



**HAL**  
open science

## **Council of Coaches - A Novel Holistic Behavior Change Coaching Approach**

Harm Op den Akker, Rieks Op den Akker, Tessa Beinema, Oresti Banos, Dirk Heylen, Bjørn Bedsted, Alison Pease, Catherine Pelachaud, Vicente Traver Salcedo, Sofoklis Kyriazakos, et al.

### ► **To cite this version:**

Harm Op den Akker, Rieks Op den Akker, Tessa Beinema, Oresti Banos, Dirk Heylen, et al.. Council of Coaches - A Novel Holistic Behavior Change Coaching Approach. 4th International Conference on Information and Communication Technologies for Ageing Well and e-Health, Mar 2018, Funchal, Portugal. pp.219-226, 10.5220/0006787702190226 . hal-02382709

**HAL Id: hal-02382709**

**<https://hal.science/hal-02382709>**

Submitted on 15 Dec 2023

**HAL** is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.

# Council of Coaches

## *A Novel Holistic Behavior Change Coaching Approach*

Harm op den Akker<sup>1,2</sup>, Rieks op den Akker<sup>3</sup>, Tessa Beinema<sup>1,2</sup>, Oresti Banos<sup>2</sup>, Dirk Heylen<sup>3</sup>, Björn Bedsted<sup>4</sup>, Alison Pease<sup>5</sup>, Catherine Pelachaud<sup>6</sup>, Vicente Traver Salcedo<sup>7</sup>, Sofoklis Kyriazakos<sup>8</sup> and Hermie Hermens<sup>1,2</sup>

<sup>1</sup>*Roessingh Research and Development, Telemedicine Group, Enschede, The Netherlands*

<sup>2</sup>*University of Twente, Department of Biomedical Signals and Systems, Enschede, The Netherlands*

<sup>3</sup>*University of Twente, Department of Human Media Interaction, Enschede, The Netherlands*

<sup>4</sup>*Danish Board of Technology Foundation, Copenhagen, Denmark*

<sup>5</sup>*University of Dundee, Dundee, United Kingdom*

<sup>6</sup>*CNRS - ISIR, Sorbonne University, Paris, France*

<sup>7</sup>*ITACA, Universitat Politècnica de València, València, Spain*

<sup>8</sup>*BTECH, Aarhus University, Herning, Denmark*

**Keywords:** Virtual Coaching, Behavior Change, Embodied Agents.

**Abstract:** A modern way of life needs a modern way of coaching. Despite the proliferation of ICT solutions for personalized health care, there is still no easy way to provide older adults with integrated coaching services. In this paper we introduce the concept of Council of Coaches — a radically new virtual coaching concept based on multiple autonomous, embodied virtual coaches, which form together a personal council that fulfills the needs of older adults in an integrated way. In this concept, coaching takes the form of an open dialog in which clients co-construct together with a selected number of coaches their own plans to go for a healthier lifestyle. Virtual coaches are presented to users by means of embodied conversational social characters. We discuss technical and social challenges on the path towards realizing the Council of Coaches concept, a radically new view of health coaching that involves the state of the art in human-computer interaction, natural dialogue, and argumentation technology.

## 1 INTRODUCTION

Due to advancements in treatment and care, the average human life expectancy has increased significantly over the past decades. Unfortunately the added years we gain at the end of our lives are not always lived in good health. Instead, more and more older adults are living under the effects of various chronic conditions. Such conditions cannot be cured, but it has been shown that a healthy lifestyle substantially contributes to their prevention, and reduces their impact on quality of life. Adopting a healthy lifestyle means changing ingrained patterns of behavior – something that is notoriously difficult to achieve without the right support. Tools that provide personalized coaching are rapidly emerging, and in some domains (e.g. physical activity) have penetrated the market. Key limi-

tations are that such tools focus on a single domain, are targeted at a young and active audience, and lack the ability to remain engaging over longer periods of time.

