"How am I Doing?" - Personifying Health through Animated Characters

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Abstract. In this paper we present an experimental study that investigates the effects of a Virtual Representation of Health (VRH) – an online virtual character that personifies an individual's health. Testing four different variations of the VRH, we aimed to understand which variation yields the strongest overall positive effect on triggering health behavior change. The results from data collected from 512 participants in three countries indicate that all tested variations can have a positive impact on health behavior change, and show that the 'richest' VRH variation, a virtual character that models health behavior using animations, juxtaposed by an animated personification of a possible future health, has the strongest overall positive effect, compared to the other tested variations.

Keywords: Health, behavior change, personification, VRH, 3D, animated characters, virtual representation, visual communication.

1 Background and Related Work

Tailored health behavior-change communication strategies aim to persuade individuals to change what they are doing and adopt a new behavior. Tailoring aims to maximize personal connections with each individual, thereby increasing the relevance, credibility, and receptivity of the communication [15]. Tailored behavior-change strategies can come in many forms, ranging from interpersonal communication between a doctor and a patient, to customized messages delivered through print, Web, or mobile apps. Tailored health communication generally has larger positive effects on health behavior change outcomes compared to other types of health communication, including greater levels of nutrition improvement and physical activity levels [11], [4], [7]. As predicted by the Elaboration Likelihood Model [14], tailored communication recipients report greater message relevance including better recall, sharing with friends and family, and more satisfaction with it than with non-tailored communication [17].

To date, the vast majority of tailored health communication studies have tested messages. In most cases these are textual/verbal messages that are sometimes presented through a video narrative or accompanied with tailored graphics to complement the text. Numerous papers published in the last decade report tests of

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web-based behavior change programs, demonstrating that such programs can help people improve their health-related behaviors, have high reach, and can be cost effective [18], [8].

Visual communication has enormous potential to motivate individuals, to teach skills, and to increase self-efficacy. Numerous studies have shown the supremacy of pictures over text or verbal messages, an effect that was named Pictorial Superiority Effect [10]. The effect can be explained by dual coding theory: verbal and information is encoded in different ways in the human brain, with the visual encoding being more direct, thus more effective [13]. Pictures have shown to play an important role in health communication (see [6] for a review), and animation may work even better than pictures (see [20]). There is also a recent body of research exploring different promising effects of avatars on (health) behavior [3]. Thus, we hypothesize that tailoring communication through animated visuals, to be more precise, animated virtual characters, may be as efficacious as message tailoring, if not more efficacious.

Behavioral economics research demonstrates that visualizations of future selves are effective at serving as triggers to save money [9], [5]. A similar strategy may work in promoting physical activity and nutrition behaviors. These behaviors are directly associated with body weight and prevention of non-communicable diseases. Like with retirement savings, investing in these behaviors today has long term consequences or benefits that are not seen immediately. Thus, showing a person the future status if they continue to behave the way they do, may serve as that trigger to change.

This study presents a novel approach to tailoring behavior change communication. It aimed to provide online users with an engaging experience designed to serve as a "trigger" [2] or "cue to action" [16] to change their health behavior. The center piece of this experience was an animated character that personified the user's health.

In contrast to related studies that have investigated the effects of animated characters in virtual reality lab settings (e.g. [3]), this study looks at the effects that animated virtual characters accessed through a web browser have on an individual's health behavior. The Internet has shown to be a valuable medium for the promotion of health behavior change [19], and recent Web technology standards like the Web Graphics Library (WebGL) allow for animated and interactive visualizations, including the display of custom virtual characters. These online visualizations can be accessed using a common web browser and can reach a far larger user base than a virtual reality laboratory; this is of great value both for research but also for putting a system on the market. We thus believe an online virtual character has merit and call the new approach the Virtual Representation of Health (VRH), which fits in with the related definitions of Virtual Representation of Self (VRS) and of Others (VRO) [1].

