The connection of the style of interactions and the collaboration in a virtual work environment

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***Abstract*— Nowadays it is becoming common for more and more people to work remotely in an online virtual space. Even the virtual presence of the partner means a difference in quality when engaged in a cooperative task. The purpose of this paper is to analyze social interactions in a virtual workspace. Earlier researches about the psychological features of online, remote, and virtual collaborations are also summarized. The research task replicates the process of creating an interesting holiday plan for tourists visiting Budapest. In the virtual tourist office, there are posters and a map available for the participants to create a feasible schedule for two days. The research was conducted in the VirCA (3D Virtual Collaboration Area), and includes a total of 12 analyses of dialogs recorded during the task. In completion of that, the participants' prior experiences and subjective impressions of the experiment are also measured. The efficiency of task output as a quality measure was compared with the dialogs' content analysis. The task completion time showed a strong positive correlation with the utterance category of coordination and also showed a strong but negative correlation with utterances of information sharing. The assertiveness had no connection with the efficiency index number, which was calculated by us. Results may provide a solid basis to gain better insight into the question of designing and planning task- and goal-specific communication. Conclusions may also bring guidance on how to use the virtual space more efficiently, making it more productive to collaborate.**

Keywords*— *Collaboration, Virtual Reality, Virtual Co-Working Space, Psychological Features of VR, Teamwork, Team Collaboration

I. Introduction

Teams are workgroups created and structured to achieve a common goal. A team can consist of up to 20 people but larger groups require greater effort for the coordination of the collaborative work. Team members need to apply more interactions and instruments for a certain common knowledge of the task to become efficient [1], [2]. Nowadays there are many tools which coordinate and distribute the tasks online and make it possible to structure the teamwork remotely, e.g. Asana, Trello, MS Project, etc. Tasks become well monitored and organized by using the tools mentioned, even if the coworkers work in different places. The synchronized collaboration experience of virtual reality tools is lower than the same experience in reality.

Despite the widespread use of such systems, very few studies aim to explore the psychological features of cooperative work in virtual environments [3]. The efficiency in this artificial transfer medium of the co-working has not been a deeply studied yet.

Hackman's input-process-output (IPO) model investigates team performance in the three related task session: input, process, and output. According to Hackman, inputs, e.g. the working environment, are very influential from the task- and teamwork perspective and determine the process' outputs [4], [5]. The inputs of virtual environment fundamentally determine the communication channels and therefore require specific cognitive processing methods.

Previous researches reveal that team members' collaboration can be facilitated by computer-assisted technology. Social economic status, hierarchy and gender differences are hidden in the virtual space that allows a more task-focused work. In some cases Computer-assisted teams proved to be more active than conventional teams, and experts are easier to access in the groups due to the mentioned reasons [6]. This anonymity can influence the process' outputs significantly: it lowers anxiety and decreases social conformity; therefore people can be straight in discussions. Besides, the responsibility is shared, which could facilitate the group to make more extreme decisions than individuals would do. Research results show that due to anonymity, people may feel invisible and meetings assisted only by computers result more innovative ideas in brainstorming. Furthermore, reclusive meeting participants are more communicative in chats and forums on PC than in real interactions [6].

II. Current Research

Our research was conducted in the VirCA – 3D Virtual Collaboration Area [7]–[10] and focused on communication as an essential element of co-working. In ordinary conditions, sufficient amount of explicit communication is needed for the

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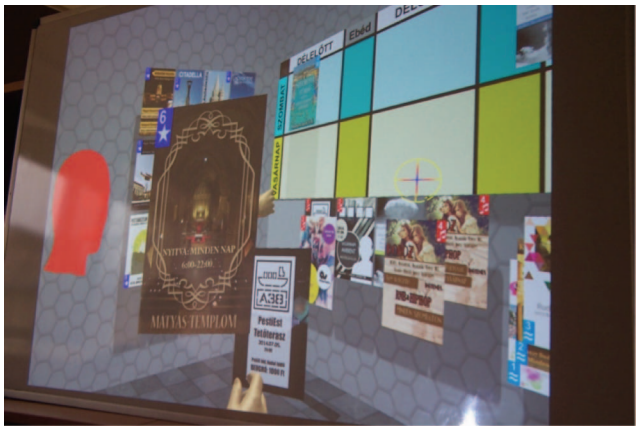
team members to work fluently and to be able to understand the task, the task-related regulations, expectations, requirements, and the principles of the common work [11], [12]. All team members have a personal internal representation about the content and the space-time features of the actual situation as a shared mental model. The assertive behavior synchronizes the act of persons during a common task. Participants can simultaneously represent themselves and listen to others' point of view in a constructive workspace. Due to its importance, the role of assertiveness during the task was also investigated.

The IPO model's process part was used to understand the most effective communication style in the virtual collaborative area. The data was organized in the sections of the IPO model.