In order to alleviate those issues of existing coaching and support tools, we propose a radically new concept of virtual coaching, called the “Council of Coaches” concept. The council consists of a number of virtual characters — each specialized in their own domain – that interact with each other and with the user to inform, motivate and discuss about health and well-being related issues (e.g. physical, cognitive, mental and social well-being). The individual coaches will listen to the user, ask questions, inform, discuss between themselves, jointly set personal goals and inspire the user to take control of his health. Any

combination of specialized council members collaboratively cover a wide spectrum of lifestyle interventions, with a substantial likelihood of positive impact on outcomes related to chronic diseases.

We envision the Council of Coaches concept to make its initial impact in the health and wellbeing domain, especially in the multi-disciplinary case of active and healthy aging. As such, the concept will be demonstrated in the area of older adults suffering from age-related impairments. Additionally, we aim to demonstrate to support the self-management in two major chronic disorders with high volume and high impact: Diabetes type 2 and Chronic Pain – often affecting the person in multiple health domains. The council of virtual coaches will initiate engaging discussions on healthy behaviors, forwarding their points of view from the different domains and providing highly personalized responses on the input of the person, using beyond state-of-the-art technology for multi-party dialogue systems, integrated with real-time interactive 3D embodied virtual agents. With the Council of Coaches system, even a passive user can be educated and convinced to take a behavior change course-of-action by passively observing and watching the automated discussions between virtual coaches about the user's behavior unfold.

Our position is that the concept of a Council of Coaches will significantly impact the effect of health coaching because it (a) increases engagement, (b) allows for additional coaching strategies, (c) allows to influence an unmotivated user.

In this paper we discuss our position — a council of autonomous virtual agents providing numerous routes to improving collaborative support settings. We motivate and further elaborate on the main concept in Section 2. Then, in Section 3 we discuss related work, relevant background and the inspiration that led to the Council of Coaches Concept. In Section 4 we provide a detailed example that walks the reader through an envisioned session with the Council of Coaches demonstrator, explaining the concept in a story-based scenario. In Section 5, we discuss the technical and functional challenges we see in reaching an infrastructure of multiple virtual coaches cooperating with their users in a personalized and holistic health and wellbeing application. Finally, in Section 6 we summarize our position and conclude the paper with a view towards its realization.

## 2 THE COUNCIL OF COACHES CONCEPT

Our new concept of virtual coaching involves multiple autonomous agents that are able to educate and motivate the user in interactive group discussions. Different expert coaches will be developed in order to demonstrate the concept, with expertise on various domains including physical activity, cognitive and mental health, social skills and participation, as well as condition specific expertise for diabetes and chronic pain.

Individual one-to-one, human-to-agent interactions have been widely explored in research and applications in various domains. Virtual embodied conversational characters for personalized coaching in the health domain are investigated for some time already. They focus on specific chronic conditions such as diabetes (Klaassen et al., 2016), or chronic obstructive pulmonary disease (COPD), targeting better adherence to medical treatment or physical activity (op den Akker et al., 2015) or on mental diseases, drug addiction (Lisetti et al., 2013), and Post-Traumatic Stress Disorder (PTSD) (Tielman et al., 2015).

Previous studies emphasize the importance of social relationship building and companionship with the virtual agent (Bickmore et al., 2010; Turunen et al., 2011). Arguably the most important prerequisite for the success of such agent-based interaction systems is that users need to remain engaged: “if a user stops interacting with the agent, then it cannot have any further impact” (Battagolino and Bickmore, 2015). Being informed, and reaching motivation to change behavior is an internal process that needs to be bootstrapped by engaging the user with the behavioral domain. By introducing the council setting of coaching, we allow ourselves to keep the discussion, and the user's internal process of change alive, by moving the dialogue forward when the user's initiative of interacting with the system is low.

