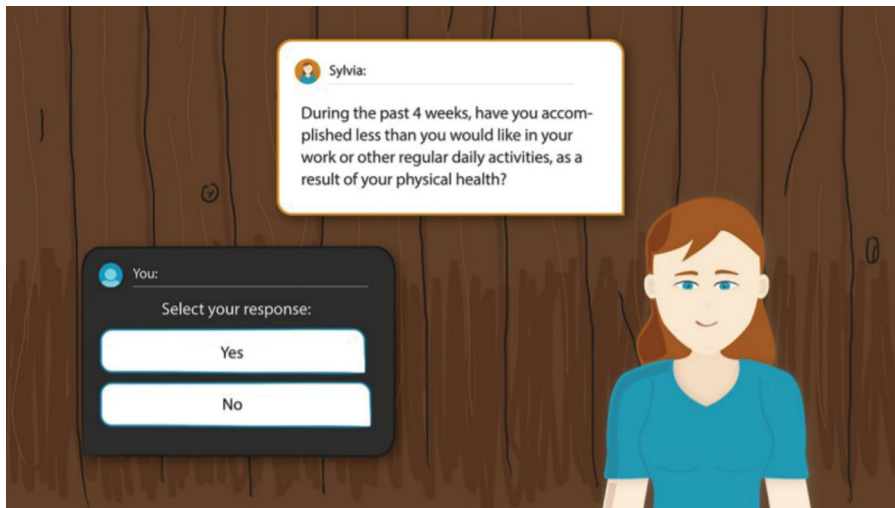
Figure 1. Example dialogue with 'Sylvia' (ter Stal et al. 2020).

through an iterative approach in which researchers and designers cooperate with, and learn from, potential users in all steps of the design process (Norman 2013). Cooperation can be operationalized via co-design, a creative process in which users, researchers and designers actively collaborate and jointly explore the needs and goals of the end-users and the technology. The process includes, for example, jointly exploring and envisioning ideas, creating and discussing sketches, and tinkering with mock-ups or prototypes (Steen 2011). Co-design is thus not simply asking users what they think of your design, but rather involving a group of users throughout the entire process and actively working together. This process is linked to an improvement in both impact and uptake of eHealth technologies (van Gemert-Pijnen et al. 2011).

Given the increasing prevalence of diet-related, noncommunicable diseases among community-dwelling older adults, and the potential of ECAs, there is a strong case for applying an ECA for supporting healthy eating behaviour. Therefore, the aim of the current paper is to describe a co-design process with older adults that informs both the content and the appearance of such an ECA. This study thus adds knowledge on the meaning of healthy eating, as well as on specific barriers to, and opportunities for, giving advice using an ECA in this target group. Furthermore, we translate this knowledge into general advice for designing an ECA in the context of health behaviour change, while reflecting on a co-design process with older adults.

Methods

Participants

In this study we involved community-dwelling older adults in the Netherlands. We defined community-dwelling older adults as people who

Table 1. Study setup, number of participants per session (session 1 and 2 were split) and aim.

	Participants		Aim
Diary	$N = 13$		Trigger participants to think about their lifestyle
Session 1	$N = 4$	$N = 8$	Identify factors contributing to healthy living and (un)healthy eating
Session 2	$N = 4$	$N = 7$	Explore healthy eating advice
Session 3	$N = 9$		Create the appearance of the ECA and its communication style

are retired and live at home. Participants were recruited in close collaboration with the National Foundation for the Elderly (NFE), a non-profit organization that aims to combat loneliness among older adults, via social activities and personal encounters. In this study we particularly involved participants of the 'community plus buses', as these are existing communities of people who conduct activities together. This made it easy for practical reasons as well as in organizing the discussions. We sent out an invitation to coordinators of these community plus buses. Two coordinators responded positively, one of whom was located in the country side, and the other one was located in an urban region. We asked these coordinators to invite participants for our co-design sessions, which took place at a cheese factory, farm/country store and the headquarters of the NFE. The two groups participated separately in a first and second session, and were merged for a third session (see Table 1). Not all participants were able to join all sessions, because of illness and planning issues.

Procedure

Two weeks prior to the first session, participants received an information package. This package contained an information leaflet, an informed consent form, a seven-day diary, and a disposable camera. Participants were asked to fill out the diary prior to the first session, and to bring the consent form, diary and camera. Participants were brought to the site where we held the session, subsequently received a lunch, and were then invited to join a fun activity (visiting a cheese factory and farm/country store). During all sessions, discussions were held as open as possible, by allowing participant to share any views and information they brought forward. Moreover, the moderators actively looked for the broadest range of perspectives, including opposing views. Each session lasted for approximately four hours. At the end of the last session, participants received a cook book to thank them for participation, and were offered a newsletter informing them about follow-up studies. The protocol and all research materials were submitted to and approved by the Social Ethical Committee of Wageningen University & Research (CoC number: 09215846).