III. Method

A. Participants

24 people participated in the research, paired randomly to collaborate in the experimental task. Their mean age is 22.91. Most of them are students of different universities of Budapest, Hungary.

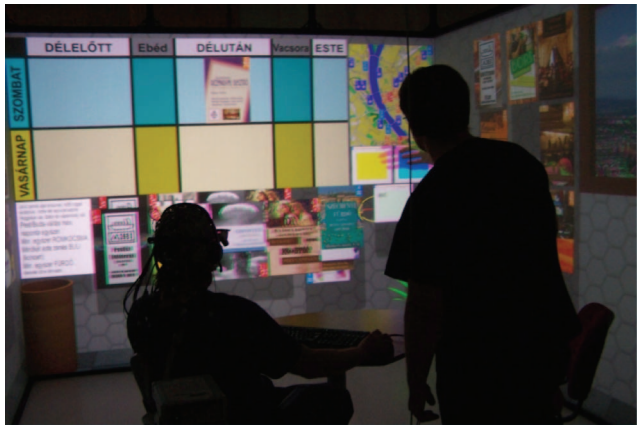


1. A participant's view of the desktop computer

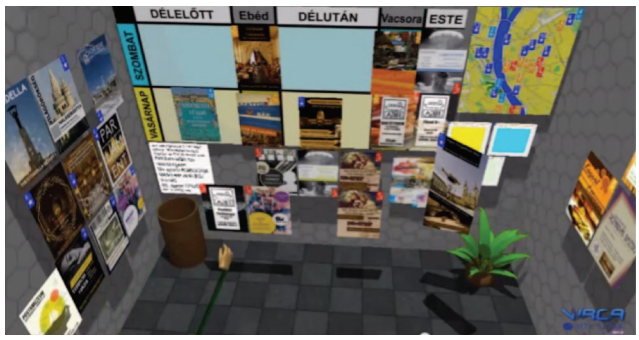
B. Procedure

One of the participants was in front of a desktop PC (Figure 1.) and the other was in an immersive 3D Virtual Cave (Figure 2). After finishing the individual practice tasks, and feeling comfortable with the control, they started to work on the task together in the virtual room.

The task was to organize a two-day trip for tourists in the city of Budapest. The plan had to conform to predefined rules including the following: the tourists were allowed to pass the river Danube only once, the visited places had to be close to each other, the tourists had to go to a spa, and visit a bar with live music, etc. The participants were instructed to use the posters, which showed several activities and events in the city. The posters contained information about opening hours and locations of the restaurants, bars, clubs, sights and events. They could also use the city map with numbers denoting the location of the restaurants, sights, and events from the posters and the "sticky notes" for adding more program information in editable note windows with collaborative typing (see all the elements of the collaborative space in Figure 3.). To complete the task they had to put the final plan of the tour program in the schedule table available on the central wall of the virtual room.



2. The participant is in the virtual 3D Cave.



3. An overview of the collaborative space: The posters (pictures), the map (on the right indicates the geographical place of the sites to visit), the colored notes are for additional contents (under the map), and the schedule table (in the middle) is the place where the chosen posters of the program have to be placed.

In this research, after data cleaning, 12 transcribed conversations, and semi-structured interviews were analyzed. The 12 conversations consist of 3428 utterances. The utterances were defined as meaningful base units of verbal interactions. The coding scheme of Juhász and Soós [11] - developed to analyze team communication in high-risk environments- was previously adapted to our experimental task to categorize the utterances [3], [13] (see Table 1.). The utterances were also coded by their role in the conversations and by their subject. Questions, instructions, asking for confirmations, providing confirmations, and informing utterances were distinguished exclusively by the role, while coordination, information sharing and usability were distinguished by the subject of the utterance. To capture a mate-feature of collaborative communication, in addition to the mentioned coding categories an utterance was coded assertive, when it helped the other participant without being asked to do so and when the communication had intention

I. THE INTERACTIONS' CODES AND EXPLANATION WITH EXAMPLES [3], [13]. ALL CATEGORIES WERE CODED BY THEIR ROLES IN CONVERSATION: QUESTION, INSTRUCTION, ASKING FOR CONFIRMATION, PROVIDING CONFIRMATION, INFORMING