For example, with a traditional, single-agent coach, the coach might ask a user (e.g. recently diagnosed with COPD) about his intention to stop smoking, with the underlying goal of implanting the idea that this would be a good idea, and providing arguments for it. However, without the user's cooperation, a discussion about the user's intentions, doubts, or difficulties will be impossible to have. Consider the example below:

**Coach:** Have you considered trying to quit smoking, Bob?

**Bob:** None of your business.

End of story. Even if a user is willing to go along with the virtual coach, the technical limitations of machines understanding free-form natural language interaction severely complicates the ability of having a meaningful, deep discussion about such topics. Consider the following example:

**Coach:** Have you considered trying to quit smoking, Bob?

**Bob:** Well eh, I guess the moment I walked out of my doctor's door, I was well it was quite a shock I tell you. I heard about COPD before but it's the type of thing you hear about other people you know? I put my hands in my pocket and felt the cigarette box, but then yes I thought to myself, better not this time. Since then I have been smoking again on and off...

**Coach:** I did not understand your response.

Again, end of story. Now, having a group discussion where the user participates in a session where multiple virtual agents are present allows us to generate an interactive performance:

**Ellis:** Have you considered trying to quit smoking, Bob?

**Ben:** Quit smoking, quit drinking, quit doing all the fun things in life! Why don't you quit whining?

**Florence:** What a stupid thing to say, Ben! Next thing you're going to tell us all about your grandfather who smoked all of his life and lived to be a 100 years old!

**Ben:** Well, for your information Florence... My grandfather was a heavy smoker and he did turn out to be 94 years old, so there.

**Richard:** Florence, Ben, cut it out, this isn't about you or your grandfather, we are talking about Bob, perhaps he has anything to say here?

**Bob:** (Say nothing.)

**Ellis:** Well, you know that smoking does not guarantee an early death. But Bob here recently got diagnosed with COPD, a condition that is almost always caused by long-term smoking.

**Ellis:** Although it may not be easy, it is very important to try and quit as a very first step in dealing with this.

**Ben:** Sure, I guess, you are the expert.

**Richard:** And it has a positive effect on your taste! Think about all the delicious things we could cook together and how excellent all the flavors will work out.

**Bob:** I am trying but find it difficult.

What this example portrays, is that even without any active participation of the user (Bob chooses to say nothing), the discussion can continue and provide some arguments and background on the topic. Then, when the user is engaged, a predefined selectable utterance can indicate the stance of the user in the current ongoing dialogue (Bob: "I am trying but find it difficult"), allowing our COPD Coach, Ellis, to continue the dialogue with e.g. advice on how to approach the smoking cessation issue. This way, it is possible to engage the user in a discussion about a personal issue without bearing on real-time natural language understanding. Furthermore, the example illustrates some of the other underlying aims of the project:

**Immersive Dialogue** — Creating a captivating dialogue, and unfolding stories between coaches (Ben and Florence don't seem to like each other now, but who knows how romance might find a way?). Such stories unfolding over multiple interactive sessions serve to further engage the user with his personal council.

**State of Art Interactive Multi-Party Conversation** — Advancing the state of the art in multi-party dialogue systems by creating dynamic, personalized dialogues that can be interrupted and driven by user responses.

**Multi-Domain Behavior Change Approach** — Approaching behavior change in a particular domain (e.g. smoking cessation) in a holistic way by involving in this case diet (stop smoking positively affects taste/food experience), or physical activity (stop smoking increases your capacity for doing sports).

### 3 RELATED WORK AND INSPIRATION

The overall concept of the Council of Coaches is inspired by the 1996 video game Civilization II, developed and published by MicroProse (Civilization 2, 1996), in which an in game "High Council" of advisors would help the player make decisions about strategic moves (see Figure 1). To the best of our knowledge, no serious applications have ever been developed or researched that employ the use of a group of advisors to educate, motivate, and engage users in the health counseling, or in fact, any other domain.

Some examples of related research can be found that explore applications of multiple virtual characters



Figure 1: Council of Advisors in Civilization II (Micro-Prose, 1996).

in various domains. We discuss relevant examples below.

