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ON THE PROPOSED CYBSPEED PROJECT EXPERIMENTAL RESEARCH PROTOCOLS

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Abstract: *CybSPEED project is a MSCA RISE project involving the collaboration of beneficiaries and partners from Bulgaria, Greece, Spain, France, Japan, Chile and Morocco. This paper gives a view of the experimental works proposed by some of the research teams to be carried out along the execution of CybSPEED. This description has been extracted from the actual experiment definitions submitted to the corresponding Ethics Committees of the institutions carrying out the experiments. The main emphasis of this paper is on the research questions behind the experiments, rather than the details of ethics and data protection guaranties.*

Key words: *Social robotics, children with special learning needs, ciberphysical systems*

1. INTRODUCTION [1]

The Research and Innovation Staff Exchange Marie Sklodowska-Curie Actions (MSCA-RISE) are devoted to the exchange of staff between European beneficiaries from academia and industry, as well as third country organizations, aiming for a cross-fertilization of ideas and techniques that will bring new inspiration to both academic and industrial participants. In some cases, the staff exchange may produce specific byproducts, such as data from specific experimentation. This is the case of the CybSPEED MSCA-RISE grant #777720. In the framework of this project, some of the beneficiaries have proposed to carry out actual experimentation with humans, some of them with children with special educational needs. This paper is an abridged account of these proposed experiments. At the time of writing the experiment leaders are working to comply with the ethical and personal data protection deliverables to obtain clearance to carry out the experiments. By no means this paper can be interpreted as a surrogate ethics and/or personal data management clearance for the experiments described here.

The main topic covered by CybSPEED is the study of the role that cyberphysical systems may plan in improving the educational assistance to children and adults with special educational needs. Specifically, the kind of cyberphysical systems that attracts most attention are the social robots, such as the well known Nao robot developed by Aldebaran, France and now commercialized by Softbank, Japan. Japan is leading all aspects of insertion of robots in everyday life, and it is a key partner in CybSPEED project.

The experimental side of the project, thus, is devoted mostly to assess the effect of the exposure of children and adults with special educational needs to the interaction with the Nao robot. Though Nao has been proposed to help children with autism spectrum disorders (ASD), the experiments also include other populations, such as children with hearing and speaking difficulties. The main research question can be stated as follows: Does the interaction with the anthropomorphic robot improve in some way the performance of the children with special needs? Each of the experimental settings defines a specific scenario and measures of children response, as will be detailed in the following. Each of the ensuing sections will describe an experiment, with a closing section on general discussion.

2. EXPERIMENT IN UGA

The first experiment that we describe will be carried out in the GIPSA lab of the University of Grenoble-Alpes (UGA) under the leadership of Prof. Franck Quaine. The hypothesis of the experiment is that the alteration of cognitive state induced by visual perception changes can have an effect of the actual motor efficiency delivered by a person. Specifically, the experiment considers healthy sportive subjects and their muscular response to changes in color of the object that they are using. The subjects are lifting a dumbbell seen through a virtual reality headset that allows to change its color in the visualization. The muscular response is measured through ElectroMiograGraphy (EMG) sensors that monitor the co-contracture of complementary muscles. The experimental hypothesis is reformulated as follows: changing dumbbell color induces changes in the effort realized by complementary muscles while the final effect (number of lift-offs) is the same. The effect can be measured quantitatively and be subject to statistical analysis, namely ANOVA tests. The sample size is small but enough to achieve statistically significant conclusions.

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In the context of the CybSPEED project objectives, this experiment serves to show that environmental conditions, such as color, which are often disregarded, might have some definitive effect on the subjects while carrying out experiments. Specifically, its results lead to question in future experimental work if children with special learning needs have some kind of specific sensitivity to color and/or other environmental conditions that can be controlled in order to improve their learning conditions and results. Though the actual population under study does not belong to the target population of CybSPEED, i.e. children with special learning needs, the conclusions of the experiment would contribute to the improvement of the conditions under which the children are treated.

3. EXPERIMENTS IN BULGARIA – PROF. ANNA LEKOVA

The group of researchers led by Prof Anna Lekova from the Institute of Robotics of the Bulgarian Academy of Sciences (IR-BAS) is proposing to carry out four different but related experiments. These experiments will actually be carried out in two sites different from IR-BAS, which are providing their approval for the experiments and their certification that the children will be treated according to the ethical standards in the EU and following personal data protection regulations. Specifically, these sites are

- Centre of Logopedics, Blagoevgrad under the responsibility of Anna Todorova Andreeva, PhD
- Day care center (DCC) "Zdravets" Bansko 2770, Bulgaria, under the responsibility of Snejana Erinina.

These experimental sites have already experience collaborating with Prof Lekova, so they have the proper preparations for the experiments (room and facilities) as well as the experimental protocol.

