On the Design of Voice-based Conversational Agents for Prevention and Management of Obesity and Overweight Condition Adolescents

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***Abstract*—The WHO European Childhood Obesity Surveillance Initiative (or COSI), reports that in the fourth round of data collection (2015 - 2017) one in three children aged from six to nine years is living with overweight or obesity [1]. Today it is broadly accepted that overweight and obesity are largely preventable if better healthcare strategies are adopted and innovative interventions are introduced [1], [2]. A promising technology that can help children and their immediate environment adopt WHO-recommended measures and provide nutritional counselling are Voice-based Conversational Agent (VCA). In this work, the service design thinking paradigm [3] is applied to design and develop a new VCA-based service. The main findings of the process are presented along with the key observation that drove the development of the proposed service.**

***Index Terms*—Overweight Kids, Obese Adolescents, Voice-based Conversational Agent, User-Centric Design, Service Design Thinking**

I. Introduction

Health plays a central role in building inclusive, competitive and sustainable societies and economies, contributing to growth, wealth and a productive workforce. Although EU citizens want a more social Europe, placing the health of the population as a top priority, Europe's health and care systems face serious challenges [4]. Non-communicable diseases (NCDs, e.g., heart disease, mental illness, diabetes mellitus, asthma, etc.) have been on the rise for several decades and by 2010 had been found to account for 86% of deaths and 77% of the disease burden in Europe [5].

A key observation is that obesity is a major cause for the development of NCDs [6]. Internationally the obesity epidemic is driving up the burden of several NCDs being one of the key factors in the development of metabolic syndrome [7]. Obesity alone has been labelled as the contributor of 80% of all T2DM and 35% of ischaemic heart disease [8]. Obesity is an important risk factor in the development of asthma [9]. Associations with impaired cognitive function, as well as the risk of dementias such as Alzheimer's disease, have more recently been recognized [10]. Studies indicate a higher intensity of atypical depression symptoms in overweight/obese depressed patients [11].

Managing obesity requires the adoption of better healthcare strategies and the introduction of innovative interventions. Today many studies indicate that overweight and obesity are largely preventable [1], [2]. Studies also indicate that in many cases, obesity starts from an early age, creating a well defined economic burden on the healthcare system [12]. As an example, the Childhood Obesity Surveillance Initiative by WHO indicates over 340 million children and adolescents aged 5-19 were overweight or obese in 2016 [1]. Addressing obesity during childhood can provide better chances for reducing long-term complications [13].

A key observation is that providing nutritional education to the people within the immediate environment of overweight kids can significantly help them develop healthy eating practices [14]. Yet, as easy as it may sound, guiding children and adolescents to develop healthy food habits needs to address several challenges. In many cases, family members are going through a very articulated daily routine, and their nourishment behaviour reflects it: kids may need to consume meals in different places and social scenarios during each day of the week. The home environment gets heavily conditioned by the adjacent social space of school and work, and by the intangible space of the Internet.

A promising technology that can help children and their immediate environment adopt WHO-recommended measures and provide nutritional counselling is that of Voice-based Conversational Agents (VCA). A VCA belongs to the category of conversational interfaces and is a form of human-computer interaction possible thanks to the implementation of ASR (automatic speech recognition), NLP (natural language processing), and AI (artificial intelligence) technologies. The major advantage of choosing a voice user interface is that it is hands-free, thus allowing the users to carry out multiple tasks: one does not have to stop, pick the phone, search for the dedicated app, open it and finally start using it [15]. It is faster than using a search engine, or typing in general, making it more convenient; just think of how many people for example prefer to record voice messages than typing them.