Early work by André and Rist describes a system in which multiple virtual characters are used to present information to a user through “presentation teams” (André and Rist, 2001) in which a virtual car salesman and two virtual buyers display a performance in which various aspect of the topic (car sales) are being discussed in front of a passive viewer (the user). The prototype described is 16 years old, and although never further developed beyond the prototype, may serve as inspiration in the realization of the Council of Coaches concept.

Traum and Rickel describe a system in which the end-user interacts with multiple embodied virtual agents in a military training scenario (Traum and Rickel, 2002). Although many of the works technological developments done in 2002 have since been improved, the work serves as one of the few known examples that are comparable to the Council concept. The authors employed a “Hollywood writer” to guide the development by creating a storyline and script for the training scenario. Inspired by the work of Traum, in the Council of Coaches system we aim to integrate creative stories that unfold between the various virtual coaches throughout the users interaction in order to enrich the individual coaches personality and increase engagement with the system overall.

There is some evidence that the use of multiple character agents can be advantageous for learners in virtual teaching systems. In (Baylor and Ebberts, 2003) an e-learning tool was developed in which the virtual support agent was divided into two separate agents representing the role of teacher and that of motivator respectively. By introducing this split, an increase in performance was obtained, perhaps because

the student was better able to ‘compartmentalize’ the information provided by the two distinct coaches. In this example the two ‘coaches’ strictly operate in a collaborative way. In the PORTIA system — a dialog system that allows users to engage in a natural dialog about the relation between food and health — the issue of discussion and arguments is in the center scope (de Carolis and Mazzotta, 2017). The system distinguishes affective and rational arguments and uses them in a persuasive dialog with the user based on a probabilistic knowledge base and user model. Arguments are presented by an Embodied Conversational Character.

The Council of Coaches concept leans heavily on existing knowledge and background in the field of coaching, personalized human-computer interaction, embodied agents, (multi-party) dialogue and argumentation theory, and behavior modeling and analysis. In the realization of this concept, we build on the myriad of knowledge obtained and learn from the tools and applications built and described in research. However, a thorough discussion of the work in these areas is beyond the scope of this position paper.

#### 4 SCENARIO: THE STORY OF JENNY

In order to get a tangible feeling for what the council of coaches is all about, below we outline a detailed scenario, that introduces our persona Jenny, a potential primary user of the system.

Jenny is 64 years old and entering the last few months of her working life as a Sales & Marketing Manager of a major hotel chain. Due to her life-long desk job, she is suffering from chronic low back pain. Jenny has just returned to her desk from a meeting with the HR department to discuss her last three months of work before retirement. Although she’s always been excited about the prospect of having more time to work in the garden and having more time to spend with her grand daughter, she is beginning to worry a little about the upcoming major change in her life. She didn’t always enjoy her working days but she liked biking to the city, the coffee breaks with Matthew and Abby and of course the contact with the customers. With her final workday rapidly approaching, Jenny is starting to worry about missing the social contacts, getting out of the house, and getting the exercise needed to get her back pain under control. Looking through the pile of paperwork she

received from the HR manager, she finds a brochure that catches her eye: “Worried about a major upcoming life event? Go to [www.council-of-coaches.eu!](http://www.council-of-coaches.eu!)”.

Later that evening at home, Jenny visits the website and reads up on the Council of Coaches application. The website says the first month of usage is free, so she decides to give it a try and creates an account. She fills in some of her user details and launches the application. When opening the application, Jenny is greeted by an old and wise looking man who introduces himself as Professor Yao:

**Yao:** Greetings, and welcome to the council of coaches it seems that you are in need of some counseling, hmm? Well, you’ve come to the right place ... I am the head of the council of coaches, and I have a few questions for you, if you have some time now?

This is not what Jenny had expected, and she is looking at the screen a little bit puzzled.

**Yao:** Hmm? Well, do you have some time?

“All right, I have some time now”, Jenny says, and the grey old figure on the screen continues. Yao asks a number of questions about what’s troubling Jenny, and finally stops to think for a little while.