Code	Definition	Example
Coordination	Acts of task distribution among the partners (assigning subtasks to do). Communication related to the physical distribution of the information in the cave. There are three types of utterances included in the coordination group, i.e. (i) utterance about *how* and *who* is supposed to do the concrete task, (ii) the information about the physical distribution of the posters in the VR, (iii) the strengths and weakness proposals.	*I've put it down here. Where's poster number 4? Ok, I take care of these.*
Information sharing for the task	Communication related to the content of the posters and programs. Utterances about (i) what kind of programs are there in the room, (ii) where they are located in Budapest, (iii) when they are available, (iv) in what order the tourist will visit the places.	*Here's the Opera for the first day. Is there a guided tour in the museum on the afternoons?*
Usability	Communication related to the usage and features of the VirCA. This includes the information provided to each other about (i) the usage of navigation tools, (ii) features of movements, (iii) technical details and their problems.	*How can I type in here? I've pushed the right button. I can't see you now.*
Assertive behavior	Assertive behavior is the ability to express clearly and confidently your needs and respects others' wants. This group of variables contains utterances of (i) *I-messages*, or assertive behavior types, (ii) other self-related messages, (iii) when a participant helped the other without being asked to do so.	*I place it next to it, optionally, and we may put a note here to indicate choice. You placed it here so I can't see anything, move it away please!*

about the other one's needs. An assertiveness ratio was calculated from the number of assertive utterances divided by all utterances. The output of the collaborative task of each pair was evaluated, and rated in order to gain an index of efficiency. The evaluation is based on the rules and mainly relays on the time management and accuracy of the task performance.

Pearson's' correlation was conducted to calculate the correlations between the utterances type and the efficiency index. Structured interviews were also conducted in order to gain qualitative insight to the features of collaboration. Results

The task completion time and the utterance category of coordination as informing had strong positive correlation ($r=0.669$, $p<0.05$). The task completion time also showed a strong but negative correlation with the code category of utterances of information sharing as confirmation ($r= -0.681$, $p<0.05$).

Surprisingly the results showed that assertiveness had no connection with the efficiency index number ($r = -0.290$, $p>0.05$). Instead of assertive communication, and supporting the mutual information needs, the collaborators informed each other mostly about their own activities or intentions.

IV. DISCUSSION

Informing about own activity and intentions is used for coordination in the VR, to develop shared representations and to compensate the lack of monitoring of the collaborator. It can be interpreted as a sign of usability difficulties in the virtual environment that is solved by verbal communication (instead of nonverbal information-based monitoring). It is matching our previous results about the usability of the virtual environment [3], [13]–[15]. The cognitive capacities used for information sharing did not let the participants to anticipate the partner's needs thus assertive communication could not express its effect. A better usability could contribute to more assertive communication that may be connected to the output quality. Besides, the time of the communication increased the task time, and it probably also improved the task-related mental model of the participants. The results show, that the more coordination the participants needed, the more time they needed to develop a task-related shared mental model and complete the task.

Coordination and interpretation can be useful in long time collaboration when there is enough time to develop a task-related shared mental model. The coordination, as a possible indicator of forming mental models, turned to be the most time-consuming element of the interactions. The utterances of information sharing as confirmation, e.g. confirmation of the information about events, had a moderate negative correlation with the task time. More confirmation may close the interactions: it confirms that the collaborator has the same information; there is no need to share it explicitly with the other one, who has no chance to answer. That could save more time for participants in projects.

Due to the result indicating that the various types of interactions have no connections with the task performance efficiency index, it is presumable that the usage of the environment needs major effort from the participants that cannot be worked around by any interactions, instead they may have used individual solutions. This can be supported by our previous results on usability features, and errors observed in this environment [3], [13], [15].

V. CONCLUSIONS AND FUTURE WORK

The results show that in a virtual work environment the interactions should be planned with a time limit taken into account. The pairs (or teams) working together with a time limit can focus their utterances on the coordination: providing the right answers in the right time, instead of spending time on information sharing. This communication style fits the groups

of the people who are already familiar with each other more. For long term projects when durable collaboration is necessary it is beneficial to communicate explicitly and to develop a project specific shared mental model [16]. But above all, the usability flaws of such virtual environment should be corrected in order to reach a seamless workflow where interpersonal skills and interaction styles can be trained.

The results are transferable to online training settings: it would be beneficial to develop customized trainings for specific jobs in an immersive virtual reality to facilitate the development of a shared mental model of the task. It would be advantageous for companies to establish such training programs with virtual collaboration for their future collaborators, since in the VR through the usage of the ICT tools can improve the cognitive processing. Among other things the VR with its avatars gives more visual input about the participants. People can better monitor intentions of others and the virtual area context provides greater association possibilities. The technical characteristics of the VR area enable both synchronous and asynchronous communication and beside of that it's possible to integrate useful technical tools to improve the collaboration. Interpreting the experimental setting and our results in the Cognitive Infocommunications framework the human capabilities are extended, human and ICT combined within a VR space could lead to new cognitive capabilities [16], [17]. In this setting, as we have shown in our previous researches, the co-evolution of cognitive processes e.g. shared representations, information search, problem solving, and planning with infocommunication devices (the VR) can be studied [13]–[16]. Connecting remote members of teams in a VR is a merging and extension of cognitive capabilities that is targeted towards engineering applications in which artificial and natural cognitive systems are enabled to work together more effectively [16]. In the future this combined system of human in VR can contribute to a more effective way of training people.

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