

The Persuasive Power of Digital Personal Assistants

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SUMMARY

In our master thesis, we have studied the topic of persuasive digital assistants. Digital assistants are Voice-controlled in-home devices, such as Amazon Echo and Google Home, and have gained more popularity and acceptance in recent years. The hands-free voice-controlled interfaces aim to support users on an everyday basis with planning, searching for information, controlling smart home accessories and entertainment. Persuasion has been studied and used multiple times in HCI research. In our work, we employ B. J. Fogg's theories of persuasion to examine how a digital personal assistant can persuade during a physical exercise session. We specifically investigated the effect of the three persuasive principles Suggestion, Virtual Reward, and Praise.

We conducted a user study with 48 participants through a controlled laboratory study, to examine if digital personal assistants can be persuasive. Based on the three principles, we created a digital personal assistant to facilitate a physical workout session and to motivate participants during various exercises. Our results showed that digital personal assistants have persuasive power, as there was a clear difference between a Neutral condition and the three persuasive feedback techniques. Virtual Reward showed the most promise, as it had the highest effect on repetitions, time, and the participants perceived motivation. Although Suggestion is rated as the least motivating of the three principles and described as being negative, there were indications of Suggestion being the best at encouraging physical effort, as it had the highest effect on participants average heart rate. Praise lacked sincerity but was otherwise mentioned as a positive reassurance, where more participants indicated that Praise would be good to use as a beginner in exercising or in combination with the two other persuasive principles. Consequently, we found that there are differences between the three persuasive principles and they have different potentials. Virtual Reward could be used for cardiovascular exercises (e.g. running, cycling), where there is often more focus on endurance, whereas Suggestion could be used for strength training, where the focus is on getting a higher heart rate over a shorter duration, and Praise could be used for beginners or to strengthen the two other persuasions.

Our work contributes to the fields of digital personal assistants and persuasion in HCI in three ways. First, based on our results from our study, we can conclude that digital personal assistants have persuasive powers. Second, we established that there is a difference between the three persuasive principles, where each of the three principles has its own strengths and weaknesses. Third, we outline the design implications and future research directions that emerged throughout the study, for the area of persuasive digital assistants. Our study took the first steps of exploring and understanding this new area, however, future work is required to fully understand the potentials and pitfalls of persuasive digital assistants.

The Persuasive Power of Digital Personal Assistants

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ABSTRACT

Digital personal assistants, like Amazon Echo and Google Home, have grown in popularity in recent years. We believe that digital personal assistants have the potential to persuade, as an assistant can leverage information about the user and utilise its connection to the users' digital ecosystem. However, to our best knowledge, there is no research on the persuasive power of these voice-controlled assistants. We conducted a user study with 48 participants, in the context of physical activity, to examine the effect of the three persuasive principles: Suggestion, Virtual Reward, and Praise. Our findings reveal that digital personal assistants have persuasive power, and the three principles had different strengths. Virtual Reward was good at encouraging endurance, Suggestion was good at encouraging physical effort, and Praise created positive reassurance for beginners. We outline design considerations that should be taken into account when designing persuasive digital assistants and possible future research directions.

KEYWORDS

Speech interaction; Digital personal assistants; Persuasive technology; Physical activity.

1 INTRODUCTION

Voice-controlled in-home devices, such as Amazon Echo and Google Home, have gained more popularity and acceptance in recent years [34, 25, 3]. The hands-free voice-controlled interfaces aim to support users on an everyday basis with planning, searching for information, controlling smart home accessories and entertainment [40, 39, 25]. The digital personal assistant embodies the idea of a butler or assistant, helping the user and household manage their everyday life.

We are now at a stage where the technology is relatively mature and stable, therefore, we seek to understand, explore, and expand the capabilities of digital personal assistants. Based on our previous work concerning digital personal assistants, we believe that persuasion could be an

interesting expansion point as a personal assistant is placed at a central location in the home, has access to information about the user, and can furthermore leverage connection to different IoT devices and its relationship with the user.

This article aims to assess the persuasive abilities of digital personal assistants. The role of digital personal assistants in persuasion is an area that, to our best knowledge, no one has paid special attention to within the HCI community, making this a novel research area. Research about digital personal assistants exists, where the focus often is on empirical studies investigating how digital personal assistants are used and perceived [40, 49, 39, 43, 27, 41], the challenges surrounding speech interaction [21, 33, 45, 32], and how to evaluate voice-interfaces [18, 22], as well as exploring digital personal assistants future design considerations [48, 6, 31, 14]. Persuasion has been studied multiple times in HCI research [42, 29, 11, 38]. In this article, we employ B. J. Fogg's notions of persuasion [16].

We designed a user study to test digital personal assistants' persuasive abilities. We chose to work in the context of motivating people to be physically active as there is a wealth of research concerning persuasion and health [e.g. 42, 29, 11, 44]. In the study, a digital personal assistant facilitated a physical workout session and used three of B. J. Fogg's persuasive principles [16]: Suggestion, Virtual Reward, and Praise to motivate participants. The main focus of the experiment was to assess the persuasive power of digital assistants and compare the effect of the three different persuasive principles.