Voice interfaces pose a substantial number of challenges

in terms of usability. In contrast to traditional graphical user interfaces (GUIs), best practices for voice interface design are still emergent [16]. In purely audio-based interfaces, the interaction tends to suffer from low discoverability: it is difficult for users to understand the scope of a system's capabilities. Low discoverability leads to user confusion over what they are "allowed" to say or a mismatch in expectations about the breadth of a system's understanding. Incidentally, while speech recognition technology has improved considerably in recent years, voice user interfaces still suffer from parsing or transcription errors in which a user's speech is not interpreted correctly. Today, effective system design to maximize conversational understanding is an open area of research. Moreover, interpreting and managing conversational state is challenging due to the inherent difficulty of integrating complex NLP tasks like coreference resolution, named-entity recognition, information retrieval, and dialogue management. Most voice assistants today are capable of executing single commands very well but limited in their ability to manage dialogue beyond a narrow task or a couple of turns in a conversation.

This work presents a new service for supporting the immediate environment of overweight kids through a VCA. Therefore the intended users of the service are the parents of overweight kids, or people that are taking care on a daily basis. The paradigm of service design thinking [3] is applied to develop a genuine understanding of the users that goes beyond statistical descriptions of their needs. Questions such as "how do you decide what to eat?" and "How do you find what you eat?" were used rather than "what to eat" that are already present in many reports from the WHO and other bodies and associations. Service design thinking is used as a co-creative process that positions users with different needs and expectations at the epicentre. The main findings of this process are presented along with the key observation that drove the development of the proposed service.

The remaining of the paper is structured as follows. In the following section, an overview of recent and relevant research results are presented along with relevant existing services. Sec. III briefly presents the methodology followed while the main outcomes of the user needs discovery are summarized in Sec. IV. In Sec. V the main outcomes of the user needs discovery are connected with the design choices of the new VCA-based service. Finally, in Sec. VI the paper concludes also by providing indications for future work.

II. Related Work

Mobile health technologies promote a healthy lifestyle, empower and control NCDs, regardless of the age and experience of users [17]. WHO predicts over 500M patients will be using mHealth apps by the end of this decade [18]. For the case of obesity, easy-to-use cost-effective mHealth programs have been implemented for the obese populations [19], [20]. Augmented mobile applications use smart wearable and built-in sensors, as well as advanced visualization techniques to measure and analyse all types of physical activities [21]. FLES is a scalable multi-device framework that increases self-awareness for health and disease prevention [22]. Food intake and calories consumption of the users are monitored to propagate awareness and share appropriate information and recommendations to control and lower the risk of obesity [23]. Recent findings on mHealth interventions to improve nutrition-related behaviours, including diet and physical activity, reported 64% of positive results [24].

Recently the use of VCA has been proposed for the delivery of mHealh. Most notably, their use to empower adolescents with autism spectrum disorder is reported in [25], suggesting positive opportunities. The Kaiser Permanente group (Kp, https://www.kpdesignconsultancy.org/) developed project Chamai to support people with mild or moderate emotional health symptoms by integrating VCA-based digital therapeutics into clinical practice.

III. Methodology

The methodology followed is based on the service design thinking paradigm [3]. The double diamond process model defined by the British Design Council was used throughout the entire process. From the large variety of tools and methods used in the practice of user-centred design, this work relied mainly on interviews as the dominant tool used in the healthcare domain. The script used during the interview was partially based on existing validated questionnaires, such as, e.g., the questionnaire used by the Family Nutrition and Physical Activity (FNPA) Child Obesity Prevention Screening [26]. In the sequel tools such as empathy maps, personas, storyboards, user journey maps and flowcharts were used to support the discovery & define phase. For the develop & deliver phase a co-design approach was adopted involving different people in the process to receive feedback and evaluate early prototypes of the service.

A. Recruitment

We recruited a total of fifteen parents of overweight or obese kids in the region of Abruzzo and Puglia in Italy. We confirmed that all users possess the technical skills to potential use a VCA-based service on their own. No compensation was provided to any of the participants for taking part in the process. We obtained informed consent for participation from all participants. We informed all participants that this study is not a clinically validated therapy, that the participants could ask questions at any point of the process, there is no commitment if they decide to stop in the middle since their participation is voluntary.