Diary

The aim of the diary was to obtain background information of the partici-
pants, and to trigger participants to think about their lifestyle. For demo-
graphics, participants were asked about their gender, age, educational level,
household composition, marital status and number of children. To gain
insight in participants' lifestyle, a combination of questions (e.g. 'Are you sat-
isfied with your surroundings?') and assignments (e.g. a mind map) were
used, based on the six aspects of the Positive Health framework; bodily func-
tions, mental functions and perception, spiritual and existential health, qual-
ity of life, social and societal participation, and daily functioning (Huber et al.
2016). Via a daily food diary sheet, participants were asked to write down
what they consumed, with whom, by whom it was prepared, and whether
they ate differently to usual. In addition, participants were asked to take a
picture daily (e.g. of their plate or fridge), in order to visualize the food con-
text. The estimated time to fill out the diary was ten minutes a day.

Session 1

The aim of the first session was to identify and understand the factors contri-
buting to healthy living and (un)healthy eating, and the context in which
these take place. Apart from the introduction and conclusion, the session
consisted of two parts:

- Questions: 'What does a healthy lifestyle mean to you?' and 'What does
  healthy food mean to you?' Answers were first written down individually
  by participants, followed by a plenary discussion during which all answers
  were written down on a flip-chart by the moderator, thus creating a list
  of answers. Then, the favourite answers were chosen by the group.
- Assignment: Participants received answering sheets and sticky notes, and
  were asked to use their diary to categorize consumed foods and their
  degree of healthiness. They then were asked to add a description of the
  moment during which unhealthy items were consumed. Next, small
  groups were formed and participants provided advice to each other on
  the moments of unhealthy eating. The assignment was followed by a
  plenary discussion.

Session 2

The aim of the second session was to explore healthy eating advice consid-
ered suitable by older adults. The session consisted of the following ques-
tions and assignment:

- Questions: 'What would be the preferred way to approach you about
  healthy eating?' and 'What kind of tone of voice should these messages

Figure 2. Answer sheets sessions 2. *Note.* English translation: 'From whom would you like to receive tips and advice regarding healthy eating/living?' 'Which signal/sound/'tone of voice' do you prefer?' 'Sunday, Monday, Tuesday. Timeline'.

have and how does such a message reach you?' Answering sheets were provided (see Figure 2), and the assignment was followed by a plenary discussion.

- Assignment: Three personas and scripts (both based on the first session) were presented to subgroups. The central question was: 'What kind of advice could be given to the fictitious person in the story and what kind of signals/sounds/tone of voice (e.g. sound, vibration, voice; also see Figure 2) could become part of the storyline?' Participants received answering sheet containing a 7-day timeline (see Figure 2), which they were asked to fill in, in order to create an overview of the number, time, and type of healthy eating advice. All timelines were discussed afterwards in plenary.

Session 3

The aim of the third session was to create the appearance of the ECA and its communication style. Both groups were merged and, after an introduction, the session started by introducing and discussing the concept of the ECA, whereby no visuals were used. This session consisted of two assignments:

- Assignment 1: Visualize what an ECA should look like according to you. Magazines, scissors, pencils, tape and other tools were provided. After an hour, each participant was asked to explain his/her design choices and elaborate on the personality and role of their ECA.
- Assignment 2: Three written dialogues with the same content, but different in length and tone of voice were provided (based on previous sessions). Participants were asked to choose one of the three dialogues as their favourite dialogue and to provide a rationale for their choice, which was discussed afterwards.

Data analyses

Scans were made of the diaries, pictures, answering sheets, and work-sheets. Audio recordings of the sessions were transcribed verbatim by an
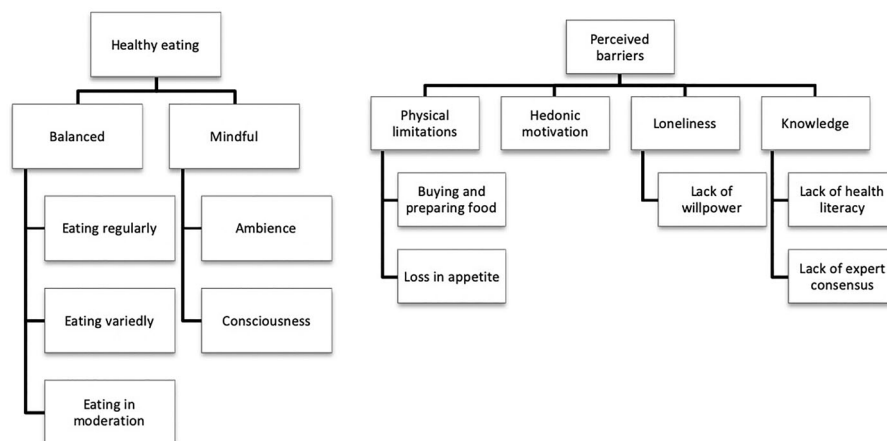
Figure 3. Thematic maps healthy eating and perceived barriers for healthy eating.

