2016 IEEE-RAS 16th International Conference on
Humanoid Robots (Humanoids)
Cancun, Mexico, Nov 15-17, 2016

Teaching Nutrition and Healthy Eating by using Multimedia with a Kompai Robot: Effects of Stress and User's Personality

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Abstract— **Teaching using multimedia is a field where social robots can contribute in a great manner. Some works in human-computer interaction and multimedia learning demonstrated that synthesized voice impairs user's learning. In this work, we investigate the importance of the system's voice (synthesized vs. human), of the embodiment (robot vs. tablet), and of the user's gender and personality on learning nutrition and healthy eating tips. The results obtained with the Kompai robot (developed by Robosoft) show that the performance on learning is better with the human voice. Moreover, the results show that user's personality plays an important role in learning. Individuals with high Neuroticism score performed better in the multimedia learning session than individuals with low Neuroticism score. Also, the stress of male participants was higher in the condition with the robot and synthesized voice than in the other conditions These findings can be used for better developing teaching systems tailored to the user's profile.**

I. INTRODUCTION

Social robots have a great potential for helping people in their daily activities, especially in tasks that need one-on-one interaction, as is the case of elderly people or children. It has been shown that a higher quality diet is related with a decreased risk of cancer and cardiovascular diseases [15], diabetes [6], and obesity [13]. Electronic Health interventions for physical and dietary behavior have been done in numerous cases, using web applications for computers or mobile-phones. For example, the authors in [2] showed the impact of computer intervention on nutrition, in [14] is presented the use of mobile-phones to promote healthy eating, and a review is presented in [5] where the results show a potential of this technology but also the need of more rigorous evaluations.

Having a robot at home in charge of reminding elderly people and/or teaching children how to have a healthy diet could have a positive impact on their lives. Human-Robot Interaction (HRI) has shown cues of learning improvement compared with other electronic technologies, e.g., Leyzberg et al. [10] show that the physical presence of a robot increases cognitive learning. Using robots as teachers or assistant teachers has been object of research in the last years. The authors in [22] used a robot as assistant teacher for children in an English learning classroom. Moreover, Tanaka et al. [21] used the Nao robot for teaching children new vocabulary. Furthermore, Socially Assitive Robotics (SAR) systems have been used before to teach topics related with health and nutrition. Kidd and Brezeal [8] developed a robot that is used as coach for following a healthy diet. Short et al. [19] presented a robot for teaching children about nutrition through play and found promising results for the use of SAR technologies for long-term one-on-one educational interventions for children.

In this context, and part of the EU Horizon2020 ENRICHME project, we want to use a robot capable of teaching elderly individuals on how to be healthy by having a healthy diet (by using speech and visual information). Nevertheless, before starting working with the final target population, the elderly, there are some relevant aspects that can influence the multimedia learning and that need to be studied in the field of social robotics. One of these aspects is stated by Mayer [12] in the Multimedia Learning Theory, where social cues like voice and embodiment affect learning. In his work with virtual agents, human voice and high-embodiment of virtual agents improve learning, but these effects may not apply when there are negative social cues like low embodiment and machine voice. In our work, we want to investigate the role of system's voice (synthesized vs. human voice) in learning. More precisely, we look if the synthesized voice on Kompai robot impairs learning compared with the recorded human voice and if the physical embodiment of the robot improves learning or not when compared with a tablet.

Personality also plays an important role in social interaction and learning. It was shown in the literature that user's personality is strongly linked with the performance on academic grades and learning. More precisely, consciousness trait has been shown to have a significant relation with good academic grades, extroversion with lower grades, and neuroticism with good scores on tests [16]. For these reasons, in this work, we take into consideration user's personality type and we investigate the influence of the user personality traits for learning nutrition and healthy eating tips.

Moreover, evaluating the learning process of the users can be used as a guide to increase or decrease the difficulty of the learning session. However, increased cognitive workload and a low score on tests can be a source of stress [17]. Heavy cognitive load can have negative effects on task completion, and it is important to note that the experience of cognitive load is not the same in everyone. The elderly, students, and children experience different, and more often higher, amounts of cognitive load. High cognitive load in the elderly has been shown to affect their center of balance [1]. We posit that monitoring the user's stress is important. A review of thermal infrared imaging in psychophysiology is presented in [7] where a decrease of the temperature on the tip of

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(a) (b)

Fig. 1: (a) Multimedia Learning using a Kompai Robot to show a multimedia presentation. (b) Kompai robot

the nose of the participants is linked with an increase of stress. In one of our previous works, we already focused on the stress caused by a robot and we measured face temperature variation with a thermal camera in a contact-free, user transparent manner [20]. The first results showed significant variation in temperature in the nose region of the participants when they are stressed. Therefore, in this work, by using a thermal camera, we also measure the temperature of the nose tip region of the participants to analyze the stress caused by the robot/tablet.