**Yao:** Based on what you say I suggest following. Do not worry Jenny we have a team of experts here to help you.  
I recommend you discuss your worries about your physical activity with Sgt Brady, he is a retired army drill instructor, but I’m sure you will find him to be reasonably pleasant enough.  
Next I recommend you talk about your social worries with Sonja, or “Sociable Sonja” as she likes to call herself. She will have some good advice on how to make sure you’re not isolating yourself. And finally, I recommend you talk to Pete. Pete was recently retired from the council of coaches, but he is having troubles letting go of his duties. I’m sure he understands well the issues that you’re facing concerning your retirement.  
Finally, coach Tracy is an expert on chronic pain, I’m sure you’ll find her to be very helpful.

Yao wishes Jenny the best of luck and tells her that she can call on him whenever she needs him. Next,

the scene changes to the council chamber, where the three coaches that Yao introduced are waiting for Jenny.

**Brady:** So you are afraid of becoming unfit for duty?! Start exercising, walking, cycling! In fact, give me 100 push ups right now!

**Sonja:** Whoa there, Brady, take a deep breath. We’ve not even been introduced! That was Sgt Brady and you have to excuse his enthusiasm, he hasn’t had the opportunity to coach anyone for a long time. Besides, we don’t even know how active Jenny is.

While everyone on the council is looking at Jenny, a short physical activity stage of change questionnaire appears on the screen. Jenny indicates that she hasn’t been very active but that she intends to be.

**Brady:** That’s good to know, but I need more information to work with. If you’re planning to become more physically active, I need to know how active you are now. Do you have an activity tracking device, Jenny?

Jenny indicates that she hasn’t got one yet, but that she may look for one in town on Saturday. The discussion between the council members continues for some time as they are discussing what seems to be the right approach for Jenny. Tracy makes sure the other coaches take into account Jenny’s chronic pain. Jenny listens and intervenes every now and then, until she decides that she has to go. She says goodbye to the council, and the council members wish her a nice day and good luck. Curious as to what Sgt Brady will have to say, she decides to bike to the local electronics store to buy an activity tracker, and plans to talk to the council again later that evening.

*Three months later...* Jenny is now officially retired. In the last three months she has used the Council of Coaches application on her laptop. Pete, the retirement coach, has especially given her some useful advice on finding some outdoor hobbies and she joined a weekend walking club in the area. She has been using her physical activity tracker to keep track of her activity and she set a personal step goal for herself together with Sgt Brady and Tracy. In her last meeting she was advised to download the mobile app for her smartphone so that the coaches could reach her when she was on the move, and she decided to install it. Having the app on her smartphone allows Jenny to contact her personal coaches whenever and wherever she decides. Jenny’s phonebook includes a new entry for Sgt Brady, Sonja, Pete, and Tracy, and

talking to them is as easy as making a phone call. She can also text them whenever she is in a more public environment. In these last three months, Jenny grew a fond affection for the coaches. She feels that each coach cares about her health, and makes her sympathize with them. Even Sgt Brady can have his good days.

## 5 CHALLENGES

In order to realize the Council of Coaches concept, a number of technical challenges need to be overcome. In Figure 2 we sketch a high-level conceptual overview of an envisioned implementation of the Council of Coaches concept, highlighted further in the paragraphs below.

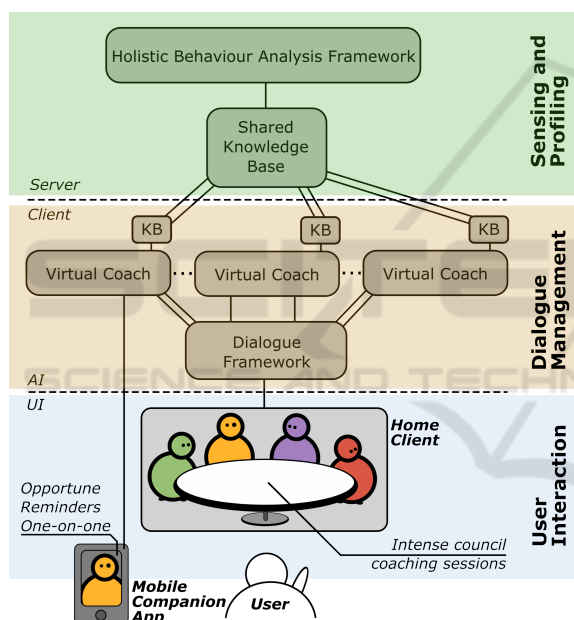


Figure 2: Council of Coaches — Conceptual Overview.