B. Data Analysis

All the interviews conducted during the first part, as well as the co-design workshops during the second part, were conducted via the Google Meet platform and were audio-recorded. The data analysis included the maps, storyboards and flowcharts produced depicting the desired VCA-based service. Fig. 1 provides an example of a co-design session carried out with a prototype VCA dialogue flow (top), user journey and maps (middle) and interaction diagram (bottom).

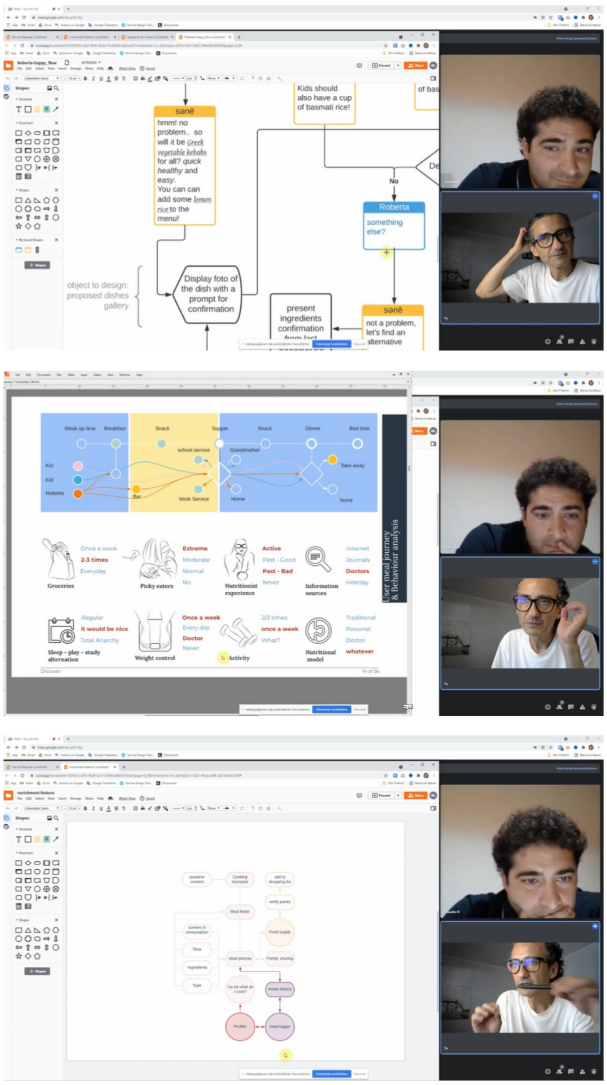

Fig. 1: Prototype VCA dialog flow (top), journey and maps (middle) and interaction diagrams (bottom) identified via interviews during the discovery phase and developed during the co-creation phase.

IV. User Needs Discovery

A. The need of nourishment

Reviewing the most important moments of this activity it is observed that most of the families have a fast and very distracted breakfast, or some have no breakfast at all, while at lunch almost every member of the family eats at work or school using dedicated meal services. Even if this is not the case, Grandparents very often take over and act as an after school or work break service by giving lunch to the family members. At last, dinner turns out to be the most convivial moment for the family members, as the dinner table becomes the place to finally gather all together and have the opportunity to share all the personal day stories while having, as considered by most of the users, a proper meal. An example of a journey map is presented in Fig. 2.

For school services, while all of the users acknowledge the fact that menus are drawn up by a certified national health service nutritionist, which guarantees quality and inspires trust, they argue on the supervision quality and assistance given to their kids during lunch, more specifically on the fact that some dishes like vegetables may not be consumed at all, because kids traditionally are picky eaters, or they get to be there while at school.

For those kids having lunch with their Grandparents, the most common complaints of the parents reflect on the cooking habits of the seniors, accusing them either of serving hyper-caloric meals or to try to satisfy their grandchildren' requests. Probably this could be a manifestation of a wider generational conflict between parents and grandparents' nutrition beliefs.