Our work contributes to the fields of digital personal assistants and persuasion in HCI in three ways. First, based on our results from the study, we can conclude that digital personal assistants have persuasive power. Second, we established that there is a difference between the three persuasive principles, where each of the three principles has its own strengths. Third, we outline the design implications and future research directions that emerged throughout the study for the area of persuasive digital assistants. Our study takes the first step in exploring and understanding this new area. However, future work is required to understand the potentials and pitfalls of persuasive digital assistants.

2 RELATED WORK

In this section, we present the topic of digital personal assistants and a short overview of B. J. Fogg’s persuasive technology theories, which our study of a persuasive digital personal assistant is built upon. We also present related work about persuasion and physical activity.

2.1 Digital Personal Assistants

Porcheron et al. define a digital personal assistant as “*embodying the idea of a virtual butler that helps you ‘get things done’*” [39]. The first well-known commercially available digital personal assistants were on smartphones, for example, Siri and Google Now (i.e. today known as Google Assistant). The assistants evolved from being software-only programs to have their own physical device, where we now have devices such as Amazon Echo, Google Home, and Apple’s HomePod. In recent years, these physical devices have gained more popularity [34, 25, 3] and their most common use includes planning (e.g. to-do lists, calendars, reminders), searching for information (e.g. news, traffic, weather), controlling smart home accessories (e.g. lights, locks), and entertainment (e.g. video, music, games) [40, 39, 25].

In HCI research, the subject of digital personal assistants has been studied multiple times. The focus within this subject has often been on empirical studies investigating how digital personal assistants are used and perceived by its users [40, 49, 39, 43, 27, 41]. Other studies focus on the challenges with speech interactions [21, 33, 45, 32], for example, the challenges with specific types of words and named content, as well as how users overcome speech recognition errors. Speech interactions are also difficult to evaluate, as established techniques, like thinking aloud does not apply to the nature of speech interaction, therefore, other studies focus on how we can evaluate speech interfaces [18, 22]. Studies also suggest and show how we can improve the interactions with digital personal assistants by adding continuous conversations [48] and personalities [6]. Finally, studies also look into the future possibilities of digital personal assistants, for example, how they can be used in workplaces [31] or how they can become a more significant part of future smart homes [14].

2.2 Persuasion

Persuasion is defined as “*an attempt to change attitudes or behaviours or both*” [16]. B. J. Fogg, a pioneer within studies of persuasion and computers, defines a persuasive technology as “*an interactive technology that attempts to change people’s attitudes or behaviours in some way*” [15]. Fogg states that there are many different ways technology can persuade, and in his book *Persuasive technology - using computers to change what we think and do*, he presents the Functional Triad and 42 principles of persuasion [16]. The

Tool Increases capability	<ul style="list-style-type: none">• Making target behaviour easier to do• Leading people through a process• Performing calculations or measurements that motivate
Medium Provides experience	<ul style="list-style-type: none">• Allowing people to explore cause-and-effect relationships• Providing people with various experiences that motivate• Helping people rehearse a behaviour
Social Actor Creates relationship	<ul style="list-style-type: none">• Rewarding people with positive feedback• Modeling a target behaviour or attitude• Providing social support

Figure 1: The Functional Triad [16].

Functional Triad is a conceptual framework that illustrates three different persuasive roles a computer technology can have: Tool, Medium, and Social Actor (Figure 1).

Technology as a Tool persuades by making desired outcomes easier or more efficient to achieve for the user and focuses on the capabilities of the technology. Technology as a Medium persuades by providing the user with compelling simulations and focuses on creating experiences for the user. Technology as a Social Actor persuades by using a variety of social cues that elicit social responses from the human user and focuses on creating a relationship between the technology and the user.

Based on Fogg’s theories, we used three principles to design our persuasive digital assistant, one from each role in the Functional Triad. From the Tool role, we choose the principle of Suggestion, from the Medium role the principle of Virtual Reward and from the Social Actor role the principle of Praise. Fogg defines the three principles as [16]:

Principle of Suggestion: A computing technology will have greater persuasive power if it offers suggestions at opportune moments.

Principle of Virtual Reward: Providing a motivating simulated environment in which to rehearse a behaviour can enable people to change their attitudes or behaviour in the real world.

Principle of Praise: By offering praise, via words, images, symbols, or sounds, computing technology can lead users to be more open to persuasion.

The Suggestion principle is about intervening at the right time and often builds upon people’s existing motivations, reminding people that “*Now would be a good time to do X*”. Virtual Reward can create situations that reward and thereby motivate people to do a target behaviour, hence making users have a more enjoyable experience and attitude towards the target behaviour. In the Praise principle, the technology expresses respect,

approval, or gratitude towards the user’s current behaviour or attitude, aspiring positive feelings in the user, making the user more susceptible to persuasion. These three persuasive principles play a crucial role in the entirety of our article and studies.

2.3 Persuasion in Physical Activity

Physical health is a central theme within the field of persuasion. In commercially available products, persuasion has often been used to help users track their activities (e.g. Apple Watch, Fitbit) and manage training programs (e.g. 7-minute workout, 30-day fitness challenge). In the HCI research field, applications of the different persuasive principles have been studied with various technologies.