2 Study Objective

The objective of our study was to test the effects of distinct user experiences on an individual's motivation and intention for health behavior change. These experiences consisted of an exposure to a virtual character – a Virtual Representation of their Health (VRH) – that represented the health status of the individual, and modeled their

health behavior or showed a possible future status of their health. The virtual character was tailored to each study participant, based on data they provided in a questionnaire just before viewing the VRH. The study was designed to measure and analyze the effects of four variations of a VRH on the motivation and intention of the user to change their eating and/or physical activity (PA) behaviors. We also wanted to understand if people appreciated this type of health communication and would like to return to the tool for ongoing support (triggers) for making and sustaining behavior change.

The following section presents how we use the information provided by a participant to tailor the VRH to their specifics – in other words, how the VRH personifies their health.

3 Personifying Health

The design of the virtual character we use as a VRH was informed by a pre-study where 172 individuals randomly) selected from the same population as the sample of the study presented in this paper described the physical, visible characteristics of health, with the aim of understanding "what health looks like". Participants were also asked about the visual characteristics of a person that does not look healthy. Participants were asked to describe these characteristics and then choose the two most illustrative characteristics for each health status (health and non-healthy). Table 1 shows an overview of the results: it presents the physical characteristics that the participants named as the first or second best visual characteristic to describe a healthy/non-healthy looking person. The characteristics most frequently mentioned for both a healthy and a non-healthy person, relate to fitness, energy level, and agility, but also to skin color (i.e., complexity) and diverse skin issues.

With the design of our VRH and its variations we cover most of the top characteristics reported by the sample, as highlighted in Table 1. The personal characteristics used to tailor the VRH to an individual include height and weight, the calculated Body-Mass Index (BMI), past 7 day nutrition behavior, and past 7 day physical activity behavior. In order to personify the individual's health, the VRH is designed to be variable for body shapes, body animations and poses, and skin texture.

The body shape of the VRH is tailored to healthy weight, overweight, or obese weight, based on the body mass index (BMI) of an individual (see Figure 1).

Poses and animations are tailored on three levels of physical activity of an individual, including a sedentary, a moderate, and a very active level (see Figure 2). The sedentary version shows the VRH seated, slowly standing up, and sitting back down. For the moderate PA level the VRH performs an easy workout (i.e., stretches, bend, twists), for the high PA level a hard workout (i.e., jumps, pushups, bends, twists).

The skin texture is tailored to show healthy-looking skin, average skin, and unhealthy-looking skin. The skin textures were exaggerated in order for differences to be noticeable between animated characters. The unhealthy skin texture includes darker patches on the skin, wrinkles, bags under the eyes, and also slightly red eyes (see Figure 3).

Table 1. Overview of the results of the pre-study "What does health look like?" The characteristics covered by our VRH variations (i.e., body shape, poses/animations, skin complexity, skin/eye issues) are highlighted

Physical characteristics that best describe a healthy-looking person	**n**	**%**
Fit	68	22.2%
Happy	55	18.0%
Energetic	54	17.6%
Healthy skin color	31	10.1%
Strong	29	9.5%
Dynamic	28	9.2%
Agile	21	6.9%
Good posture	12	3.9%
Other	8	2.6%

Physical characteristics that best describe a *not* healthy-looking person	**n**	**%**
Lacking energy	61	20.3%
Tired	56	18.6%
Shortness of breath	40	13.3%
Moving slowly	30	10.0%
Pale skin color	29	9.6%
Bags under the eyes	16	5.3%
Poor/bad balance	14	4.7%
Bad posture	12	4.0%
Not flexible	12	4.0%
Skin problems	11	3.7%
Swollen hands or feet	7	2.3%
Other	7	2.3%
Red eyes	6	2.0%

Fig. 1. Illustration of the healthy (left), overweight (center), and obese (right) versions of the (female) VRH

Fig. 2. Illustration of sedentary (first left), moderate (second left), and very active (third left) levels of physical activity. The VRH further personified moderate and high physical activity levels without animation using rather closed or open stances (first and second right).