When the parents eat at work the most common issue for those who get their lunch from home is the inability to heat it, so they are constrained on consuming cold dishes, while for those who benefit from a service, the major problem seems to be the lack of choice after a while. Lastly, all working parents expressed the need to have a light lunch so they can take over again working, but without sacrificing on quality and possibility of alternate.

All of the users suffer the fact that meal choices at lunch are perceived as top-down impositions on their lifestyle that after a while become a point of concern.

As for dinner, a main concern is how to vary the choice of food from the day before and most importantly from what the kids had for lunch. Parents express that it is hard to guess what was the behaviour of their kids during lunch, if they consumed it, how much did they eat of it, etc. Other problems relate to the amount needed to prepare a meal or the lack of a family nutritional plan. More often than not, cooking is perceived as a burden or an obligation, thus leading often to poor choices. It is reported that during dinner, it is often the case that there is little left to converse about, leaving the stage to TV, or streaming service or at the kids' exuberance.

B. The need of food supply

Most users pointed out that usually they visit the supermarket once a week, and during the week they visit small neighbourhood shops from two to three times a week for the fresh ingredients. Within the family, only one user shops every day. During the user reviews it was observed that users understand the importance of helping local farmers not only in relation to the ethical values of helping the local community but also to gain access to fresh, seasonal ingredients. At the same time, most users prefer to buy their vegetables and salads already washed and prepared for consumption, as time is always limited. Some users also reported an averse towards frozen products while one of them indicated them as an essential choice.

C. The need of information

During the interviews, all users described the need to be informed or stay updated on nutrition and exercise with topics varying from recipes, ingredients and diet plans, to fitness

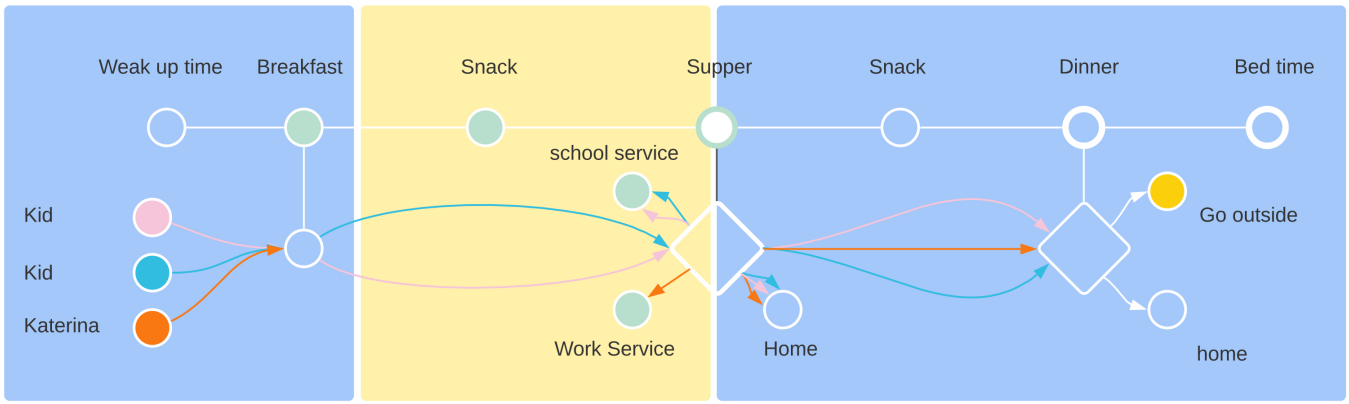

Fig. 2: Journey map representing the activities identified via interviews during the discovery phase.

workouts and certified medical research on nutrition. All of them refer to the internet for information, some of them use hearsay, while very few ask certified professionals for advice if they are in their friend zone. One of them - that takes part in a local food supply association, reads books and newsletters on the subject other than using the internet and YouTube. While they all admit that TV has plenty of shows with information on this topic, no one seems to be engaged in watching these programs. As for their Kids, it turns out that information programs are decided on a local basis changing from school to school and almost always coming from associations or professionals outside the National Health System or the National School Organization.