In research, several technologies have been used in the context of physical activity and persuasion. Commonly used tools for persuasion are tracking devices that monitor users’ physical activities (e.g. smartphones, fitness trackers, and other smart sensors). These trackers collect sensor data which is used in different ways and in combination with different persuasive principles. In studies, the sensor data is, for example, used in physical standalone devices [30] or through companion applications on smartphones [42, 20, 8, 46, 23, 5] or on computers [29, 17]. The use of these applications includes displaying statistical data through dashboards [20, 8], providing game experiences [23], social facilitation [38, 10, 13, 4] and comparison [17, 46, 8], as well as visualising users physical activity through metaphors of, for example, a flower field [5] or a fish tank [29]. Other studies look into how to persuade users to be physically active while being outside in motion, for instance, through voice input in the user’s ear while exercising [11] or installations embedded in the surroundings [44, 38]. Different technologies have utilised persuasion, but research on persuasion with digital personal assistants is to our best knowledge non-existent.

B. J. Fogg’s persuasive theories have been studied before in the context of physical activity [35, 46, 11]. Some of the persuasive principles that have been used are: Suggestion, Self-monitoring, Simulation, and Competition. In these studies, they often mix different persuasive principles, making it challenging for the authors to pinpoint the different effects of each persuasion principle accurately, but only conclude the designed overall persuasive abilities. In our article, we separate the three persuasive principles, Suggestion, Virtual Reward, and Praise to measure and compare the different effect of the persuasive principles.

3 USER STUDY

To test the persuasive abilities of digital personal assistants, we designed a controlled laboratory study in which a digital personal assistant, called IDA, was used to both facilitate a physical workout session and to act as a motivator during various exercises. The focus of the study was to assess the persuasive abilities of IDA in general, as well as to compare the three persuasive feedback techniques. In the following sections, we describe the design of our user study, and this includes a description of: IDA, the participants, the tasks, set-up, procedure, and measurements.

We designed a within-group experiment, where we manipulated IDA’s persuasive feedback, creating four conditions: (1) Suggestion, (2) Virtual Reward, (3) Praise, and (4) Neutral (no persuasion). We measured how IDA’s use of each of these persuasive principles affected the participants during physical exercises, as well as the participants’ perception of IDA’s use of the principles.

3.1 IDA - A Persuasive Personal Assistant

To carry out this experiment, we built a digital personal assistant to minimise participants biased attitudes towards a specific device or brand. IDA, short for Intelligent Digital Assistant, was created using components from a Google AIY Voice Kit including a microphone for input, a speaker for output, and an LED button lighting up to indicate when IDA was listening for commands (Figure 2). IDA is connected to the Google Cloud Services speech-to-text and text-to-speech, respectively to process voice commands and to produce voice outputs. The voice input was restricted to “yes” and “no”, to create a more straightforward interaction flow less prone to failures and voice recognition errors.

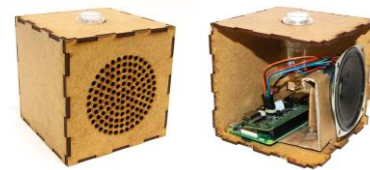


Figure 2: Picture of IDA.

IDA was designed to carry out an entire exercise session without our intervention to create a realistic experience. IDA introduced the session, exercises, and what the participants should do, as well as motivated the participants with persuasive feedback during each exercise and lastly helped participants relax between every exercise. IDA gave one of four types of feedback during an exercise, corresponding to the four conditions: Suggestion, Virtual Reward, Praise, and Neutral.

3.2 Participants

A total of 48 participants (26 males and 22 females) participated in the experiment. Participants were recruited through posts on social media and at Aalborg University's department of computer science. The participants' age varied from 17 - 56 years, with an average age of 28.3 years. The participants varied in how physically active they perceived themselves to be, where 56.2% were active, and 43.8% were neutral or perceived themselves to be inactive. Their experience with digital personal assistants also varied, where 27.1% of the participants used digital personal assistants on phones or physical devices, while 50% had tried it and 22.9% had no previous experience using a digital personal assistant.

3.3 Tasks

To test the four conditions, we chose four different physical exercises as tasks in the experiment. Each of the chosen exercises focused on different muscle groups to minimise fatigue. The exercises were: (1) jumping jacks, (2) lunges, (3) bent over flyers, and (4) shoulder press. We created a video for each exercise, explaining and showing how the exercise should be performed, so all participants had a common understanding. All participants were asked to perform the exercise for as long as possible, and while they performed the exercise, IDA would give them persuasive feedback. The number of repetitions, the participants' heart rate data, and time spent on each exercise were used to determine each techniques' persuasiveness. Each exercise and condition were randomised for each participant using the Graeco-Latin square design, to account for the differences between the exercises and to control the impact of fatigue and learning effect between each condition.

IDA's persuasive feedback was designed so it could be used regardless of what exercise the persuasive technique was matched with, making the feedback more general. The timing of the feedback during each feedback technique followed a predetermined pattern. The first feedback was given 8 seconds into the exercise, the next 10 seconds after, whereafter the time interval between feedback was incremented with one second each time. IDA's feedback during each of the four conditions are described in the following subsections:

In the Suggestion feedback, IDA would suggest either to keep exercising or to put more effort into the exercise. In the time-related suggestions IDA would, for example, say: *"May I suggest you keep doing the exercise for a longer period of time"* and *"Since you have already done the exercise for some time, I bet you can do it for a little longer."* In the effort related suggestions IDA would, for instance, say: *"What*

about putting all the energy you have into the exercise" and *"Try to put even more effort into your movements"*.