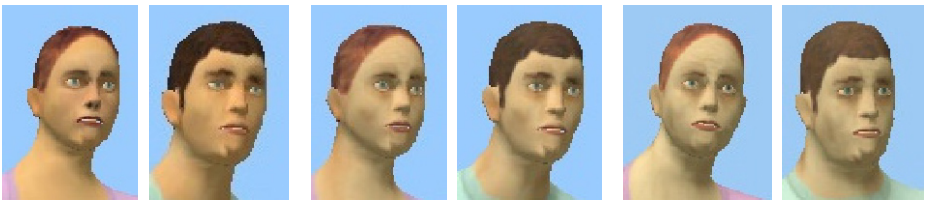

Fig. 3. Illustration of the healthy (left), average (center), and unhealthy (right) variations of the skin of the VRH, for both gender versions

4 Experiment Design and Hypotheses

We developed a controlled experiment with four conditions, in order to compare four types of Virtual Representations of Health. The VRH was implemented using WebGL (Web Graphics Library) and can be accessed through a modern web browser on a common webpage. The experimental conditions were designed as follows:

1. a VRH that is tailored solely on current health status; *a non-animated virtual character*
2. a VRH that is tailored on current health status juxtaposed with a second VRH that personifies possible future health status; *two virtual characters, one present and one future, in still poses*
3. a VRH that is tailored on current health status while also modeling current health behavior; *an animated virtual character*
4. a VRH that is tailored on current health status while also modeling current health behavior, juxtaposed with a second VRH that personifies possible future changes in health status; *two animated, one present and one future, virtual characters*

With this experiment, we aimed at understanding the differing effects of the four variations of exposure a VRH, leading to four significantly different experiences for the participant. Thus, a control group without any exposure to a VRH was not needed to answer our research question.

We hypothesized that the experience of viewing one's VRH that both models current health behavior through animations and personifies changes in future health status through juxtaposition, that is, condition 4, has the greatest positive effect on motivation, intention (H1). We based this main hypothesis on the sub-hypotheses that (H1a) viewing a juxtaposition of a present VRH and a VRH representing a possible future health has a more positive effect on motivation and intention than viewing only one VRH, and that (H1b) viewing a VRH that models current health behavior using animations has a more positive effect on motivation and intention than viewing still versions of a VRH.

Further, we expected participants in experimental condition 4 to be more motivated, and have a higher intention to, return to the VRH tool than those in any other experimental condition (H2).

The theoretical foundations for the study include B.J. Fogg's Behavior Change Model and Petty and Cacioppo's Elaboration Likelihood Model [2], [14]. We

hypothesized that the experience of seeing a virtual representation of the own health status now and in the future, will serve as a trigger to change. To control for the other variables in the Fogg model, (ability and motivation), participants were recruited based on being motivated and able to improve nutrition and physical activity behaviors. The study is further based on the assumption that the more tailored (i.e., relevant) the trigger is, the more likely a person is to change [14], [15].

Experimental conditions 1 and 2 (shown in Figure 4) used still poses. For tailoring on the physical activity level of a participant the VRH was displayed in either a closed pose (personifying a low level of physical activity), an average pose (for a moderate level of activity), or an open stance (representing a high level of agility).

Fig. 4. Experimental conditions 1 (left) and 2 (right)

Experimental conditions 3 and 4 (shown in Figure 5) used repeating animations instead of still poses. For tailoring on the physical activity level of a participant the VRH was displayed in either a slow movement (i.e., getting up slowly from a sitting position; personifying a low level of physical activity), a moderate speed movement (for a moderate level of activity), or a fast, agile animation (showing the VRH perform a complete workout; representing a high level of agility).

Fig. 5. Experimental conditions 3 (left) and 4 (right)

5 Methods

An online experiment was used to examine the differing effects of the four user experiences. The study participants were recruited through an online recruitment agency and came from three European countries (German, Great Britain and Poland). Eligibility criteria included being motivated to improving health behavior, being able to improve eating and physical activity behaviors, the use of a modern web browser supporting WebGL (to be able to view the VRH in the browser), and the ability to complete questionnaires in English. The study was approved by the local ethics commission.

Before the exposure to the VRH, participants completed a pre-test, in which they were asked to enter their age, gender, email, education level, country of origin and residency, height, and weight. They were asked to indicate on 7-point Likert scales how many days a week they currently engaged in physical activity and followed a healthy diet, as well as how motivated they were, and how much intention they had to engage in healthy behaviors (PA and eating) in the week to follow. After the pre-survey questionnaires which in average took about seven minutes to complete, they were shown their tailored VRH.

After viewing their VRH (for in average just over one minute), participants were again asked about their motivation and intention to engage in a health (PA and nutrition) behaviors in the week to come.