independent agency and reviewed by the research team for accuracy by comparing the audio recordings with the written transcripts. Pseudonyms were developed for each participant to maintain confidentiality. All data was uploaded in ATLAS.ti qualitative data analysis software. Analysis was guided by a thematic analysis approach, and combined a deductive and inductive approach (Braun and Clarke 2006). Literature was used to define deductive codes, and consisted of the framework for Positive Health (Huber et al. 2016), a list of food groups used to define aspects of healthy eating (Margetts et al. 1997), a list of perceived benefits of healthy eating (de Almeida et al. 2001), a list of perceived barrier statements towards healthy eating (Lappalainen et al. 1997), and a list of behavioural change techniques (Michie et al. 2013). One researcher (LK) read and reread all transcripts in order to identify an initial list of inductive codes. The codebook was further developed independently by two researchers (LK, MB), merged, and differences were discussed, leading to a final and agreed upon codebook. This codebook was used to create thematic maps to cluster and categorize the data. The following four themes emerged: Better diet, source and medium of healthy eating advice, ECA and other. The following thematic maps were created: Healthy living, healthy eating, perceived barriers, healthy eating advice, and personality traits. See Figure 3 for two of these thematic maps.

Results

Demographics

The total sample consisted of one male and twelve female participants, ranging from 69 to 92 years of age ($M = 88$, SD = 7.04). A majority completed at least high school (8/13), other participants' highest completed level of education was college education (2/13), vocational education (2/13) and elementary school (1/

13). Most participants were single; almost all had been married (12/13), but their partners in most cases passed away (11/12). Thus, only one participant was living together with their spouse. More than three-quarters of the sample had children (10/13), ranging from 1 to 4 children ($M = 2$), all of which had left the parental home.

The diary

Understanding the context

Typical eating behaviour of participants included having a cracker or yoghurt for breakfast, two sandwiches for lunch, and potatoes with vegetables and meat for diner (see Figure 4). S/he consumed what s/he had planned, and often consumed the same foods every day (especially for breakfast and lunch). The meals were usually prepared him- or herself, and eaten without company. Daily activities often consisted of household chores, spending time on the computer, reading a book or the newspaper, and, if possible, some form of physical activity (e.g. walking or cycling). In order to increase self-perceived health, a good dietary pattern and ample physical activity were deemed important. Physical limitations were experienced as an important obstruction to perform various physical activities, such as spending time outdoors. Overall, the quality of life was rated as quite satisfying, although loneliness, and a lack of social contacts, was often mentioned as a major factor for a poorer quality.

> I would like to have more contacts, but everybody is busy. (F, 88)

> The sad moment at the end of the day when eating alone and coming home alone. (F, 69)

After filling out the diary for seven days, participants often indicated how much they appreciated the attention which was given to older adults in general via this study. They also mentioned regularly that the diary made them more aware of their current eating behaviours.

> With great pleasure I have completed this diary, and look forward to discussing all these topics with others. Thank you for organizing this course for the older adults. (F, 85)

The co-design sessions

Creating content: healthy living

The most important aspects of healthy living mentioned could be divided into four themes: 'social context', 'autonomy', 'positive mindset' and 'nature' (see Figure 3). The social context, related to not feeling lonely and having many social contacts, was mentioned most often. For example, one

Figure 4. Pictures of a meal (participants, from top to bottom: F, 92; F, 84; F,83).

participant moved to another neighbourhood where she could be with people her age. For her, this was an important step to increase her quality of life. The second theme, autonomy, referred to the desire to maintain independence in old age. One participant explained this by telling a story of

how her grandchildren kept mentioning that 'mommy wants to do it herself'. This also included dealing with physical limitations, which were discussed frequently, as these were seen as limiting a healthy life. For example, because of mobility limitations participants were not able to visit family members, or because arthrosis made it difficult to go cycling. Two other themes were having a positive mindset and spending time in the nature. They agreed it was important to think positively, which made them feel happier. Furthermore, they felt they were living healthier when frequently spending time in nature, which made them feel good. Three out of four themes, and how they are interrelated, were perfectly summarized by one of the participants during the session:

> I wrote down mens sana in corpore sano. And that means a healthy mind in a healthy body. Well having said this, this obviously means a lot. For me, that means that you feel comfortable by lots of open air, not too much food and drinks, good contacts with neighbours around you and no illness please. (F, 75)

Creating content: healthy eating

The most important aspects of healthy eating could be divided into the themes 'balanced' and 'mindful' (see Figure 3). In addition, fresh and natural foods were also mentioned a couple of times as being healthy.

