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AUDIO AND CHAT COMBINED – ARE TWO MEDIA BETTER THAN ONE?

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Abstract

Meetings and collaborative work are part of the everyday business life. Audio communication in the form of VoIP and instant messaging-based chat communication offer new and inexpensive ways to communicate in groups. Our previous research has shown that the selection of either audio or chat has a significant impact on the collaborative productivity. This experiment observes the impact of selecting both audio and chat communication at the same time. We analyze whether the polychronicity helps to achieve a higher productivity. This work provides quantitative, experimental-based data. We show with this data that typical users are overwhelmed by the combination of both media. The complexity of listening to the audio conversation, reading the chat dialog and observing the shared whitespace together with communicating seems to induce too high a cognitive load on the user, thus preventing productive work. This paper shows the importance of quantitative experiments about polychronicity and proposes further work about the correlation of media synchronicity and polychronicity research.

Keywords: Media Choice, Media Richness, Audio, Chat, Experiment

1 INTRODUCTION

Cooperative group work and decision making in the form of meetings is a major part of work life. 30-80% of managers' time is spent in meetings (González & Mark, 2004; Romano Jr & Nunamaker Jr, 2001; Panko & Kinney, 1995; Rice, 1973). But these meetings and workshops can be highly inefficient. At least one third of the time is spent in unproductive meetings (Romano Jr & Nunamaker Jr, 2001; Rice, 1973; Green & Lazarus, 1991; Elsayed-Elkhouly et al., 1997), resulting in billions of dollars loss (Elsayed-Elkhouly et al., 1997; Sheridan, 1989). Nevertheless, the time spent in meetings is increasing steadily (Romano Jr & Nunamaker Jr, 2001; Rice, 1973; Elsayed-Elkhouly et al., 1997). Thus, every improvement in meeting and workshop productivity could save money. Not all meetings can be conducted face-to-face, the rest requires electronic communication channels to all group members. Audio conferences are an established mode of communication for distributed group meetings (González & Mark, 2004; Romano Jr & Nunamaker Jr, 2001; Hudson et al., 2002). In the last years, chat communication and instant messaging has seen an increased use in business areas (Cameron & Webster, 2005; Muller et al., 2003; Herbsleb et al., 2002; Quan-Haase et al., 2005; Muller et al., 2002). The usage of this medium started in the late nineties as a private communication channel (Nardi et al., 2000; Grinter & Palen, 2002; Boneva et al., 2006), but since then has been incorporated into both business and learning areas (Kinzie et al., 2005; Chatterjee et al., 2005). Chat is used increasingly as a part of the communication infrastructure used for meetings (Rennecker et al., 2006). Thus, both audio and chat communication are used to include distributed group members into meetings.

Two previous experiments in November 2004 and November 2005 showed (Löber et al. 2007, Grimm 2006, Müry 2005) a significant effect of the choice between audio and chat, and the size of the group on both cooperative productivity and user satisfaction. Audio groups with four members showed a significantly higher productivity than chat groups for a task characterized by ambiguity. Also, audio users were significantly more satisfied with their communication system than were chat users.

The two experiments indicated that for groups with seven members the results were completely different. Both audio and chat groups showed nearly identical productivity. Audio groups with seven members were less productive than audio groups with four members. Chat groups with seven, on the other hand, were significantly more productive than chat groups with four members, but failed to reach the productivity level of audio groups with four users. For groups of seven the chat users showed a significantly higher satisfaction with the communication system than the audio users.

In this work we focus on groups of seven, since there is obviously room for improvement for both audio and chat groups. We know that the selection of either audio or chat communication for a given group size influences productivity. But new instant messaging and voice communication software products like skype offer both media at the same time for home users, while software giants like Microsoft and IBM offer companies highly integrated unified communication products. Thus, we formulate the research question: What is the effect of using both audio and chat communication for collaborative group work on productivity?