To the best of our knowledge, no work has already simultaneously focused on multimedia learning theory by using a robot and on the effects of stress and user's personality and gender on learning. The rest of the paper is structured as follows: section II describes the experimental design setup, section III presents the experimental results, and finally section IV concludes the paper.

II. EXPERIMENTAL DESIGN SETUP

A. Multimedia Learning Scenario

A multimedia presentation (of a 8 minutes duration and a total of 10 slides) using a web application of how to be healthy by having a healthy diet was presented to each participant by using different embodiments (a tablet or a robot) (as it can be seen in Figure 1). At the beginning of the experiment the participant was informed about the final goal of the project, which is using the system for teaching the participants (potentially the elderly) on how to be healthy by having a good nutrition. Afterwards, the presentation on the robot or tablet started with a brief explanation of the topic and the instructions. The participant had the choice to repeat the speech of each slide, go back to the previous slide, or go to the next slide. These options are provided in order to facilitate the learning at the pace of each participant. At the end of the presentation, the participant completed a test with 7 questions related to the information provided during the presentation, for which they had open time to complete it, and he/she gets his/her score and an encouragement for the next time session. The participants also completed the Big 5 personality test [3] so as to determine their personality traits.

B. Multimedia design

The implementation of the user interface was done in a web aplication developed in HTML and javascript following the guide proposed by [11] in the Multimedia Learning Theory, mainly the use of representative images related to the speech of the presentation, few words on each slide, words and images close on space and meaning and buttons for repeating, going back, and forward through the slides. One of the slides used on this experiment is shown in Figure 2.

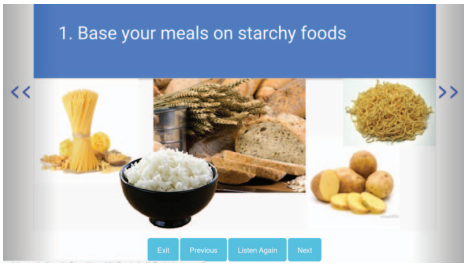

Fig. 2: Multimedia design used in our experiment

C. Hypotheses

Based on the literature, our hypotheses are as follows:

1) Human voice is better than synthesized voice for multimedia learning.
2) Robot embodiment is better than the use of a tablet for multimedia learning.
3) Robot embodiment and synthesized voice is more stressful for the users than a tablet and human voice.
4) Stress will be negative related with time to perform the test and time will be positive related with the score on the test (meaning less stress).
5) Neuroticism trait is positively related with the test score of the multimedia learning.

D. Conditions

45 persons between 21 and 64 years, 24 males and 21 females, undergraduate and graduate students and employees of an academic French institution conducted the experiment. Even if the current study was not tested with the target population, the elderly, the study is based on personality and gender, and we can expect that the effects presented in this study could also be present with elderly people. The experiment with the elderly is planned in the near future.

The participants were randomly divided in 4 groups according to our 4 conditions, using a robot (R) vs. a tablet (T), and synthesized voice (SV) vs. human voice (HV):

1) Robot and synthesized voice (R-SV): 5 male and 7 female participants.
2) Robot and human voice (R-HV): 7 male and 5 female participants.
3) Tablet and synthesized voice (T-SV): 6 male and 5 female participants.
4) Tablet and human voice (T-HV): 6 male and 4 female participants.

TABLE I: Post-Experiment Questionnaire

Q1	Did you find this information useful? Choose a score from 1 (Not at all) to 5 (Very much)
Q2	Were you aware of all these health tips? Choose a score from 1 (Not at all) to 5 (Very much)
Q3	Did you find the audio information accompanying the slides helpful and clear? Yes/No
Q4	Was the audio sufficiently loud? Yes/No
Q5	Was the audio understandable? Yes/No
Q6	Was the verbal information sufficiently rich in details? Choose a score from 1(Not at all) to 5 (Very much)
Q7	Did you like the male voice? Yes/No

The robot used in our experiments is a Kompai robot, a robot developed by the Robosoft company as a home care system. It includes a tablet PC where the multimedia information was presented, this computer was also used as tablet in the conditions 2 and 4. The synthesized voice was generated with the MaryTTS [18] software using a French male voice. The human voice was recorded by a French male individual.