The Virtual Reward feedback consisted of IDA playing a baseball fanfare and afterwards saying *"Level one"*, where the level number increased for each feedback given.

In the Praise feedback, IDA would praise the participants' persistence, elevated heart rate, and come with a general positive outburst about the participant. The praise feedback, for example, included IDA saying: *"What a great start"*, *"You are doing very well"*, *"Your persistence shows that you don't give up so easily"*, and *"Based on your high heart rate, I can see you are putting a lot of effort into the exercise"*.

In the Neutral condition, IDA would not give any feedback. The condition's sole purpose is to have a baseline to compare to the three persuasive feedback techniques.

3.4 Setup

We set up the space to resemble a living room, where furniture (e.g. sofa, coffee table, cupboards, lamps, plants) were placed in the room, together with IDA (Figure 3). IDA was connected to an activity tracker (Fitbit) which the participants would wear during the study, as well as a Chromecast connected to a TV used to show the exercise videos. A camera with a microphone was placed in the room to enable the observer and facilitator to observe the participants interaction with IDA during the exercises. There was sufficient space in the middle of the room, so the participants could comfortably perform the exercises.



Figure 3: Setup layout.

3.5 Procedure

Every trial of the experiment involved the following procedure for each participant. First, the participant was given a brief introduction to the purpose and procedure of the experiment. The participant was informed that we were investigating how digital personal assistants could assist during physical activity, but we did not make it explicit that we were investigating the effectiveness of different

persuasive techniques. The participant was asked to review and sign a consent form, allowing us to gather and analyse their data. After consenting, the participant was given the activity tracker to wear during the experiment and told that only IDA would be present while they performed the exercises. After the facilitator left the room, IDA introduced herself and described the procedure of the exercises.

For each exercise, IDA showed the video describing how to perform the exercise and explained that the participant should continue doing the exercise for as long as possible and press the button to indicate when they were done. After the participant verbally confirmed being ready to begin, IDA started to count down, and the participant would then do the exercise for as long as possible. Meanwhile, IDA would give feedback based on one of the four conditions. After each exercise, the participant had a 1-minute break where IDA played a breathing exercise video on the TV, to relax and lower the participant's heart rate before the next exercise.

After the break, IDA would introduce the next exercise, which would follow the same procedure as the previous except it would be a new exercise and a new condition. After the participant had completed all four exercises, trying the four different conditions, IDA thanked for the participation in the experiment and said goodbye. The facilitator would then enter the room and ask the participant to fill out a questionnaire and then interview the participant. The entire experiment took an average of 35 minutes per participant, where the quickest took 25 minutes and the slowest 58 minutes.

3.6 Measurements

The observed behaviour and physiological measures of the participants were used to determine the effect of IDA's persuasive feedback and included the time, repetitions and the participants' heart rate during each of the conditions. The time was measured between the interval from IDA's countdown to when the participant pressed the button. Repetitions were counted manually by using a tally counter. The heart rate data was collected with the activity tracker and used to calculate the peak and average heart rate, to measure the participants' physical effort.

The participants' self-reported data is derived from the post-experiment questionnaire and the semi-structured interview. In the post-experiment questionnaire, participants were asked to rate how motivating they found IDA during each condition on 5-point Likert scales. In the semi-structured interview, the participants were interviewed about their overall experience of interacting

with IDA during physical activity, as well as their experience with the four different types of feedback.

For each participant, we collected demographic information about gender, age, experience with digital personal assistants, both on phones and physical devices, their motivation to track their physical activity and how physically active they perceived themselves to be.

4 STATISTICAL FINDINGS

In this section, we assess the persuasive abilities of IDA in the context of physical activity and compare the four conditions: Suggestion, Virtual Reward, Praise, and Neutral. The conditions were compared with the following measurements: repetitions, total time, heart rate average, and perceived motivation. First, we analysed whether there was a main effect of persuasion type on our dependent variables through repeated measures one-way ANOVA and post-hoc Bonferroni. Second, we performed two-way repeated measures ANOVA analysis to investigate interaction effects between persuasion type and gender, age, experience with digital personal assistants on phones or physical devices, motivation to track physical activity and how physically active they perceived themselves.

4.1 Repetitions

Results show that there was a main effect of persuasion type on the number of repetitions each participant performed ($F(2,87) = 8.031, p < .01$). Figure 4a illustrates that the participants performed more repetitions with Virtual Reward ($M = 78.7, SD = 78.7$). The effect of Praise ($M = 57, SD = 39.4$) and Suggestions ($M = 56.6, SD = 32.3$) are fairly equal. The Neutral condition ($M = 46.7, SD = 27$) has the lowest average of repetitions performed. Post-hoc Bonferroni comparison indicates there is a statistically high significant difference in number of repetitions between Virtual Reward and the Neutral condition ($p < .01$), a significance compared to Praise ($p < .05$), but no significance compared to Suggestion ($p = .12$). The participants, therefore, performed more repetitions when experiencing Virtual Reward compared to the Neutral condition and Praise.