D. The need for activity

All users understand that physical activity is necessary for a healthy lifestyle, and they try to make their kids practice at least 2 hours a week, although nobody specified where this time limit comes from. A crucial issue here for some is the total lack of public services for kids, other than church groups maybe. Youtube is the most trusted source for information and workouts, while only one user had an app installed, but she never moved on the premium program. Most interestingly one user acknowledges the need to bound activity with sociality, as she confesses that she will never workout by herself, but with a group of friends, yes.

E. The need for treatment

Obesity and overweight are admittedly visible problems for all the users, nevertheless, many of them have behaviours that go in the opposite direction. Those suffering from a chronic condition of obesity, or simply feel the need to lose weight, and choose the public path of treatment, at some point feel left alone without a person of reference because of the impossibility to have the same doctor every time. In addition, the process of making appointments for exams and consults is time-consuming and articulated in more steps. Another issue is the impossibility to have support in moments of struggle, outside of an appointment. For those instead who prefer the private consultant while they appreciate the extended availability of support via email or chat, and the all-in-one solution (exams + consult), the first concern is trust (is she any good? Is she certified? Is she even a doctor?) and usually they choose based on hearsay, while for someone the outcome is not always positive. In any case, some of the users reconnect to the consultant experience as the only instructional moment on their nutrition.

V. On the design of a VCA-based service

Given the identification of the user needs, they were translated into features that compose a service useful and desirable. The features that make up the new VCA-based service are organized in five macro-categories: Activity, Food Supply, Information, Nourishment and Treatment (see Fig. 3). The interaction of the individual features is depicted in Fig. 4.

Meal Planner Assistance. The user-centred research indicates that the happiest users are the ones with a weekly meal schedule. Such a schedule can help get control of the time and effort needed to adequately prepare a meal of choice whatever their family members' alimentary need is.

Profile Creation. The creation of an adequate schedule needs to take into consideration all the family's needs and likes. For example, what if a user is vegan? or intolerant to some ingredients, or need to be under a constrained nutrition plan.

Meal Log. All the users expressed the need to vary, aiming to achieve a more complete diet and to overcome the boredom of repeated meals. Moreover, logging meals is one of the most emphasized best practices recommended by WHO.

Suggest Related Ingredients. In terms of the need for variation, two completely different users expressed the need to discover new ingredients and alimentary cultures. Suggesting alternative/related ingredients may also be presented playfully, thus becoming an engaging factor to the planner assistant.

Cooking Time. One of the most important factors in deciding what to cook and this way the meal planner should be able to provide adequate solutions based on cooking time. Given this broadly accepted fact, many cooking datasets and web services have their recipes categorised this way.

Members' Participation. A central feature of the service is the identification of the members that will participate in a

Fig. 3: The five macro categories of the features that make up the service.