Balanced was by far the most important theme, and was mentioned often and throughout all sessions, both related to a healthy lifestyle in general and to healthy eating more specifically. When discussed further, three subthemes emerged for balanced. The first subtheme was 'eating regularly', and meant eating throughout the day and at set times. Participants explained that it was something they had learned when they were young. The second subtheme was 'eating variedly', and referred to the consumption of different foods every day. For example, different spreads on bread and different kinds of fruits. The last subtheme was 'eating in moderation', referring to eating a suitable portion size. Participants commented that they did not feel well when they ate too much.

Mindful referred to the activity of eating, beyond the actual consumption of foods. Two subthemes emerged; 'ambience' and 'consciousness'. Ambience referred to making the meal 'cosy', for example by sitting at the table with candle light. Although some felt it was too confronting to make it cosy, since it put the emphasis on being lonely. Consciousness referred to the enjoying of food, via little bites and with all attention towards the process of eating.

Creating content: perceived barriers and healthy eating advice

When discussing the perceived barriers of the participants towards healthy eating, four themes could be distinguished: 'Physical limitations', 'hedonic motivation' 'loneliness' and 'knowledge' (see Figure 2).

A first and most often mentioned physical barrier towards a healthier diet was the process of buying and preparing food. When the body ages, it was often mentioned that these tasks become harder and cost too much effort. The participants also discussed the use of meal-delivery companies, but were rather negative about the quality and service. A second physical limitation was the loss of appetite, both for foods and drinks. Participants found it difficult sometimes to remember to eat if their body did not indicate any appetite. During the session, we asked participants to share pieces of advice with others, in order to help them overcome their perceived barriers. Although not all participants were interested in changing their eating behaviour, they all actively contributed to the discussion and had clear ideas and opinions. When discussing the pieces of advice, it became clear that a variety of practical tips was already applied. These include buying pre-cooked vegetables, asking for smaller senior portions in restaurants, or spreading cooking activities over the day. Participants also mentioned how they liked learning from each other, and already applied various advice from other participants in between sessions.

> I prefer self-cooked. And I find that difficult these days. Because I have a limitation and then with the gas and the draining of hot water for your potatoes. That is hard though. (F, 88)

Second, participants explained that they were motivated rather hedonically; they felt that they were old enough and should be allowed to 'cheat' and 'enjoy foods', for example, during birthday parties. This was confirmed by the diaries, in which they reported that most 'unhealthy foods' were consumed during social activities. Some also felt that people should not be 'forbidden' to eat unhealthy foods. Participants were most interested in receiving small and practical tips in order to 'cheat less'. The tip mentioned most often by the group was finding a healthier substitute. This related, for example, to the 'half past five moment', when one craves something salty. Instead of having some chips, they advised choosing a broth soup. Next were the mindfulness tips. Similar to one of the definitions of healthy eating, participants advised to eat 'consciously'. For them, this included listening to their own body. For example, responding to signals when one has eaten enough. Last were the practical tips, including doing groceries with a full stomach, drinking plenty of water, and choosing a smaller portion size.

The topic loneliness recurred frequently during all sessions. During the discussion of healthy living, social contacts were often mentioned as an important driver for a healthy lifestyle. In relation to eating, an absence of others to share a meal with seemed to instil a lack of willpower to prepare a meal. A first barrier was that participants did not find it worthwhile to cook a meal for one person only. Second, they did not feel comfortable to consume a meal without company. When discussing the various type of advice, the

piece of advice that was mentioned most often was to go out and contact other people. Participants often mentioned that they cannot simply wait inside for people to contact them. However, it was also indicated by multiple participants that this is not always easy, as feeling lonely is often related to a lack of energy for finding and maintaining social contact.

The theme knowledge related to a lack of expert consensus, something which seemed to confuse them (e.g. with regard to drinking wine). They found it rather confusing that scientific insights change over time, and it made them follow their own common sense. This also related to a lack of health literacy. Some particular foods were discussed, and it became clear that health literacy differs among the participants (e.g. healthiness of orange juice, nuts, and certain biscuits). Pieces of advice to overcome the knowledge barrier consisted of looking online and in magazines for information.

From content to visualization: source and medium of healthy eating advice

We asked participants about who should give them advice and how this message should reach them. Different suitable sources for bits of healthy eating advice were found: 'me', children, and the culinary specialist. The first person was the participant him or herself. Their reasoning was in line with their aforementioned need for autonomy. They knew what is best for themselves and preferred to actively find information themselves, for example through magazines or via the Internet. The second preferred source were their children. Participants agreed that they generally accepted suggestions with regard to healthy eating habits from their children. They could imagine a video message by their children, which could be broadcasted via their television, could be useful. A last source is the culinary specialist, for example a cook. They generally agreed that the cook was a credible source when it comes to preparing meals. Participants suggested for these messages to be send via various cooking shows and cooking magazines.