4.2 Time

Results show that there was a main effect of persuasion type for how much time they spent during each condition ($F(2, 100) = 4.234, p < .05$). Figure 4b illustrates that the participants spent varying amounts of time in each condition. Neutral ($M = 110.81, SD = 68.33$), Praise ($M = 124.95, SD = 70.39$), Suggestion ($M = 119.06, SD = 46.16$), and Virtual Reward ($M = 162.36, SD = 133.26$) were all

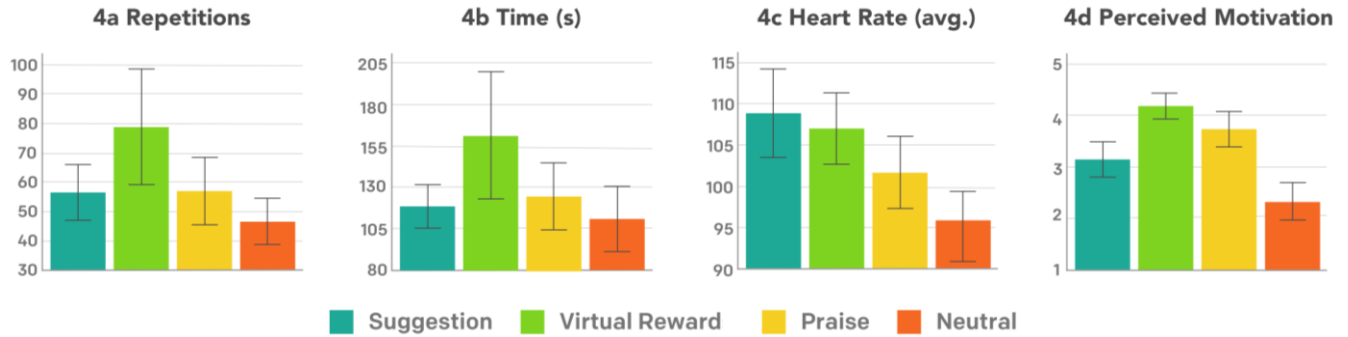


Figure 4: Comparison of the four conditions: Suggestion, Virtual Reward, Praise, and Neutral.

different if we only look at the mean. When we look at the standard deviation we see the overlap of the conditions, which is also reflected in the post-hoc Bonferroni comparisons, as there is no statistical indication that any of the conditions consistently made the participants perform longer.

4.3 Heart Rate

Results show that there was a main effect of persuasion type for the average heart rate for the participants, in each condition ($F(3, 130) = 8.155, p < .01$). Figure 4c illustrates that the condition with the highest average heart rate was Suggestion ($M = 108.85, SD = 18.6$), followed by Virtual Reward ($M = 106.96, SD = 15.03$), then Praise ($M = 101.65, SD = 15.06$), and the lowest average heart rate was for the Neutral condition ($M = 95.15, SD = 14.74$). Post-hoc Bonferroni comparisons show that when comparing Virtual Reward ($p < .01$) and Suggestion ($p < .01$) to the Neutral condition, we found a high significance for both conditions. The heart rate and participants physical effort is higher when the participant is experiencing either a suggestion or a virtual reward, and lower when experiencing the Neutral condition.

4.4 Perceived Motivation

Results show that there was a main effect of persuasion type for the perceived motivation for each condition ($F(3, 141) = 23.314, p < .01$). Figure 4d illustrates the difference between the conditions perceived motivation. The highest rated condition was Virtual Reward ($M = 4.19, SD = .842$), Praise was second ($M = 3.75, SD = 1.158$), Suggestion was third ($M = 3.15, SD = 1.185$), and the lowest rated was Neutral ($M = 2.35, SD = 1.263$). Our results indicate that participants perceived some of the conditions more motivating than others. Post-hoc Bonferroni showed that Praise ($p < .01$) and Virtual Reward ($p < .01$) were highly significant compared to the Neutral condition and Suggestion ($p < .05$) was significant to the Neutral condition. Also, Virtual Reward was highly significant compared to Suggestion ($p < .01$). The participants

perceived themselves to be more motivated with the persuasive techniques compared to not having the techniques in the Neutral condition and that Virtual Reward is perceived more motivating than Suggestion.

4.5 Gender

We analysed gender and the conditions with a two-way ANOVA and t-tests to see if they had an effect on repetitions, time, heart rate, and perceived motivation. We found that the number of repetitions a participant could perform was overall significant when compared to gender ($F(2,84) = 4.457, p < .05$). We found a significance for men when being persuaded by Virtual Reward ($t(45) = 2.345, p < .05$). Men ($M = 98.92, SD = 82.08$) performed almost double the number of women ($M = 54.82, SD = 34.83$). Men performed more repetitions than women, when being persuaded by the Virtual Reward technique, and on an overall basis, gender matters for the number of repetitions.

4.6 Physical Activity

We analysed the participants perceived physical activities and the conditions with a two-way ANOVA and t-tests to see if they had an effect on repetitions, time, heart rate, and perceived motivation. It was statistically considerable that participants who perceived themselves to be physically active performed more repetitions in different conditions on overall ($F(4,88) = 2.459, p = .52$). When comparing the conditions, there was a high significance in the number of repetitions and the participants who perceived themselves to be physically active, when being persuaded by either Virtual Reward ($t(46) = 2.784, p < .01$) or Praise ($t(46) = 2.858, p < .01$). Those who are physically active do considerably more repetitions and that we certainly can say that those who are physically active do more repetitions when being persuaded by Virtual Reward or Praise.