E. Post-experiment Questionnaires

The participants were asked to fill two post-experiment questionnaires. In the first one, the participants provided some feedback on the experiment. The second one aimed at getting the participants' personality traits by using the Big 5 Personality test [3]. These questionnaires were applied on another computer in order to avoid bias.

The first questionnaire (7 items) is presented in Table I. The second questionnaire is the Big 5 personality test (45 items).

F. Image Analysis

Participants were recorded from front-face point of view using two cameras, an Asus camera, which recorded RGB-D images, and an Optris infrared camera, which recorded infrared images to analyze temperature variation. Faces were detected using the Dlib toolkit [9] from both images. From the infrared images the nose-tip region was obtained and a butterworth low-pass filter with the method proposed in [23] for estimating the optimum cutoff frequency was applied to the sequence of images. Other biological signals such as heart beat rate, or skin conductivity could also give some important information but there were not dealt with in this work.

III. RESULTS AND DISCUSSION

The parameters used to evaluate the learning of the participants were the results of participants' good answers on the test after the multimedia session and the time they took to complete it. These two parameters are the dependent variables. As independent variables were taken the 4 conditions explained in the experimental design setup section (robot and synthesized voice, robot and human voice, tablet and synthesized voice, and tablet and human voice), the gender of the participants, and the five personality traits (Openness, Consciousness, Extroversion, Agreeableness, and Neuroticism). The personality traits were categorized as high (value > 3) and low (value$<= 3$). A Saphiro test was applied to verify the normality of the data.

TABLE II: Male participants performed better in time on the test on the human voice condition on the robot

Human voice		Synthesized voice	
Mean (secs)	std dev	Mean (secs)	std dev
80.2857	21.2893	120.6000	26.5103

A. Hypothesis 1: Human voice

A multifactor ANOVA ($n = 45$) having performance time as dependent variable and embodiment (robot, tablet), voice (human, synthesized), and gender (male, female) as independent variables gave us cues of the interaction between system embodiment and voice, and system embodiment and gender. Analyzing the same independent variables with good answer scores as dependent variable showed no significant interactions. We also divided the data by gender and we found a significant interaction between performance time as dependent variable and embodiment and voice as independent variables on male participants ($F[1, 20] = 7.0451$, $p = 0.01522$). Moreover, we found a significant interaction between performance time and voice in the conditions with the robot ($F[1, 10] = 8.571$, $p = 0.0151$) for male participants. We applied a pairwise t-test for these variables and the result shows a significant difference with $p = 0.015$ between human voice and synthesized voice for male participants ($n = 12$) in the conditions with the robot. Male participants in the human voice conditions finished the test quicker than male participants in the synthesized voice conditions, the means and STD are shown in Table II and illustrated in Figure 3.

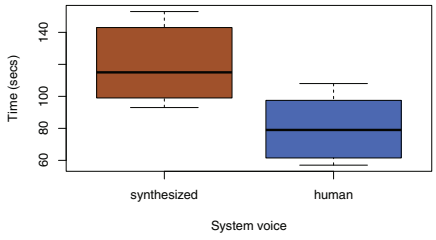

Fig. 3: Male participants got better time performance in the human voice condition with the robot (R-HV)

B. Hypothesis 2: Robot embodiment and Learning

Similarly to the analysis of Hypothesis 1, a series of multifactor ANOVA were applied having time performance and answers as dependent variables, and conditions, personality traits, and gender of the participants as independent variables. No statistically significant difference could be observed between these variables.

TABLE III: Mean and STD of temperature variation of nose-tip region of the participants in the 4 conditions, The mean in Condition 1 (robot and synthesized voice) presents a decrease on temperature, meaning higher stress.

Condition	Mean	std dev
1	-0.8260	0.6724
2	0.5942	1.4248
3	0.5966	0.9771
4	0.8866	0.8550

C. Hypothesis 3: Robot embodiment and Stress

An ANOVA test with nose-tip temperature variation as dependent variable and condition as independent variable showed a significant interaction ($F[1, 19] = 4.7963$, $p = 0.0412$) between condition 1 (R-SV) and variation of temperature of the nose-tip region of male participants and the rest of the conditions. A pairwise t-test revealed a difference with $p = 0.040$ between condition 1 (R-SV) and condition 2 (R-HV), $p = 0.046$ between condition 1 (R-SV) and condition 3 (T-SV), and $p = 0.046$ between condition 1 (R-SV) and condition 4 (T-HV). The mean of the temperature variation of the nose region of male participants in condition 1 (R-SV) showed a decrease in temperature (meaning increase of stress), while the others conditions showed an increase in temperature. The means and standard deviation are shown in Table III, and illustrated in Figure 4.