When discussing the role of the dietician and GP, the opinions varied. Participants agreed they were both a credible source. However, some participants associated a dietician and GP purely with 'medical advice' and found them too patronizing, which made them not a suitable source for healthy eating suggestions.

> '[I prefer my daughter] better than an annoying dietician, whom I have a fight with within 30 seconds. You go to the general practitioner and then they will put you in contact with a dietician. Please do, I am outside within two seconds. Because they know, they only talk about apples and nuts and … ' (M, 69)

Visualization: appearance and communication style

When we first introduced the concept of an ECA in the third session, participants reacted with resistance and misperception towards the technology.

Figure 5. Two ECAs as designed by participants.

Participants thought, for example, that someone behind the scenes needed to control the ECA in real-time. However, this changed when one of the participants shared her positive experience with seeing an assistive robot on television. Thus, when the benefit of an ECA became clear, participants seemed to rethink their opinion.

The assignment remained challenging for some participants. Most found it easier to discuss their own health behaviour, over the design of a fictional ECA. But in the end, all participants did design an ECA, although very different from each other (see Figure 5). We did not provide an example, and participants were free in choosing their own method. Some participants drew a human-like figure, while other participants wrote about a strip figure (Tom Poes), or created a mood board from magazines. During the plenary discussion about their thoughts, ideas and design motivations we held afterwards, it became clear that the style should be either a cartoon or realistic, but not something in between. Participants mentioned that they found the in-between styles rather scary. Regarding gender and race there were no clear opinions. Ultimately, there were five commonly preferred personality traits: 'friendly', 'warm', 'trustworthy', 'concerned' and 'competent' (see Table 2). The tone of voice should fit these characteristics, but very importantly, it should absolutely not be patronizing, and should include some humour. This was mentioned multiple times throughout the sessions, by different participants. They further mentioned that the preferred tone of voice depends on the context.

Table 2. Preferred personality traits.

Personality trait	Example quote
Friendly	'Friendly, not controlling. Then I am immediately antagonized … (F,88). Yes, I am old, not retarded.' (F, 75)
Warm	'And also, with warm thinking, with a heart full of warm thinking. Yes, that's that heart, isn't it?' (F, 88)
Trustworthy	'Helpful in the background, but [the agent] knows how to intervene at the right time.' (F, 83)
Concerned	'Offering a helping hand.' (F, 73). ' … and occasionally bring a flower for the weekend' (F, 85)
Competent	'.. it has to be sweet, intelligent, and able to participate in discussions' (F, 84)

Discussion

Principal findings

Via the diary and co-design sessions, we explored how an ECA could support community-dwelling older adults with healthy eating. The first main finding is that older adults approach eating from a holistic perspective. This means that they do not only evaluate eating in terms of nutrients, ingredients, or components, but in terms of eating mindful and well-balanced. This holistic perspective also means that it is important for developers to understand the target group's views on healthy living, in order to understand healthy eating. Second, action planning and self-monitoring are the preferred approaches towards changing eating behaviour among older adults. The aim is to increase perceived competence levels, support autonomy and address feelings of loneliness. The third and last main finding is that ECAs bear the potential to support older adults with healthy eating behaviours in an engaging manner. However, it remains important to consider possible underlying health issues many older adults face. Considering the context, these principal findings should guide the development of the content of the ECA. Finally, we propose three recommendations for designing the appearance of the ECA.

Comparison with prior studies

We found that healthy living for older adults means that they are satisfied with one's social context, feel autonomous, have a positive mindset and spend ample time in nature. This perspective on healthy living neatly aligns with the Self-Determination Theory (SDT) of Ryan and Deci (2000). Briefly, SDT postulates that human beings have three essential psychological needs – autonomy (feeling of being the origin of one's own behaviours), competence (feeling effective), and relatedness (feeling understood and cared for by others). Both the social context and autonomy as identified in the present study are clearly in line with the SDT. Feeling competent was not directly discussed, but was reflected in the various practical skills discussed for

healthy eating participants mastered in order to cope with their (physical) limitations due to the process of ageing.

Having physical limitations, feeling lonely, and lack of knowledge, were experienced as barriers towards healthy eating. These barriers all fall within the key domains of factors influencing eating behaviours, as identified in a systematic literature review by Host et al. (2016). Our study adds hedonic motivation, i.e. enjoying foods, to this list. As hedonic hunger is not predictive of weight regulation (Burger, Sanders, and Gilbert 2016), it illustrates why interventions should not prohibit the consumption of 'unhealthier' foods. Instead, interventions should address the individual needs, and stimulate, for example, healthier substitutes or eating mindfully. This is a change strategy which is often applied in SDT-based interventions (Samdal et al. 2017). In the present study, action planning and self-monitoring were mentioned as the most suitable behaviour change techniques (BCTs), whereby practical suggestions from peers could inspire other older adults. Research shows that these BCTs, which facilitate self-regulation of behaviour, are indeed associated with effectively changing healthy eating behaviours in the long term (Samdal et al. 2017).