### 5.1 Coaching Strategies and Knowledge Design

Moving beyond existing literature on coaching strategies, in the Council of Coaches concept, the presence of multiple coaches allows for approaches in which coaches either apply separate coaching strategies at the same time or join together in applying one strategy. Examples of such a multi-coach strategy could be ‘good coach, bad coach’, or a ‘set up’ to elicit information from the user (as in one of the previous examples where Sonja uses Sgt Brady’s ‘Give me 10 push ups!’ statement to ask Jenny about her activity

stage). Defining these joined strategies as a general scheme so that they can be adopted by coaches when desired could be a possible implementation. For example, a simple scheme to elicit information could be: ‘Coach 1: Makes a controversial statement.’ and ‘Coach 2: Moderates the statement, and asks for information.’.

Having multiple coaches in the council that each have their own expertise also allows for the introduction of new coaches when their expertise is required. Plugging in a new coach will introduce new topics for conversation and this will require that the other coaches also share some knowledge on the subject. Representing this knowledge and the coaches in such a way that they can be added as modules in the system could facilitate this process.

### 5.2 Holistic Sensing

Having a clear understanding of the user behavior is essential to elicit effective and relevant coaching strategies. Despite the fact that significant progress has been made in the sensing and quantification of behavior in recent years, the vast majority of existing solutions are domain specific, i.e., focusing exclusively on either physical, emotional, cognitive or social aspects. More importantly, most applications claim to infer human behavior in a broad sense when they merely detect some activity-related parameters, such as step counts, calories burned or floors climbed.

In order to realize the Council of Coaches concept, a multi-domain sensing and behavior analysis framework must be realized that can feed the necessary knowledge bases of the individual agents. This knowledge will provide relevant background information for improving the user-coach interaction and supporting the dialogue and argumentation process with objective and continuous behavior-related contents. The concept moves beyond current trends in automatic behavior analysis while approaching the problem in a holistic fashion, thus modeling, inferring and combining the distinct domains of behavior including physical, emotional, cognitive and social aspects.

### 5.3 Dialogue and Argumentation Design

One of the advantages of having multiple coaches is the ability to apply the concept of ‘dialogue as performance’. That is, the coaches are able to persuade and re-engage a (passive) user by performing, in essence, a play. This opens up new approaches to persuasion dialogues, with research questions such as

how to model a “silent user” and whether “passive participation” is effective in engaging users. A major challenge lies in enabling such, essentially agent-agent, dialogues that are able to convince the non-participating partner. Both from the perspective of coaching and the perspective of argumentation technology, this requires further study.

Another challenge presents itself in developing new dialogue types, in particular facilitation. Motivation to change should be elicited from the user, rather than being imposed by the coaches — an opportunity particularly made possible by the Council of Coaches setting. This focus on facilitating decisions, as opposed to direct persuasion, differs from standard persuasion dialogue models, with coaching offering a new domain for dialogue theorists. It will open up new research questions such as how to have a generally amicable dialogue (e.g. deliberation) which has as its intention an outcome which is generally associated with an adversarial kind (e.g. persuasion).

Having dynamic strategies, in which the coaches adjust their conversational strategies to the unfolding dialogue, will also be considered. In highlighting the social behavior via multiple virtual agents, the project will open the way for both incorporating findings from, and adding to, social psychology concerning group dynamics, dominant agents and the role of a moderator (and whether there should be one).