4.7 Overview

Our results also showed that the participants were motivated to exercise longer and harder while receiving persuasive feedback from IDA compared to the Neutral

condition. Each condition had different effects. Virtual Reward showed the most promise, as it had the highest effect on repetitions, time and the participants' perceived motivation. Although Suggestion is rated as the least motivating of the three principles, it is also the best at encouraging physical effort, as it had the highest effect on participants average heart rate. Participants perceived Praise as being highly motivating, but the measurements did not support this perception.

We did not find any significant effect on persuasion from the factors age, previous experience with using personal assistants and using a fitness tracker in our sample.

5 INTERVIEW FINDINGS

In this section, we describe the findings from our interview with the participants about their experience with IDA and observations during the experiment. The data was analysed in NVivo with a top-down approach from categories that were established from topics in the interview guide.

5.1 Suggestion

In the Suggestion condition, IDA was often seen as a negative narrator or as giving constructive criticism. 14 participants spoke positively about getting suggestions from IDA, saying that it helped them pressure themselves: *"I definitely believe it helps me set the bar higher"*. 31 participants perceived the suggestions as a negative experience, which was expressed with statements such as: *"She [IDA] is making a fool out of me"*, *"I was thoroughly provoked"*, and *"Pretty damn annoying, that thing [IDA] is not in charge!"*. In the observation of the experiment, it was noticeable that some of the participants felt so provoked by IDA's suggestions that they told her to *"Shut up"*.

Several participants were suspicious of what prompted the suggestions, and they got offended when the suggestions did not fit their engagement in the exercise: *"If I am already working my ass off, it cannot continue saying that I need to be doing a better job!"*. The participants explained that the suggestions needed to match their actual effort and the feedback to resemble that of an actual fitness coach based on how they performed.

Observation showed that 16 of the participants listened and reacted to IDA's suggestions during the exercise. They specifically reacted to the effort related suggestions, for example, when IDA said, *"I suggest you put some more energy into your movements"*, the participants actually put extra effort into the exercise.

5.2 Virtual Reward

The Virtual Reward condition was the most popular of the four conditions, as 39 participants spoke positively about it. The participants identified Virtual Reward as a game and described it as a *"fun"* experience. Interestingly, what many of the participants liked about the Virtual Reward was the competition aspect. They would like IDA to keep track of their performance over time so that they could surpass their previous results. There were also some who wanted to compete against others, saying: *"I want to be the best"*. There was only one participant who did not like the Virtual Reward as he found it boring: *"I could more or less predict what would happen - not that interesting"*.

Even though most of the participants liked the Virtual Reward, several found it confusing: *"What does a level mean?"*. Participants shared many theories and preferences to how these levels should be given, such as *"time"*, *"heart rate"*, and *"repetitions"*. A general opinion amongst participants was that the metric should be known for the user to relate to the rewards that are given. Several participants mentioned setting a goal during the exercise: *"I will take it to [level] 10 now"*. In some instances, they reached their precise goal while others reported thinking to themselves: *"Aaah, one more [level]!"*. However, a few participants wanted more guidance and wished that IDA would set a goal for them as a fitness coach could.

5.3 Praise

In general, the participants perceived the Praise condition as positive feedback. 23 of the participants expressed that they liked the positive reassurance from IDA, and it motivated them: *"You felt that you were doing something right, I wanted to continue for longer"*. Especially the participants who considered themselves beginners in performing physical activities expressed that it was more pleasant to be praised: *"I am not that active, so I would prefer praise instead of a stick, as a carrot is better for beginners."* Other participants explained they liked the *"good guy"*-attitude, however, they did not find praise motivating: *"It makes me stop because she [IDA] is actually satisfied"*. 16 participants disliked the praise, and one specific participant said *"be quiet"* when she was praised and ended the exercise quickly because she in general disliked being praised. Some participants highlighted that the praise did not match their actual effort: *"The praise does nothing for me - the fact that I raised my arm 10 times is no big deal"*.

The majority of the participants thought IDA's praise was missing credibility and sincerity, mainly due to factors like pronunciation and tone of voice. Several participants accentuated IDA's tone as being sarcastic. It was repeatedly

requested amongst the participants that the Praise was based on contextual information about their performance, as this would seem more factual and credible.

5.4 Interaction with IDA

In this section, we look into how the participants interacted with IDA to understand how they perceived this technology. We observed that 19 of the participants talked to IDA beyond the expected commands, and this included responding to IDA's greeting and farewell with, for example, "Hi IDA" and "Goodbye, have a great day too". Participants also replied to IDA's praise, for instance, saying "Thank you", and "You are also doing great IDA", when IDA came with a suggestion to keep going, one participant replied with "I am sure you [IDA] think so". Furthermore, several talked about IDA as either a personal trainer or a companion to work out with: "It is very fun if you don't have a partner to exercise with [...] then you're not on your own". Some spoke about IDA as a machine, while others wanted IDA to have anthropomorphic characteristics, for example, one participant said: "I am missing some compassion, I need to feel like it [IDA] is with me while I do exercises". Participants were not only looking for compassion, but a variation of human abilities, particularly sight, as participants often wanted IDA to be able to "see" them. In general, the participants did not trust IDA's ability to track them from the activity tracker around their wrist unless it would be able to collect more data about them such as repetition and being able to track if they conducted their exercises correctly.