Immediately post exposure to the VRH, participants completed a post-test, where they were again asked to indicate how motivated they were, and how much they intended, to engage in healthy behaviors in the week to follow.

Outcome variables included motivation to engage in more PA, intention to engage in more PA, motivation to engage in a healthier diet, and intention to engage in a healthier diet. Each behavior was asked in reference to the coming week (e.g., motivation to engage in a healthier diet in the coming week). Further, we measured motivation and intention to access the VRH tool again.

6 Results

A total of 293 men and 219 women (N=512) from three European countries participated in this study (n=186, Germany; n=177, Poland; n=149, UK). The mean age was of 33 years. Probably due to the eligibility criteria, the sample was more inclined to healthier weight than the European average: only 39% were overweight or obese; in Europe, more than 52.6% of the adult population report to be overweight or obese [12].

We conducted t-tests for data analysis. Significant positive changes were seen in motivation to be more physically active for participants in all conditions (see the means comparison illustrated in the left chart in Figure 6). Condition 4 showed the most positive and most significant effects overall. The pre-post change of intention to be more physically active in the week to follow was highest for condition 2, and significant only for conditions 2 to 4 (see the means comparison illustrated in the right chart in Figure 6). For significance levels refer to Table 2 below.

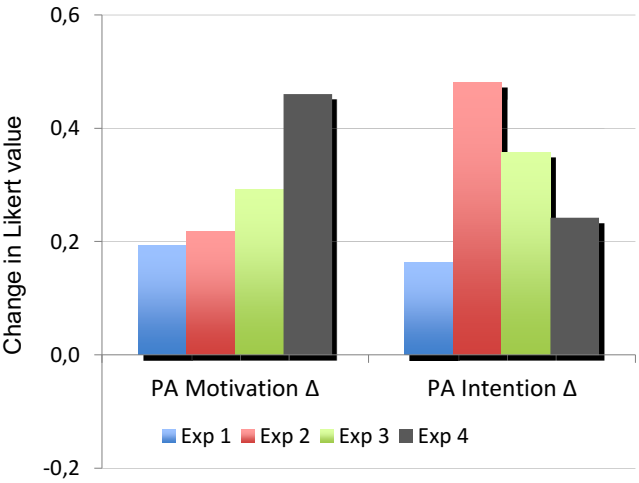

Fig. 6. Means comparison of the change (pre-/post-exposure) in motivation (left) and intention (right) to engage in more physical activity

Pre-post changes in motivation to improve nutrition behavior were significant only for participants in condition 4. The pre-post changes in intention to improve nutrition behavior, all conditions showed significant and positive changes, while condition 4 showed the largest change (see the means comparisons illustrated in Figure 7; for statistical significance levels refer to Table 2 below).

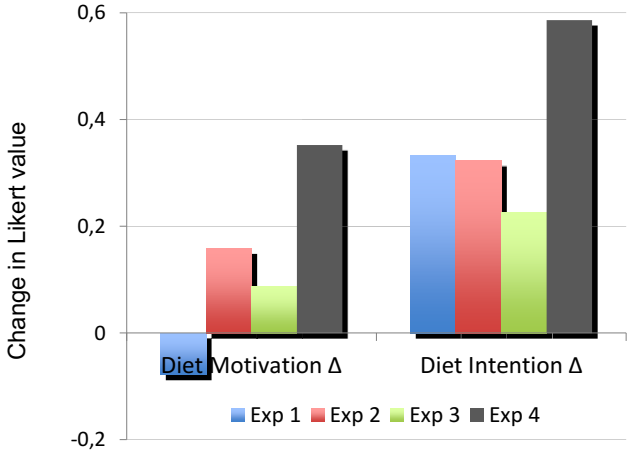

Fig. 7. Means comparison of the change (pre-/post-exposure) in motivation (left) and intention (right) to engage in a healthier diet (i.e., better nutrition)

Table 2. Overview of the outcome measures including statistical significance levels (+ = positive effect, - = negative effect; * = p<.05, ** = p<.01, *** = p<.001, n.s. = not significant)