Design advice

The design of an ECA should, ideally, always be based on the needs and preferences of the specific target group. Based on our study, we formulated the following three pieces of design advice:

- Include the following personality characteristics into the ECA: friendly, warm, trustworthy, concerned, and competent.
- Match the role of the ECA to the topic.
- Use informational, non-judgmental language and include humour.

Interestingly, the personality characteristics we identified via an open discussion resemble the most important personality characteristics identified by ter Stal et al. (2019), following a card-sorting task. The exception is the characteristic 'warm', which was deemed important in our study, and not in their study. According to older adults, the personality characteristics of an ECA are more important than their appearances (ter Stal et al. 2019). While co-designing an ECA, we therefore recommend designers to ask users to rate the ECA on these five characteristics, and, if needed, discuss how the design can be improved to match these characteristics more closely.

When discussing the source of healthy eating advice, it became clear that people have different preferences regarding the source of the advice, which also depended on the topic at hand. For example, they found a cook

suitable for receiving recipes, but preferred discussing more sensitive issues with their children. This implies that different health topics might require ECAs in different roles, providing different types of advice (van Velsen et al. 2019). However, none of the current ECA-based intervention consider different roles (Kramer et al. 2020). We therefore advise to test whether the ECAs' role (e.g. a cook or peer) matches the topic at hand (e.g. viewing recipes or providing mindfulness tips).

The importance of using informational, non-judgmental language, is reflected by the need for autonomy (Teixeira et al. 2020; Ryan and Deci 2000). According to Teixeira et al., one way to achieve this is by using language that conveys freedom of choice, collaboration, and possibility. They advise to avoid constraining, pressuring, or guilt-inducing language (e.g. use 'might' or 'could' instead of 'should' and 'must'). In addition, we emphasize the importance of using humour in the communication style. This is not a new practice, as one of the first ECAs in the field of health behaviour change already includes humour (Bickmore, Caruso, and Clough-Gorr 2005).

Reflection on a co-design process with older adults

We would like to emphasize how the process of co-design turned out to be a positive experience for both participants and researchers. We aimed to create an engaging setting, starting with the diary, which had an appealing layout and a positive tone of voice. We also clearly emphasized that the older adults were the experts. So, we also treated them in this way, and mentioned that their important contribution was used to generate new scientific insights. In addition, we arranged transport, lunch and an appealing location. This setup required a rather high time (and financial) investment, but did return in an intrinsic motivation of participants to discuss their lifestyle and nutritional pattern, and to share emotional stories. At the end of the last sessions, participants were even eager to being kept informed about the project and participate in any further studies. They also let us know that they highly appreciated the attention which was given to them as a group.

Conclusion

We explored how an ECA could support older adults to improve their eating behaviour. Therefore, a thorough understanding of the drivers for their behaviour is needed. It is important to realize that older adults do not evaluate food in terms of nutrients, but in terms of eating mindfully and in a well-balanced manner. Furthermore, the broader concept of healthy living needs to be understood in order to understand healthy eating. The preferred behaviour change techniques towards healthy eating behaviour are action planning and self-monitoring. These techniques should aim to increase

perceived competence levels, support autonomy and address feelings of loneliness. An ECA has the potential to support older adults in this, whereby a combination of humour and the use of non-judgmental language is an important asset. Designers are advised to select the right role for the ECA, combine the most important personality characteristics, and use informational, non-judgmental language, as it increases the chance of engendering behaviour change.

Acknowledgements

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

Notes on contributors

Lean L. Kramer is a PhD researcher, focussing on how Embodied Conversational Agents should be developed to reach optimal appreciation and actual health behaviour change.

Marije Blok is manager of Innovation at the National Foundation for the Elderly. She works as a PhD researcher at VU University, focussing on technology for social and emotional wellbeing at later age.

Lex van Velsen is manager of the eHealth cluster at Roessingh Research and Development. His research interests include eHealth design, requirements engineering, trust, and privacy.

Bob Mulder is an assistant professor in strategic communication. His research focuses on interpersonal health communication for behaviour change.

Emely de Vet is professor in consumption and healthy lifestyles. She studies drivers of (un)healthy behaviour and strategies to enable healthy and sustainable lifestyles.

ORCID

Lean L. Kramer http://orcid.org/0000-0002-1409-2853
Marije Blok http://orcid.org/0000-0001-6467-5590
Lex van Velsen http://orcid.org/0000-0003-0599-8706
Bob C. Mulder http://orcid.org/0000-0003-0357-1370
Emely de Vet http://orcid.org/0000-0002-4452-2367

References

Bickmore, T. W., L. Caruso, 2005. and, and K. Clough-Gorr. "Acceptance and Usability of a Relational Agent Interface by Urban Older Adults." *CHI '05 Extended Abstracts on Human Factors in Computing Systems*, 1212–15. doi:10.1145/1056808.1056879.