The majority of the participants agreed that the experience of interacting with IDA could be improved, as IDA did not understand natural language and needed a more human voice. Several participants wanted more than following the exercise program that was presented to them, one participant said: "It would be fun if we could have a conversation". Although IDA only responded to "yes" and "no", it was evident that participants expected they could have a more casual language when they spoke to IDA, for example, instead of saying "yes", participants said "yep", "yeah", and "I am ready". All of the participants agreed that IDA's voice needed improvement: "She has a very dull voice. She has to be bubblier and ka-pow". Some further explained that since IDA, in this case, is meant to motivate users to do physical activities, it needs a more believable and enthusiastic tone of voice.

5.5 Future Use

In the future, 35 of the participants stated that they could see themselves make use of IDA in their own home or as an assistant on their phones, however, IDA had to be

improved in specific areas to accommodate their needs. The remaining 13 participants could not see themselves use IDA, as they already had a well-established fitness routine, or they could not see themselves be motivated by technology. Two participants working within health care, one with elders and one with disabled, highlighted that IDA would be ideal for rehabilitation training.

The participants' feedback showed that they enjoyed the connectivity between IDA and the TV, as they felt it gave a more immersive experience. Several participants wanted more statistical information about their performance (e.g. repetitions, heart rate, time) and feedback on their execution of the exercise. This information could either be shown on a real-time dashboard through the TV or highlighted by IDA, for example, with a message saying, "You have now done 30 repetitions". Additionally, several participants wanted to be able to modify the exercises, bodily focus areas, duration, and the ways IDA motivate them during the exercise. Some participants stated that if IDA was their digital personal assistant, they wanted their accounts (e.g. calendar and music streaming service) synchronised to be reminded to exercise when convenient and incorporate music they like into their workout routine.

6 DISCUSSION

Our findings showed a clear difference between the Neutral condition and the three persuasive feedback techniques, indicating that digital personal assistants do in fact have persuasive power. Virtual Reward had the highest effect on repetitions, time, and the participants' perceived motivation, and was often described as a fun experience or a game. Suggestion was perceived as the least motivating of the three principles and described as being very negative. However, as Suggestion has the highest effect on participants average heart rate, it indicates that it was the most effective at encouraging physical effort. Participants described Praise as a positive reassurance, but it lacked sincerity. Some participants indicated that Praise would be well-suited for beginners within physical activity or in combination with the two other persuasive principles.

In this discussion, we aim to compare our findings with B. J. Fogg's functional triad and the different persuasive roles. Furthermore, we discuss the implications of our findings for the design of persuasive digital assistants and the possible future research directions within this area.

6.1 The Functional Triad

In this section, we compare our findings to B. J. Fogg's Functional Triad [16] and the three persuasive roles: Tool, Medium and Social Actor. The participants expressed

different improvements that could be made to IDA, and in general, these improvements can be divided into the three persuasive roles. In the Tool role, we saw improvements such as providing the user with more information (repetitions, time, heart rate), and integrating account information and specifically calendar data to tailor the persuasion to fit the user and enable the assistant to persuade at the most opportune moment. In the Medium role, the improvements mostly revolved around the exercise execution and the question “*am I doing it right?*”. The participants wanted help to rehearse the exercise, for example, by IDA showing a silhouette of the participant with corrections to the body position. In the Social Actor role, participants wanted IDA to have a more human voice, express more sincerity and act as a personal trainer or workout-companion. Although the suggested improvements can be divided into these three roles, there was a clear understanding from the users that mixing all the different improvement and persuasive techniques would create the best digital personal assistant.

6.2 Implications for Design

Our findings implicate different prospects to implement persuasion in digital personal assistants. In this section, we highlight three different design perspectives: user-controlled, system-automated, and sentient. The three prospects require additional development; one could be implemented now, one would potentially require years of development and one could be realized in the distant future.

The user-controlled implementation of persuasion should allow the user to tailor the digital personal assistant’s persuasive personality based on their preferences. The drawback is that users will most likely pick the persuasive personality they enjoy the most or perceive to be the most motivating, but it is not necessarily the persuasion that has the most effect performance-wise.

The system-automated implementation should leverage collected data about the user, and machine intelligence to achieve the most effective persuasion. The digital personal assistant could try different persuasions, measuring the effects and based on the results, tailor the persuasion to achieve the best results performance-wise. The persuasion should also adapt to the context and the user’s mood, as persuasion that works in one situation does not necessarily work in another. For example, on a bad day, the user might not respond well to a bossy assistant, but would perhaps respond better to a comforting assistant.

A sentient digital personal assistant could persuade by being responsive and conscious of the impressions gathered from the user, responding as a real human with personality and empathy. Utilising the same persuasive techniques as humans and combining it with the

computational power of digital personal assistants could create strong persuasive abilities. Futuristic personal assistants with capabilities exceeding technology as we know it are common in popular culture and science fiction [47, 26, 24]. In *Blade Runner 2049* [47] the sentient holographic companion, Joi, understands the emotional needs of her user to such an extent that they develop a romantic relationship. Imagine having a digital personal assistant who is your friend, who knows you, your needs and desires, and always have your best interest at heart. In science fiction, the different possible fears about sentient assistants have been displayed, for example, in the movie *2001: A Space Odyssey* [26] HAL 9000 tries to kill its users, and in the movie *Her* [24] there are questions about the ethics of having a relationship with a personal assistant. The question is to what extent should we make digital personal assistants sentient?