#### 5.4 Human-Computer Interaction

Anthropomorphic virtual agents are designed as simulated social role models in various domains and applications, among which the role of a life style coach or therapist in the health domain. Several studies have shown that the visual presence and appearance of such agents have a major impact on motivation and affect (Baylor et al., 2009). In order to be effective in persuading the user, a coach should use affective as well as rational arguments and adapt its persuasive strategy to the goals and value preferences of the user. As multiple coaches introduce additional challenges in terms of the Coaching Strategies (Section 5.1) and the dialogue (Section 5.3), so too new challenges arise in the visual representation of a group of embodied agents.

Different models enabling Embodied Conversational Agents (ECAs) to exhibit social attitudes through their verbal and non-verbal behavior have been proposed. For instance, in (Gillies et al., 2004), the system *Demeanor* supported the design of virtual

characters within a group with different social attitudes (expressed through posture and gaze). In (Rehm and Endrass, 2009), the authors proposed a toolbox for manipulating the decision making of agents in a group based on different theories on social relations. In (Lee and Marsella, 2011), the authors designed the nonverbal behavior of Embodied Conversational Agents depending on their conversational role and their social relations. In (Cafaro et al., 2012), the authors conducted a study where users evaluated the perception of an ECA's attitude (friendly, hostile, extraversion) in the first seconds of an encounter with an ECA exhibiting different behaviors (smiles, gaze and proxemics). As an emerging field, the Council of Coaches concept is expected to build on and contribute significantly to the area of multi-party embodied interaction.

#### 5.5 Responsible Research and Innovation

Finally, the Council of Coaches concept introduces radically new ways of interaction between digital systems and users. This innovative interaction will be demonstrated in the area of health and wellbeing for elderly users — a target group that can be considered especially vulnerable. For these reasons it is imperative that the research and innovation process follows the principles of Responsible Research and Innovation (RRI). In the realization of this concept, we need to make sure that the new tools and coaching methods, as well as the actual R&I processes contribute effectively to the needs of future users and society at large, are aligned with societal values and ethical considerations, and have a realistic chance of succeeding in the competitive market of e-Health and e-coaching tools.

### 6 CONCLUSIONS

Despite the proliferation of ICT solutions for personalized health-care, there is still no easy way to provide older adults with integrated coaching services. Council of Coaches introduces a radically new virtual coaching concept based on multiple autonomous, embodied virtual coaches, which form together a personal council that fulfills the needs of older adults in an integrated way. Each coach has his own expertise, personality and style of coaching; they might not always agree with each other, but they all share a single goal: to support the user across every aspect of wellbeing, including physical, social, cognitive and mental support. The Council members listen to the user,



inform the user, help the user to set personal goals and inspire him to take control of his health. Give the council your thoughts, or listen and observe how the individual coaches exchange their views on numerous issues. Apply your new skills in daily life and if the need arises, contact any of the coaches anytime, anywhere. . .

The fields of behavior change, health information provision, e-learning, and human-computer interaction in general will greatly benefit from the Council of Coaches approach. By developing a framework in which multiple, completely autonomous agents can hold interactive dialogues with a user, we open up the possibility for numerous new and exciting innovations in those research fields. We presented the overall concept and the major technological and social challenges in realizing the Council of Coaches and will take the necessary steps to overcome these challenges in the next three years.

## ACKNOWLEDGEMENTS

The European Commission has provided funding for realizing the Council of Coaches concept in the same-titled project under Grant Agreement No. 769553.