Three of the experiments involve games where audition and expression play a principal role. The contrast is between the human teacher and the Nao robot as a teacher. The fourth experiment involves a copycat game with two robots, the Nao and another robot with facial expressions (EmoSan). The second robot tries to mimic the emotional state of the child, while Nao perceives and directs the game. There is no contrast between human and robot in this experiment.

The goal of the first three experiments is to enhance the communication abilities of the children, while the fourth experiment is directed to the perception of children emotional states and enhancing his/her own conscience about them. The interaction protocol in the case of the three first experiments consists in a warming up period where Nao tells some story, followed by one of five games based on sounds or spoken word plays (shape recognition, recognition of emotions, shopping, identifying means of transport, and body sounds), ending with conclusion stage of happy stories. All interaction is carried out in Bulgarian. The fourth experiment consists in the listening of stories told by Nao while the second robot EmoSan mimics the emotions detected on the child via the emotiv brain activity detector.

Regarding the means of observation and measurement of experiment output, there are significant changes among experiments. The first experiment only uses self-assessment questionnaires, while the second experiment adds the use of kinect depth camera, and the third experiment adds both kinect depth camera and the emotiv brain activity sensor. Software for the analysis of child movement interpretation using the kinect camera will be developed previous to the experiment. Also, software for the analysis of the brainwave signal provided by emotiv will be developed in order to achieve experiment 3. The fourth experiment uses Emotiv brain activation sensor for emotion detection using a brain-computer interface approach.

The experiments will be carried out over a heterogeneous population of children with different background diagnoses: 1) Hearing impairments, 2) ASD, 3) CP and 4) Moderate intellectual disabilities, but the final statistical analysis would be stratified according to these classes. The sample size is small in all experiments, due to the difficulties to find candidate children.

The experimental hypothesis per experiment can be summarized as follows:

1. The main hypotheses of the first experiment is that speaking, listening and understanding are enhanced in the robotic vs human special educator conditions because the robot reduces the stress in the children and emotionally, quickly and automatically captures attention and enhances the perceptual processes.
2. The main hypothesis of the second experiment is that it is possible to ascertain the emotional state and responses of the child using the kinect, Microsoft, USA, depth camera.
3. The main hypothesis of the third experiment is that using the EMOTIV provides a systematic measuring technique, based on quantitative measures of brainwaves and rhythms in time. This is more effective way to collect and process feedback whether the child feels well completing the command/task given by the robot or the human.
4. The fourth experiment main hypothesis is that neurofeedback proves that robots reduce the stress in the children during play-like activities because it is their friend not a teacher.

In the framework of CybSPEED the experiments led by Anna Lekova will help to answer several key questions posed in the project:

- Are there specific effects of anthropomorphic robots on the learning ability of children with special learning needs? In other words, may the robots be used with advantage to enhance learning performance of children with special learning needs when compared with the human teachers?
- Is the effect of the robot homogeneous across the diverse disorders that fall in the generic label of children with special learning needs? The proposed experiments by Anna Lekova will recruit children with diverse diagnostics and needs, specifically 1) Hearing impairments, 2) Autism Spectrum Disorder (ASD), 3) Cerebral Palsy (CP), and 4) Moderate intellectual disabilities. Therefore, it would be possible to assess differential effects of the robot interaction.
- Is the anthropomorphic robot effectively reducing the emotional stress of children in the learning environment settings? If we are able to assess the

emotional response of the child while being taught by either robot or human, we will be able to provide a satisfactory answer to this most controversial question.

4. EXPERIMENTS IN BULGARIA – PROF. MAYA DIMITROVA

The experiment to be carried out under the direction of Maya Dimitrova address the Automatic Memory and Attention Effects in Learning from a Humanoid Robot. The general hypothesis of the experiment is that in different cases of learning differences the limited cognitive resource is an obstacle to developing the anticipation mechanism during listening to a story as revealed by the blinking rate before and after the event, that is being attended to. The aim is to investigate several possible patterns in relation to autism spectrum condition (ASC), Cerebral Palsy (CP), and Generalised developmental disorder (GDD) in comparison to a control group of neurotypical children.

The experiment protocol consists in the children paying attention to the Nao robot telling them first a zoology lesson, secondly a story (Fearless John). The attention of the children will be measured by blinking rate measured by a gaze detector apparatus. The hypothesis test will be done by significant differences in blinking rate between population classes. The language of interaction will be Bulgarian.

The experiments will be carried out in Day Care Centre DPkids-Sofia under the responsibility of its manager. As the only data that will be recorded are the blinking rate of the children while attending the story, pseudonymisation is easy, and no personal data will need to be recorded.

In the context of CybSPEED this experiment will help to answer two related questions:

- Are there specific effects on the attention of children of the anthropomorphic robot Nao? Blinking rate is the measure of choice to assess the children attention and its statistical analysis will be answering this question.
- Are there significant differences on the attention capture by the robot between children with different diagnosed syndromes? As the experiment covers different populations of children in their diagnosis, it will be possible to assess these differences.

