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Promoting Physical Activity for Elderly People with Immersive Virtual Reality (IVR)

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ABSTRACT

Physical and social activities should be included in an efficient e-coaching for older adults and immersive virtual reality (IVR) is efficient if behavioral changes are transferred to the real physical world. In an experiment con-ducted with 42 older adults (63-85 years-old), participants were asked to interact with a specific immersive virtual reality (IVR) daily for 4 months in their homes, at least 15 minutes per day. Results demonstrate several positive impacts related to the use of the IVR (decrease of weight, decrease of waist circumference, number of steps outside) even if the time spent to use this IVR system decreases. So, the transfer from the IVR to the real world is very encouraging.

Keywords: Immersive virtual reality, Older adults, Physical activity, Isolation, Loneliness

INTRODUCTION

As people generally live longer, maintaining physical autonomy of older adults, and thus their independence, is a key challenge that all modern societies must face and succeed to ensure the economic and social wellbeing of the entire population. Moreover, loneliness is also a key challenge in the social domain related to aging. Nonetheless, the e-coaching literature does not (yet) reflect this trend. In this vein, we assume two ideas: (a) first, physical and social activities must be included in an efficient e-coaching; (2) second, an IVR is efficient if behavioral changes are transferred to the real physical world. Several studies confirmed that immersive virtual reality (IVR) can be relevant and acceptable for older people to promote and maintain physical and social activities (Appel et al., 2020; Baker et al., 2018, 2019; Dilanchian, Andringa & Boot, 2021; El Kamali et al., 2020; Kim, Darakjan & MacFinley, 2017). Moreover, several recent studies showed that the older adults reported positive experiences and positive attitudes with immersive virtual reality (IVR; Abeele et al., 2021; Appel et al., 2020; Dinet et al., 2021).

Contrary to many studies related to IVR where no theoretical background exists (Armitage & Conner, 2000, 2001)], our experiment is based on the Theory of Planned Behavior (TPB) to describe and to predict the results. The Theory of Planned Behavior (TPB; Figure 1) is one of the most widely cited and applied behavior theories, by adopting a cognitive approach

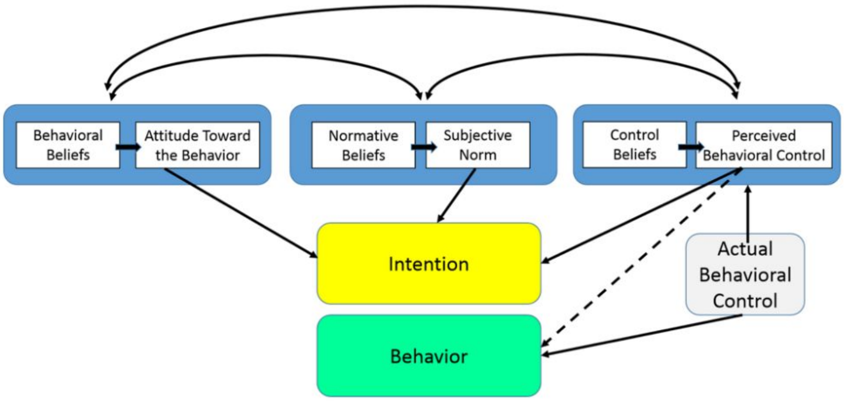

Figure 1: The theory of planned behavior (TPB; Ajzen 1985, 1991).

to explaining behavior which centers on individuals' attitudes and beliefs (Munro et al., 2007; Nisbet & Gick, 2008; Taylor et al., 2007; Terry, 1993). The TPB evolved from the theory of reasoned action which posited intention to act as the best predictor of behavior (Ajzen, 1985, 1991; Ajzen & Madden, 1986; Bandura, 1997; Bandura, Freeman & Lightsey, 1999; Fishbein & Ajzen, 1975; Hardeman et al., 2002). Intention is itself an outcome of the combination of attitudes towards a behavior. The TPB states that behavioral achievement depends on both motivation (intention) and ability (behavior-al control). It distinguishes between three types of beliefs - behavioral, normative, and control. The TPB is comprised of six constructs that collectively represent a person's actual control over the behavior: (1) Attitudes - This refers to the degree to which a person has a favorable or unfavorable evaluation of the behavior of interest; (2) Behavioral intention - This refers to the motivational factors that influence a given behavior where the stronger the intention to perform the behavior; (3) Subjective norms - This refers to the belief about whether most people approve or disapprove of the behavior; (4) Social norms - This refers to the customary codes of behavior in a group or people or larger cultural context; (5) Perceived power - This refers to the perceived presence of factors that may facilitate or impede performance of a behavior; (6) Perceived behavioral control [10] [20] - This refers to a person's perception of the ease or difficulty of performing the behavior of interest. This construct of the theory was added later, and created the shift from the Theory of Reasoned Action to the Theory of Planned Behavior.

METHOD

We hypothesize that the navigation in the immersive virtual reality (IVR) will have positive impacts on real behaviors (walking) in the real world. Forty-two older adults participated to our experiment (63-85 years-old), half of whom interacted with a specific immersive virtual reality (IVR) daily for 4 months in their homes and half of whom served as a standard-of-care control.

Table 1. Distribution of study participants.