## REFERENCES

- André, E. and Rist, T. (2001). Presenting through performing: On the use of multiple lifelike characters in knowledge-based presentation systems. *Knowledge-Based Syst.*, 14(12):313.
- Battagolino, C. and Bickmore, T. (2015). Increasing the engagement of conversational agents through co-constructed storytelling. In *Intelligent Narrative Technologies and Social Believability in Games: Papers from the AIIDE 2015 Joint Workshop*.
- Baylor, A. L., Arellano, D., Varona, J., Perales, F. J., Bailenson, J. N., et al. (2009). Promoting motivation with virtual agents and avatars: role of visual presence and appearance. *Philosophical transactions of the Royal Society of London. Series B, Biological sciences*.
- Baylor, A. L. and Ebbers, S. (2003). Evidence that multiple agents facilitate greater learning. In *Artificial Intelligence in Education: Shaping the Future of Learning Through Intelligent Technologies; U. Hoppe, M.F. Verdejo, J. Kay (Eds.)*, pages 377–379. IOS Press.
- Bickmore, T. W., Puskar, K., Schlenk, E. A., Pfeifer, L. M., and Sereika, S. M. (2010). Maintaining reality: Relational agents for antipsychotic medication adherence. *Interacting with Computers*, 22(4):276 – 288. Supportive Interaction: Computer Interventions for Mental Health.
- Cafaro, A., Vilhjálmsón, H. H., Bickmore, T., Heylen, D., Jóhannsdóttir, K. R., and Valgarðsson, G. S. (2012). First impressions: Users' judgments of virtual agents' personality and interpersonal attitude in first encounters. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*.
- de Carolis, B. and Mazzotta, I. (2017). A user-adaptive persuasive system based on a-rational theory. *International Journal of Human-Computer Studies*, 108(Supplement C):70 – 88.
- Gillies, M., Crabtree, I. B., and Ballin, D. (2004). Customisation and context for expressive behaviour in the broadband world. *BT Technology Journal*.
- Klaassen, R., op den Akker, R., Di Bitonto, P., van der Burg, G.-J., Bul, K., and Kato, P. (2016). Pergamon: A serious gaming and digital coaching platform supporting patients and healthcare professionals. In Varajao, J., Cruz-Cunha, M., Martinho, R., Rijo, R., Bjorn-Andersen, N., Turner, R., and Alves, D., editors, *Intern. Conf. ENTERprise Information Systems/Intern. Conf. Project MANagement/Intern. Conf. Health and Social Care Inform.Systems and Techn., 2016; CEN-TERIS/ProjMAN/HCist*, pages 261–269. SciKA.
- Lee, J. and Marsella, S. (2011). Modeling side participants and bystanders: The importance of being a laugh track. In *Lecture Notes in Computer Science (including subseries Lecture Notes in Artificial Intelligence and Lecture Notes in Bioinformatics)*.
- Lisetti, C., Amini, R., Yasavur, U., and Rishe, N. (2013). I can help you change! an empathic virtual agent delivers behavior change health interventions. *ACM Trans. Manage. Inf. Syst.*, 4(4):19:1–19:28.
- op den Akker, H., Cabrita, M., op den Akker, R., Jones, V. M., and Hermens, H. J. (2015). Tailored motivational message generation: A model and practical framework for real-time physical activity coaching. *Journal of biomedical informatics*, 55:104–115.
- Rehm, M. and Endrass, B. (2009). Rapid prototyping of social group dynamics in multiagent systems. *AI & SOCIETY*.
- Tielman, M., van Meggelen, M., M.A., N., and Brinkman, W. (2015). An ontology-based question system for a virtual coach assisting in trauma recollection. In *Brinkman WP., Broekens J., Heylen D. (eds) Intelligent Virtual Agents, IVA 2015. Lecture Notes in Computer Science*, vol 9238. Springer.
- Traum, D. and Rickel, J. (2002). Embodied agents for multi-party dialogue in immersive virtual worlds. In *Proceedings of the First International Joint Conference on Autonomous Agents and Multiagent Systems: Part 2, AAMAS '02*, pages 766–773, New York, NY, USA. ACM.
- Turunen, M., Hakulinen, J., Stahl, O., Gambäck, B., Hansen, P., Gancedo, M. C. R., de la Cmara, R. S., Smith, C., Charlton, D., and Cavazza, M. (2011). Multimodal and mobile conversational health and fitness companions. *Computer Speech & Language*, 25(2):192 – 209.