Bickmore, T. W., L. Caruso, K. Clough-Gorr, and T. Heeren. 2005. "It's Just like You Talk to a Friend' Relational Agents for Older Adults." *Interacting with Computers* 17 (6): 711–735. doi:10.1016/j.intcom.2005.09.002.

Bickmore, T. W., R. A. Silliman, K. Nelson, D. M. Cheng, M. Winter, L. Henault, and M. K. Paasche-Orlow. 2013. "A Randomized Controlled Trial of an Automated Exercise Coach for Older Adults." *Journal of the American Geriatrics Society* 61 (10): 1676–1683. doi:10.1111/jgs.12449.

Brandt, C. J., G. I. Søgaard, J. Clemensen, J. Søndergaard, and J. B. Nielsen. 2018. "Determinants of Successful eHealth Coaching for Consumer Lifestyle Changes: Qualitative Interview Study among Health Care Professionals." *Journal of Medical Internet Research* 20 (7): e237. doi:10.2196/jmir.9791.

Braun, V., and V. Clarke. 2006. "Using Thematic Analysis in Psychology." *Qualitative Research in Psychology* 3 (2): 77–101. https://doi.org/10.1017/CBO9781107415324.004. doi:10.1191/1478088706qp063oa.

Brinkman, W.-P. 2016. Virtual health agents for behavior change: Research perspectives and directions. Paper Presented at the Proceedings of the Workshop on Graphical and Robotic Embodied Agents for Therapeutic Systems.

Burger, K. S., A. J. Sanders, and J. R. Gilbert. 2016. "Hedonic Hunger is Related to Increased Neural and Perceptual Responses to Cues of Palatable Food and Motivation to Consume: Evidence from 3 Independent Investigations." *The Journal of Nutrition* 146 (9): 1807–1812. doi:10.3945/jn.116.231431.

de Almeida, M. D. V., P. Graça, C. Afonso, J. M. Kearney, and M. J. Gibney. 2001. "Healthy Eating in European Elderly: Concepts, Barriers and Benefits." *The Journal of Nutrition, Health & Aging* 5 (4): 217–219. http://europepmc.org/abstract/med/11753481. PMID: 11753481.

DeSalvo, K. B., R. Olson, and K. O. Casavale. 2016. "Dietary Guidelines for Americans." *JAMA* 315 (5): 457–458. https://doi.org/10.1001/jama.2016.0077. doi:10.1001/jama.2015.18396.

Gasser, R., D. Brodbeck, M. Degen, J. Luthiger, R. Wyss, and S. Reichlin. 2006. "Persuasiveness of a Mobile Lifestyle Coaching Application Using Social Facilitation." In *International Conference on Persuasive Technology*, 27–38. Berlin: Springer. doi:10.1007/11755494_5.

van Gemert-Pijnen, J. E. W. C., N. Nijland, M. van Limburg, H. C. Ossebaard, S. M. Kelders, G. Eysenbach, and E. R. Seydel. 2011. "A Holistic Framework to Improve the Uptake and Impact of EHealth Technologies." *Journal of Medical Internet Research* 13 (4): e111. doi:10.2196/jmir.1672.

Govindaraju, T., B. W. Sahle, T. A. McCaffrey, J. J. McNeil, and A. J. Owen. 2018. "Dietary Patterns and Quality of Life in Older Adults: A Systematic Review." *Nutrients* 10 (8): 971–918. doi:10.3390/nu10080971.

Host, A., A. T. McMahon, K. Walton, and K. Charlton. 2016. "Factors Influencing Food Choice for Independently Living Older People-A Systematic Literature Review." *Journal of Nutrition in Gerontology and Geriatrics* 35 (2): 67–94. doi:10.1080/21551197.2016.1168760.

Huber, M., M. Van Vliet, M. Giezenberg, B. Winkens, Y. Heerkens, P. C. Dagnelie, and J. A. Knottnerus. 2016. "Towards a 'Patient-Centred' Operationalisation of the New Dynamic Concept of Health: A Mixed Methods Study." *BMJ Open* 6 (1): e010091–11. doi:10.1136/bmjopen-2015-010091.

Kramer, L. L., S. ter Stal, B. C. Mulder, E. de Vet, and L. Van Velsen. 2020. "Developing Embodied Conversational Agents for Coaching People towards a Healthy Lifestyle: A Scoping Review." *Journal of Medical Internet Research* 22 (2): e14058. doi:10.2196/14058.

Lappalainen, R., A. Saba, L. Holm, H. Mykkanen, and M. J. Gibney. 1997. "Difficulties in Trying to Eat Healthier: Descriptive Analysis of Perceived Barriers for Healthy Eating." *European Journal of Clinical Nutrition* 51 (2): 36–40. http://www.ncbi.nlm.nih.gov/pubmed/9222722.