Outcome measures	**Experimental conditions**			
	1. Still pose	2. Still pose & personifying future	3. Modeling health behavior	4. Modeling & personifying future
Physical activity				
Change in motivation to improve PA behavior	+* (p=.05)	+* (p=.02)	+** (p=.004)	+*** (p=.001)
Change in intention to improve PA behavior	+ n.s. (p=.113)	+*** (p=.001)	+*** (p=.001)	+* (p=.048)
Nutrition				
Change in motivation to improve nutrition behavior	- n.s. (p=.251)	+ n.s. (p=.085)	+ n.s. (p=.389)	+*** (p=.001)
Change in intention to improve nutrition behavior	+*** (p=.001)	+*** (p=.001)	+* (p=.022)	+*** (p=.001)

We measured a high level of motivation to revisit the tool with a 7-point Likert scale; the mean values are reprinted in Figure 8. No significant differences in motivation or intention between groups could be determined.

Fig. 8. Mean values of the motivation and intention to return to the VRH tool. The bars are based on Likert level 4 as it is the medium value between "totally motivated to return" (7) and "not at all motivated to return" (1).

7 Discussion

These results confirm our hypothesis that the experience of viewing one's VRH that both models current health behavior through animations and personifies changes in future health status through juxtaposition (H1), that is, condition 4, serves as the overall strongest trigger to change, when compared to using still poses instead of animations or to personifying only the current health. This is especially true for eating behavior. Thus, looking into the 'mirror of the future' has potential to be that trigger or cue to take action needed by those interested and able to change their health behavior.

As the related sub-hypotheses H1a and H1b are concerned, neither could be confirmed by the results. While all outcome measures except 'change in intention to improve nutrition behavior' yielded a result that we had expected (i.e., 4 > 1, 2 > 1, 3 > 1), only one measure each could confirm H1a and H1b, respectively. H1a was partly confirmed only for the nutrition motivation measure, where conditions 2 and 4 yielded stronger effects than the other conditions. H1b on the other hand was partly confirmed only for the PA motivation measure, where conditions 3 and 4 yielded stronger effects than the other conditions.

Our hypothesis H2 could not be confirmed by the data – the analysis did not show any significant difference in motivation or intention to return to the VRH tool between the experimental conditions.

Being aware that the sub-conditions H1a H1b were mutually exclusive to begin with, we also attribute the mixed results concerning H1a and H1b partly to the fact that the conditions were not separated clear enough in this first experiment with an online VRH. Future experiments could be set up using fewer experimental conditions and directly juxtapose even more similar variations of the VRH. This way each effect can be better attributed to a single design element. It might also be cleaner to clearly separate the health behaviors physical activity and nutrition, and conduct distinct experiments for each, with the aim of better singling out what type of VRH – and what design factors – may be beneficial to the motivation or intention to change that particular behavior.

In order to base this new research strand, it would be of value to empirically investigate also what value a VRH has as compared to non-visual communication strategies, or to visual representations of health that are not based on a virtual character. Numerous questions still exist about how to provide the most relevant, action-prompting communication to prompt health behavior change. This study serves as a first step in such research looking at an online, visual representation of an individual's health. We know that the VRH can serve as a self-reported trigger to intend to change and it increases motivation. The next step is to build on this first evidence and conduct a study with longer-term assessments that measures behavior. Ideally, these assessments include objective measures of health status and behavior, both possible through some of the modern monitoring and tracking devices (also: wearable tech) we have seen presented for example at this year's Consumer Electronics Show (CES) in Las Vegas. More research is also warranted to examine the extent of tailoring needed to maximize benefits. In terms of user experience,

further study of the effects of frequency and dose of each exposure and to what extent people identify with the VRH will be beneficial. Further, bringing in the social element, that is showing a person their own VRH and as it compares with others' may further improve the efficacy for some individuals.

8 Conclusion

The study demonstrates that non-verbal communication, in the form of animations and virtual characters can be an effective approach in behavior change communication. It shows that displaying current and future health status has motivational impact on current physical activity behaviors. In terms of nutrition, the future self may not be so critical. Much more research is warranted, including investigation into other individual factors that may be important, such as personality, motivations, and goals. Future research in this area should look more into investigating possibilities of engaging experiences as triggers and calls-to-action on smartphones and other pervasive devices, also taking into account the social factor.

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