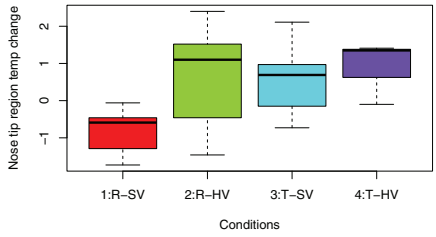

Fig. 4: Temperature of the nose-tip region of the participants decreased more in Condition 1 (robot and synthesized voice) than in the others conditions, meaning more stress for the participants in Condition 1.

D. Hypothesis 4: Stress, and time and test score

A negative correlation with value of -0.6287 with $p = 0.0164$ using a Pearson correlation test was found between the temperature variation on the nose-tip region of the participants ($n = 45$) and the time they took to complete the test, a higher time is linked with a decrease in temperature (see Figure 7), this correlation can be seen in Figure 5. Another negative correlation with value of -0.3754 with $p = 0.0110$ using the same test was found between the score of the participants on the test and the performance time, a higher score is linked with a quicker performance time to complete the test. This correlation is shown in Figure 6, the means and STD are shown in Table IV.

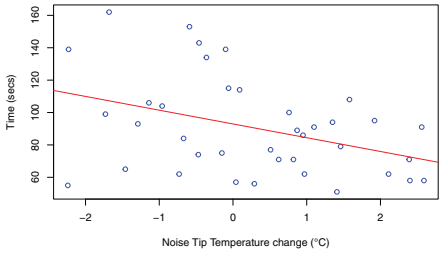

Fig. 5: Negative correlation between temperature of the nose-tip region of the participants and performed time of participants on the test, which shows that stress is linked with a higher time performing the test.

TABLE IV: Mean an STD of time performed (in seconds) by the participants on the test grouped by score (good answers) on the test.

Score	Mean (secs)	std dev
2	122.66	27.31
3	102.00	26.46
4	83.83	23.71
5	82.75	30.31
6	75.50	12.45
7	86.00	39.59

E. Hypothesis 5: Neuroticism

A multifactor ANOVA with good answers as dependent variable and the 4 conditions, gender, and the five personality traits as independent variables was applied to validate this hypothesis. A statistically significant interaction between gender and Neuroticism ($F[1, 16] = 5.9745$, $p = 0.0264$) was found. Following this interaction, we divided the data by gender, and a significant relation with ($F[1, 22] = 5.0802$, $p = 0.0345$) was found. Male participants with high level of Neuroticism got a better score on the test than male participants with low level of Neuroticism, the result of this ANOVA is shown in Table V and the plot of the scores of male participants grouped by level of Neuroticism is shown in Figure 8.

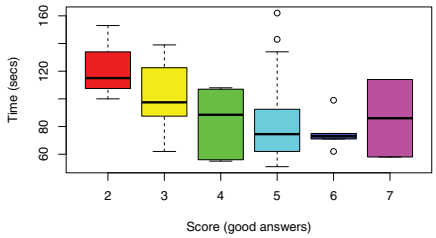

Fig. 6: Mean and SD of the performed time grouped by score of the test of the participants, lower score is linked with higher time performing the test.

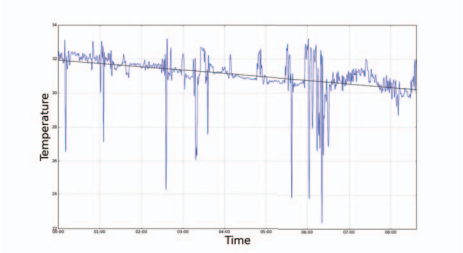

Fig. 7: Temperature decrease in the nose-tip region of one participant

TABLE V: Male participants with high level of Neuroticism got a better score on the test (good answers) than male participants with low level of Neuroticism

High Neuroticism		Low Neuroticism		
Mean	std dev	Mean	std dev	
5.3333	0.5163	4.1111	1.2782	
Sum sq	Mean sq	Df	F	p
6.7222	6.7222	1	5.0802	0.0345

F. Questionnaire of feedback

We analyzed the post-experiment questionnaire providing feedback on the experiment (questionnaire presented in Section II). We applied an ANOVA test with the questions as dependent variable and gender as independent variable. We found a relation between Question 1 (the perceived usefulness of the information) and the gender of the participants ($F[1, 45] = 6.3015$, $p = 0.0159$). Female participants perceived the nutrition information as more useful than male participants. The results of the one-way ANOVA are presented in Table VI and the perceived usefulness of the information grouped by gender is illustrated in Figure 9.