Margetts, B. M., J. A. Martinez, A. Saba, L. Holm, and M. Kearney. 1997. "Definitions of 'Healthy' Eating: A Pan-EU Survey of Consumer Attitudes to Food, Nutrition and Health." *European Journal of Clinical Nutrition* 51 (2): 23–29. PMID: 9222720

Michie, S., M. Richardson, M. Johnston, C. Abraham, J. Francis, W. Hardeman, M. P. Eccles, J. Cane, and C. E. Wood. 2013. "The Behavior Change Technique Taxonomy (v1) of 93 Hierarchically Clustered Techniques: Building an International Consensus for the Reporting of Behavior Change Interventions." *Annals of Behavioral Medicine: A Publication of the Society of Behavioral Medicine* 46 (1): 81–95. doi:10.1007/s12160-013-9486-6.

Norman, Donald A. 2013. *The Design of Everyday Things. Human Factors and Ergonomics in Manufacturing*. New York: Basic Books. doi:10.1002/hfm.20127.

Ponathil, A., F. Ozkan, J. Bertrand, S. Agnisarman, S. Narasimha, B. Welch, and K. Chalil Madathil. 2020. "An Empirical Study Investigating the User Acceptance of a Virtual Conversational Agent Interface for Family Health History Collection among the Geriatric Population." *Health Informatics Journal* 26 (4): 2946–2966. doi:10.1177/1460458220955104.

Provoost, S., H. M. Lau, J. Ruwaard, and H. Riper. 2017. "Embodied Conversational Agents in Clinical Psychology: A Scoping Review." *Journal of Medical Internet Research* 19 (5): e151. doi:10.2196/jmir.6553.

Rabbi, M., A. Pfammatter, M. Zhang, B. Spring, and T. Choudhury. 2015. "Automated Personalized Feedback for Physical Activity and Dietary Behavior Change with Mobile Phones: A Randomized Controlled Trial on Adults." *JMIR mHealth and uHealth* 3 (2): e42. doi:10.2196/mhealth.4160.

Robinson, E., S. Higgs, A. J. Daley, K. Jolly, D. Lycett, A. Lewis, and P. Aveyard. 2013. "Development and Feasibility Testing of a Smart Phone Based Attentive Eating Intervention." *BMC Public Health* 13 (639): 639–637. doi:10.1186/1471-2458-13-639.

Ruttkay, Zsófia, and Catherine Pelachaud, eds. 2004. *Brows to Trust: Evaluating Embodied Conversational Agents*. 7th ed. Berlin: Springer Science & Business Media.

Ryan, R. M., and E. L. Deci. 2000. "Self-Determination Theory and the Facilitation of Intrinsic Motivation, Social Development, and Well-Being." *American Psychologist* 55 (1): 68–78. doi:10.1037/0003-066X.55.1.68.

Samdal, G. B., G. E. Eide, T. Barth, G. Williams, and E. Meland. 2017. "Effective Behaviour Change Techniques for Physical Activity and Healthy Eating in Overweight and Obese Adults; Systematic Review and Meta-Regression Analyses." *The International Journal of Behavioral Nutrition and Physical Activity* 14 (1): 42–14. doi:10.1186/s12966-017-0494-y.

Stal, S. ter., M. Broekhuis, L. van Velsen, H. Hermens, and M. Tabak. 2020. "Embodied Conversational Agent Appearance for Health Assessment of Older Adults: Explorative Study." *JMIR Human Factors* 7 (3): e19987. doi:10.2196/19987.

Stal, S. ter., M. Tabak, H. Op den Akker, T. Beinema, and H. Hermens. 2019. "Who Do You Prefer? The Effect of Age, Gender and Role on Users ' First Impressions of Embodied Conversational Agents in EHealth." *International Journal of Human–Computer Interaction* 1: 1–12. doi:10.1080/10447318.2019.1699744.

Steen, M. 2011. "Tensions in Human-Centred Design." *CoDesign* 7 (1): 45–60. doi:10.1080/15710882.2011.563314.

Teixeira, P. J., M. M. Marques, M. N. Silva, J. Brunet, J. Duda, L. Haerens, J. La Guardia, et al. 2020. "A Classification of Motivation and Behavior Change Techniques Used in Self- Determination Theory-Based Interventions in Health Contexts." *Motivation Science* 6 (4): 438–455. doi:10.1037/mot0000172.

van Velsen, L., M. Broekhuis, S. Jansen-Kosterink, and H. Op den Akker. 2019. "Tailoring Persuasive Electronic Health Strategies for Older Adults on the Basis of Personal Motivation: Web-Based Survey Study Corresponding Author." *Journal of Medical Internet Research* 21 (9): e11759. doi:10.2196/11759.