	IVR group (N=21)	Control group (N=21)	Total (N=42)
SEX (n, %)			
Male	8 (38%)	7 (33,3%)	15 (35.7%))
Female	13 (61%)	14 (66.6%)	27 (64,2%)
AGE			
Mean (SD)	78.4 (6.7)	77.8 (6.9)	78.1 (6.8)
Min.-Max.	64-85	63-84	63-85
SCORE MMSE			
Normal (>24)	17 (80.9%)	16 (76,1%)	33 (78.5%)
Mild (21-24)	4 (19%)	5 (23,8%)	9 (21,4%)
Moderate (10-20)	0	0	-
Severe (<10)	0	0	-
AIDS (n, %)			
Use glasses	19 (90%)	20 (95.2%)	39 (92,8%)
Hearing diff.	5 (23,8%)	6 (28.5%)	11 (26.1%)
Limited mobility	2 (9.5%)	2 (9.5%)	4 (9.5%)

Participants

Forty-two seniors participated to our experiment (64.2% females; mean age = 78.1 years-old; range from 63 to 85 years-old). Distribution of participants is presented in Table 1. Participants are distributed in two separate groups: 21 participants in the experimental group and 21 participants in a control group. Participants in the experimental group were asked to interact with a specific immersive virtual reality (IVR) daily for 4 months in their homes, at least 15 minutes per day. No specific information has been provided for participants who served as a standard-of-care control.

Eligibility Criteria and Distribution of Participants

Participants were included in our study if they were (1) adults over 60 years old; (2) could communicate in French fluently; (3) were able to consent to participate in the study; (4) live in cities located in the East of France; and (5) had normal or mild levels of cognition (scored >21 on Mini-Mental State Examination or MMSE). Individuals were excluded if they met any of the following criteria: (1) vision impairment at a level that would make it impossible for them to use the immersive virtual reality (IVR) system; (2) open wounds or skin conditions on the face, or chronic neck pain/injury that might make it unsafe to wear the IVR headset; (3) inability to provide consent.

The Immersive Virtual Reality (IVR) Used

The IVR used in our study was specifically created for a series of experiments investigating the behaviors of pedestrians with specific needs (e.g., seniors, adults with motor impairment) in urban areas. This IVR has been developed by Human Games© company and requires the use of an HTC Vive headset (Figure 2). Participants in the experimental group were asked to spend at

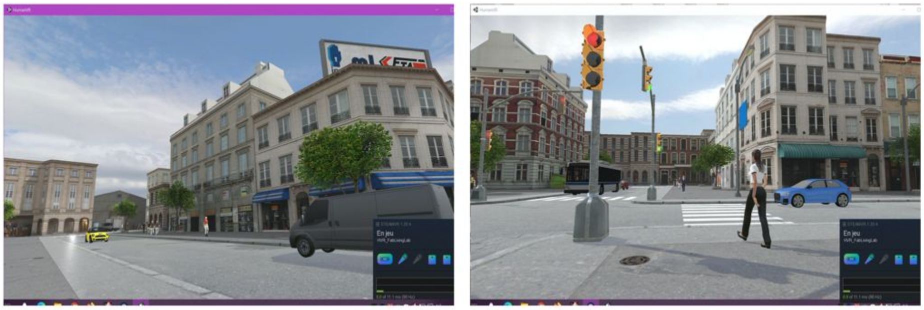

Figure 2: Two screenshots of urban scenes extracted from the IVR created by Human Game© for our study.

least 15 minutes per day, in their home, within this specific IVR while they were seated. They were asked to "simply explore the virtual town and to navigate in this town to become familiar with it". Several training sessions were organized to familiarize participants with the IVR system.

Dependent Variables

Whatever the group (experimental vs. control), each participant was asked to come in the laboratory to collect several objective and subjective data related to daily life activity and affect: (1) Weight (in kg.); (b) Waist circumference (in cm.); (3) The number of steps per day outside; assessed by a pedometer (Fitbit©) provided for each participant; (4) The time of use per day of the IVR (in min.), only for the experimental group; (5) Perception of intensity of activity, assessed by a Likert-scale: "Ac-cording to you, over the past 7 days, how often did you take a walk outside your home or yard for any reason? For example, for fun or exercise, walking, walking the dog, etc. (from 0 "Never" to 7 "Often").

RESULTS AND DISCUSSION

As Table 2 shows, three main group differences and within differences have been obtained: (1) The mean weight and the mean waist circumference of participants using the specific IVR system decrease significantly while these data remain stable for the control group; (2) The number of steps outside and the perception of intensity of activity increase significantly for participants using the specific IVR system, while these data re-main stable for the control group; (3) the positive impacts related to the use of the IVR exist even if the time spent to use this IVR system decreases.

Even if future studies are needed to control the possible impact of some individual factors (e.g., gender, status, hobbies), our experiment confirms that as immersive virtual reality (IVR) has become more accessible, affordable, and comfortable, there provide an unique opportunity to use these technologies to enable older adults to escape from their often confined area (Appel et al., 2020). More precisely, the use of a specific IVR can modify positively human behaviors of older adults from the virtual world to the real

Table 2. Results obtained for the two groups (experimental IVR Group and Control Group).

	Month 1	Month 2	Month 3	Month 4	*p.*
WEIGHT (in kg.)					
IVR Group	66.8	64.3	63.1	63.7	.002
Control Group	67.1	66.5	66.6	67	*ns*
WAIST CIRCUMFERENCE (in cm.)					
IVR Group	102	100	98.7	97.5	.003
Control Group	101	100	99.8	100.5	*ns*
NUMBER OF STEPS OUTSIDE					
IVR Group	3890	6895	7789	7604	<.001
Control Group	4002	4069	4238	3791	*ns*
TIME OF USE OF IVR (in min. per day)					
IVR Group	15	36	23	12	.02
-	-	-	-	-	-
PERCEPTION OF INTENSITY OF ACTIVITY (from 0 to 7)					
IVR Group	1	3,1	5	5,5	<.001
Control Group	0,8	1	1,2	1.3	*ns*

and physical world. In other words, impacts of an immersive virtual reality can be positive because its use can help individuals (here, older adults) to adopt new intentions and new positive behaviors in real and physical world.

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