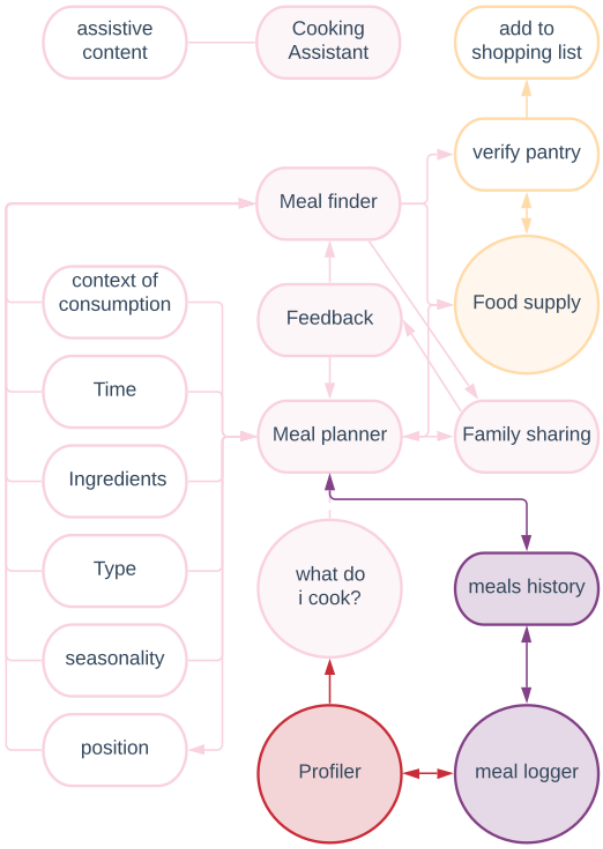

Fig. 4: The meal planner functionality and interaction diagram.

meal. One of the most instructive experiences pointed out by the users is the presentation of the available choices that make up a meal to the kids, making it one of the first steps towards the expected behavioural shift to healthier choices. This feature enables the possibility to share menu choices across more devices possible, so all family members can express their preferences and their reasons: informing a kid the reasons why she should have vegetables and presenting them in more than one fashion with the possibility to choose, is a different experience than imposing it to them.

Meal Finder. The above features are composed into the final element, that of identifying potential meal candidates. What if there are unexpected guests, or a dinner with friends is requested, or the user wishes to find a specific recipe; given a simple sequence of options/choices the user should be provided with a series of proposals and corresponding recipes.

Cooking Assistant. What if the user does not know how to cook the selected meal? Audio with possible assistance from video, guides the users in a step by step cooking progress but with added functionality that they do not have to use external timers, or remember to use specific ingredients.

Although many of the features may be used autonomously and offer some commodities, the main concept of the service is that they can, and they should be used in a synergic manner for the desired outcome. For the implementation of the VCA-based service, the Dialogflow platform by Google was selected due to its maturity, flexibility and ability to support the Italian language. Dialogflow enables the development of VCA that can be realised in a text-based or voice-based format. Moreover, Dialogflow enables the integration with Ambient Assisted Living services available in the environment of the users and thus integrate other internet-enabled smart objects such as body or kitchen weight scales, wearables, smartphones with the features presented above [27].

VI. Conclusions

Throughout the interviews and the co-design sessions, it was evident that one of the main challenges was the very diverse environment, daily routines and nourishment behaviour of the kids that consume a different number of meals, in different places and social scenarios every day. The home environment gets heavily conditioned by the adjacent social space of school and work, and by the intangible space of the Internet. Interestingly, regardless of the lifestyle of the kids and their supporting environment, during periods of increased pressure - especially when a person is on a diet - there is an increased need for participation and sociality. Even the most disillusioned users admitted that they could benefit from a coach, someone to support them during hard times. The importance of a VCA-based service was emphasized by almost all participants, clearly indicating it as very attractive.

Information is an essential part for the goal that this service wants to achieve, found in different forms and media: in dedicated channels about nutrition and fitness, or database entries for ingredients and nutritional models, but most importantly informational content will be spread everywhere from

meal suggestions to recipes, to diet plans. For example, the VCA service can be extended to present the nutritional label of ingredients or become a shopping assistant, ordering the ingredients through existing web services.

Currently, the first release of the service is undergoing an evaluation during which some of the users that participated in the work reported here volunteered to use it for a specific period. During this phase, the usage of the service will be monitored using automated quantitative tools. In parallel, qualitative analysis will be carried out using interviews and questionnaires. An important element of this process is to assess the the adaptability of the proposed system and identify possible limitations. Future work directions include the expension of the service to the school environment where it is observed that kids need further support. One possibility would be to include teachers and support personnel from the school. Another possibility would be to include people of the same age as the kids, such as friends and classmates. Involving friends and classmates of the students is by itself a difficult task also due to the potential psychological side-effects.

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