6.3 Digital Assistants, Persuasion and Subception

Enabling digital personal assistants to be proactive, have more sensors, analyse its users, and have more access to user’s personal information, might increase the challenges surrounding digital personal assistants and persuasion.

In Denmark, the first prominent digital personal assistant smart speaker in Danish was Google Home, launched in September 2018. The launch was followed by criticism of Google Home in the media, questioning the continuous recording of users’ conversations and relying on access to their personal data [7, 19, 28]. One participant in our study also highlighted explicitly that he does not trust digital personal assistants, and would never allow them into his home. Other participants stated they did not want the digital personal assistant to have too much control over when they should be physically active. Showing that there are some problems in trusting digital personal assistants.

B. J. Fogg also received critique on his work on persuasion technologies, as persuasion both have the potential to do good, it also has a darker side where it can be misused for personal or corporate gain. The philosophical question “*is computer-mediated persuasion ethical?*” [2] has been one of the significant concerns regarding persuasive technologies, where subception is often mentioned as the cause. Subception, short for subliminal perception, is when a stimulus occurs without conscious recognition [9].

Advancing the persuasive power of digital personal assistants adds a whole new dimension of concerns. With their prominent placement in the home and always-on technology, they have the potential to influence their users in varying ways using what it has learned about its users. Digital personal assistants can be beneficial in many ways, and in our study, we saw how they can help users during physical activity. We also imagined they could be used in

other cases within persuasion, for example, helping people to quit smoking [37], achieve weight loss [42], eat a healthier diet [12, 36], or be more sustainable [1]. Nevertheless, we can often be blindsided by the possibilities that we forget to look at the potential implications and dangers of this new technology. A company like Amazon, who is also a web retailer, would perhaps be interested in making Alexa persuade users to buy products through their services. If digital personal assistants would be more proactive, it could also be a platform where political messages and advertisers could be let into the intimacy of the home. If the user is unaware of the persuasion, being manipulated and misinformed, it is no longer just persuasion but also subception. The questions are where do we draw the line between persuasion and subception, and do we trust that manufacturers and third-party app developers of digital personal assistants will not misuse the power of persuasion, because, as the saying goes: with great power comes great responsibility.

6.4 Research Directions

Based on a discussion about our results, we see four research topics as especially interesting. The first of them being about language, sincerity and personality of the personal assistant, where it is uncertain to what degree it affects persuadability. The second being about how other persuasive principles and theories, besides B. J. Fogg, can work on personal assistants, and if a general overview of the strengths and weaknesses can be made. The third is to what degree connectivity with the users' smart appliance and digital ecosystem, can affect the persuadability. The fourth, and maybe the most important, being the users' perception of persuasion and subception on an always listening device that is trying to persuade them.

6.5 Limitations

A limitation to our short-term controlled laboratory study is that we are not able to measure the long-term effect of the persuasion in real life settings. Another limitation is that other alternatives to our design of the three persuasive principles could be made and cause different effects. IDA did not have the same functionality as a commercially available digital personal assistant, which could be a limitation to the participants' perception of IDA.

7 CONCLUSION

In this article, we investigated through a controlled laboratory study, if digital personal assistants could be persuasive. Based on three of B. J. Fogg's persuasive principles, Suggestion, Virtual Reward, and Praise, we created a digital personal assistant to facilitate a physical

workout session and to motivate participants during various exercises.

Our results showed that digital personal assistants have persuasive power, as there was a clear difference between the Neutral condition and the three persuasive feedback techniques. Virtual Reward showed the most promise, as it had the highest effect on repetitions, time, and the participants' perceived motivation. Although Suggestion is rated as the least motivating of the three principles and described as being very negative, there were indications of Suggestion being the best at encouraging physical effort, as it had the highest effect on participants average heart rate. Praise lacked sincerity but was otherwise mentioned as a positive reassurance, where more participants indicated that Praise would be good to use as a beginner or in combination with the two other persuasive principles. Consequently, we found that there are differences between the three persuasive principles and they have different potentials. Virtual Reward could be used for cardiovascular exercises (e.g. running, cycling), where there is often more focus on endurance, whereas Suggestion could be used for strength training, where the focus is on getting a higher heart rate over a shorter duration, and Praise could be used for beginners or to strengthen the two other persuasions.

Designing these persuasive digital assistants requires some considerations. First, it needs to be taken into consideration that people are different and affected differently by persuasion, some also prefer or feel more motivated by a specific type of persuasion. Second, using a combination of different principles, instead of only one, could potentially increase the effect of the persuasion. Third, to be more useful and persuasive the digital personal assistant needs to be more context-aware and integrated with the users' digital ecosystem, for example, using calendar information to suggest workout sessions at opportune moments.

Future work is also required, therefore, we highlighted four possible research directions. First, what is the impact of voice, language, and sincerity on persuasion? Secondly, how can other persuasive principles work with personal assistants, and what are their strengths and weaknesses? Third, how can the digital personal assistants leverage its connectivity to persuade? Fourth, what impact does persuasion and subception in digital personal assistant have on users?

To summarise, we can conclude that digital personal assistants have persuasive power, and the persuasive principles have different strengths. There are design considerations that need to be taken into account when designing persuasive digital assistants and furthermore future research directions that need to be explored.

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