5. EXPERIMENTS IN BULGARIA – PROF. ROMAN ZAHARIEV

Two experiments will be carried out in Bulgaria under the direction of Prof. Roman Zahariev, both involving the robot AnRI that is under development in IR-BAS. The experiments will be conducted at the Social Services Center named Day Center "St. Nedelya", Sandanski. In essence they consists in the presentation of the last version of the AnRI robot to subjects with diverse degrees of disability. The first experiment protocol consists in the programming of the AnRI robot by the subject with an assistant, while the second consists in the AnRI robot performing some storytelling or presentation. The experiments are recorded in video for future analysis taking all precautions of anonymity (recording from the back of the patients and caregivers). The evaluation consists in questionnaires filled by the experimental subject or her/his attendant.

Relative to CybSPEED objectives, these experiments try to answer the following questions:

- Are the people with extreme disabilities welcoming the help and even the company of humanoid robots? How sensitive are their responses to the interaction with humanoid robots?
- Is it feasible to deploy mobile robots with humanoid features in the environment of people with extreme disabilities?
- Children with learning special needs are actually receptive to robotic interaction, so that they are willing to engage in learning tasks with them.

6. EXPERIMENTS IN GREECE, PRAXIS – MR. YANNIS AGGELIDIS.

The experiment that will be carried out in Praxis facilities in Kavala will be directed by Mr. Ioannis Aggelidis, the technical preparations in order to achieve the experiments will be carried out by AMA (HUMAIN-Lab) of EMMA-TECH, led by Prof V. Kaburlasos.

The experiment is focused on children with autism spectrum disorders (ASD) that will be recruited from the population of children under treatment in Praxis, after the corresponding informed consent and guaranties for anytime withdrawal and retraction of data. The main hypothesis of the experiment is that the presence of the anthropomorphic robot has a definitive effect on the attention of children with ASD. To test this hypothesis we measure several time variables which are related to the attention of the child to the human versus the robot, such as the time until establishing eye contact and the time until a response is obtained from the child. The experiment is designed as a longitudinal experiment, where the same children will be exposed to the robot in several sessions along a period of one year. This long term controlled exposure may allow to assess the evolution of the response of the child to the robot. Measurement of child reaction will be carried *in sit*u and also by posterior analysis of the anonymized video-recording.

The experiment will help to answer quite hot questions in the CybSPEED scientific program:

- Is there any gender difference in response to the Nao robot in children with ASD? This is a really interesting question that has received little attention in the literature.
- Is there an effective difference in response to the human teacher versus the Nao in children with ASD
- Are there differences in response to Nao among diverse special kinds of ASD?
- Is there any time effect on the long term exposure of the children to Nao? Does the child get uninterested? Does the child accept the Nao as an everyday tool?

7.- CONCLUDING REMARKS

The CybSPEED project research objectives are linked to the idea that anthropomorphic robots may reduce some stress factors that impede the learning process of some children with special educational needs. Specifically,

some children with ASD have shown positive reactions to simple anthropomorphic robots such as the Nao. However, the ASD includes a wide variability of symptomatic features, so that there is a need for a wide assessment of this finding over a large sample of ASD diagnosed population. Fine differential diagnosis would be required to have a proper understanding of the robot-child relations and when/how this relation can be helpful for the child. A quite important issue that it has not been solved in the literature is the novelty effect. Attention to the robot is due to its novelty? Does this attention remains after the robot has become a part of daily life? How we can measure this effect in a non-invasive way? What is the ecological validity of interventions carried out so far? If the social robots are intended as therapeutic or assistive tools, we need to assess their value in the real life setting, hence we need to observe the child-robot relation without affecting or interfering it. This poses a real technological, and ethical, challenge, that of precise/non-intrusive human behavior in real life conditions. If we add the need to observe the child from inside, i.e. how the neural activity correlates with external behavior, then we have an extraordinary challenge. Some of the experiments related above make some steps to work on these issues.

The discovery of the special relation between ASD children and social robots boosted the interest in their use as assistive devices to other populations with special needs. In particular, the question arises: could they be a positive factor to boost learning performance for children with special educational needs other than ASD children? The main issue again is whether the anthropomorphic robot may boost social skills related learning performance, such as joint attention, as well as individual skills, such as concentration, in some children with special educational needs. What is the differential effect regarding the child clinical diagnosis? Again, we need to correlate what we know of the child with the effect of the robot presence and interaction. Little research has been reported in this area of work, and the experiments proposed above will significantly add to the scarce available body of knowledge. The experiments include recruited subjects from population with hearing disabilities, cerebral palsy, and other. Therefore, some differential effects would be observed according to the child diagnostic status. These observations have additional value for the general deployment of social robotics. Special adaptive properties may be required for the social robotic systems to go beyond mere fancy curiosities to useful complements of our daily life, hence insights on how diverse populations integrate this new element in their life is crucial to understand the real lasting value of social robotics.

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