G. Discussion

The results found in this work validated most of the hypotheses we formulated.

Hypothesis 1 was validated but only with male participants. Male participants obtained a better score on the test in the condition with the robot with the human voice (R-HV) than in the condition with the robot with the synthesized voice (R-SV). This difference was not found in the conditions with the tablet.

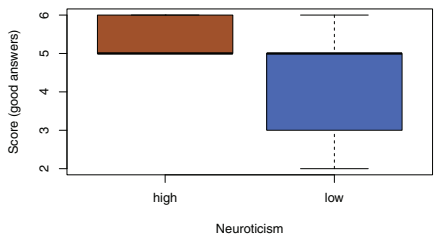

Fig. 8: Male participants with high level of Neuroticism got better score (good answers on the test) performance than male participants with low level of Neuroticism

TABLE VI: Female participants perceived the nutrition information as more useful than male participants (on a 7-point Likert scale)

Female		Male		
Mean	std dev	Mean	std dev	
4.047619	0.9206	3.3750	0.8753	
Sum sq	Mean sq	Df	F	p
5.067	5.0671	1	6.3013	0.01591

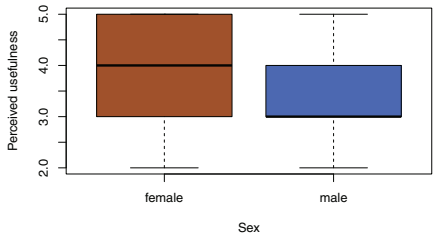

Fig. 9: Female participants perceived the information on nutrition as more useful than male participants (on a 7-point Likert scale)

Hypothesis 2 was not validated. Even when the use of robots as passive-social medium has showed the importance of the embodiment of robots [4], the robot used on this experiment did not elicit an improvement on the user's performance. We could argue that the performance could be as equal on the tablet and the robot because the participants put their attention only on the tablet regardless the use of the robot, nevertheless, according to the measures of the thermal camera, the robot induced more stress on the participants than the tablet. These results can be explained by the multimedia learning theory [11] because of the synthesized voice used in Condition 1 and also for the low level of embodiment of our robot that lacks of arms, legs, and facial expressions. A more anthropomorphic robot could potentially have a better impact on users' learning.

Hypothesis 3 was validated. The condition with the robot and synthesized voice (R-SV) generated more stress in the participants than the condition with the robot and human voice (R-HV) and the conditions with the tablet, this was shown by a decrease in temperature in the nose-tip region. The use of the human voice on the robot did not show any cues to relate it with the adaptation gap hypothesis, on the contrary, participants got a better performance on the test.

Hypothesis 4 was also validated. Stress showed a negative correlation with the performed time of the participants on the test, and time showed also a negative correlation with the score obtained. This means that when users got stressed they tended to spend more time on the test and their learning (score) tended to be poor.

Hypothesis 5 was validated, but only with male partici-

pants. High Neuroticism male participants performed better on the test than low Neuroticism male participants.

IV. CONCLUSION AND FUTURE WORK

In this work, we investigated the role of embodiment (robot vs. tablet), and system's voice (synthesized voice vs. human voice) in a teaching nutrition and healthy eating scenario using multimedia. The results showed an increase of stress in the condition where the robot and synthesized voice (R-SV) were used, which means a negative correlation with performance on learning. Robots can be helpful in assistive tasks like the one proposed in this paper, but we need to be aware of the stress caused to the users, in the case of the teaching by using multimedia this could be done by lowering the learning time in the first sessions.

Furthermore, we need to pay more attention to users with high level of Neuroticism, who scored better on the test, but probably this was due to their anxiety, other negative effect that could be generated by the robot's presence.

Female participants did not show any significant difference on their performance under the 4 different conditions as male participants did, we suspect that this is due to their interest in learning about the learning topic proposed in the experiment. Also the male voice of the system could have had an impact on the performance of the participants. Another study using also the female voice would maybe needed so as to verify the results that we obtained in this work.

We plan to continue performing more experiments focusing on the effects caused by the robot on users' personality. Companion robots have a great potential of helping people with useful tasks like teaching nutrition to elderly people.

ACKNOWLEDGMENT

The first author thanks to the Mexican Council of Science and Technology for the grant CONACYT-French Government n.382035. This work has been partially funded by EU Horizon2020 ENRICHME project grant agreement no. 643691C.

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