2 MEDIA CHOICE AND POLYCHRONICITY THEORIES

Most research into the media choice field has been done into the selection process of a medium. Only a minority of studies has been focused on the effects of the media choice (Dennis et al., 1999). These studies look into the effects of media choice between one medium and another, based on various theories. All those theories postulate that different media can be characterized by identifiable criteria. The media richness theory (Daft and Lengel 1986; Daft et al. 1987) is the most popular theory in this area of research. Daft and Lengel postulate that every medium has a measurable amount of "richness." This richness is the ability of a medium to convey a shared meaning. Media can be characterized by four criteria: feedback, multiplicity of cues, language variety and personal focus. Daft and Lengel propose that tasks that are ambiguous and equivocal require media with high media "richness" in order to communicate. Previous research has shown very inconsistent results, indicating that the media richness theory might not explain the effects of media choice adequately (Kahai, 2003; Kock, 2004; Robert & Dennis, 2005). Also the media richness theory lacks explicit statements regarding the effects of media choice in conjunction with group size. Furthermore, there is no prediction about the suitability of two or more media for communication tasks.

Studies by Diehl and Stroebel (1987; 1991) and Mullen et al. (1991) have shown that in conventional brainstorming sessions, an increase in group size can decrease the productivity of the group. This effect is caused by productivity blocking. This blocking occurs when group members must wait for their chance to communicate, because another person is using the communication channel exclusively. This problem can happen with audio groups which are forced to use a single voice channel. Nunamaker et al. (1991) and Gallupe et al. (1992) have shown that electronic brainstorming software - using written communication to allow parallel communication - can negate the productivity blocking.

The media synchronicity theory by Dennis and Valacich (1999) incorporates these insights into group work. The theory characterises media by five criteria:

Immediacy of feedback is the capability of the medium to allow the receiver of a message to give feedback immediately

Symbol variety characterizes the scope of possible communication styles available to the user

Parallelism is the number of concurrent communications in which the user can participate at the same time

Rehearsability describes the support of the medium for drafting communication prior to sending

Reprocessability is the ability of the medium to allow easy later reuse of communication by the receiver.

Some of these criteria are mutually exclusive, such as immediacy of feedback and parallelism (Schwabe, 2001). There is also no single best medium, as the selection of a communication medium is based on the requirements of the communication process. Dennis and Valacich identify two major communication processes: conveyance and convergence. Conveyance is the dissemination of information to all group members to alleviate a lack of information. Convergence is the creation of a

shared interpretation about the information. For communication phases of conveyance, Dennis and Valacich propose the use of media with high parallelism and low immediacy of feedback. When the communication process requires convergence media with high immediacy of feedback, low parallelism should be used.

Previous research has shown some promising results (Dennis et al., 1998; Murthy & Kerr, 2003; Maruping & Agarwal, 2004; DeLuca & Valacich, 2006; DeLuca & Valacich, 2005), but a final confirmation of the media synchronicity theory is still open. The media synchronicity theory does not include explicit propositions regarding the effects of group size on the media characteristics. But the parallelism characteristic is a clear indication of the recognized importance of group size on the communication process. The media synchronicity theory lacks any weighting of the five media characteristics.

The media synchronicity theory proposes to sequentially change media according to communication needs. For ambiguous tasks, Dennis and Valacich recommend two communication phases. In the first phase the group should use media with high parallelism and low immediacy of feedback in order to communicate their information and the associated interpretation. The high parallelism allows a fast exchange of this information. In the second phase the group members create a shared meaning of this information and agree on this understanding (Dennis & Valacich, 1999). For this communication phase, the group should use a medium with low parallelism and high immediacy of feedback, to help compare the individual point of view with the other interpretations and to comment on them. This change between conveyance and convergence communication phases can be repeated several times during a communication task. Dennis and Valacich (1999) propose to switch media according to the different communication phases. But beyond the generic recommendation they fail to formulate tangible predictions about the effect of this media choice. Furthermore, there are no propositions regarding the usage of multiple media at the same time.

The sequential usage of several media with fundamentally different characteristics requires a constant re-adaptation of the user to the communication process. This effort becomes even worse when both media are used in parallel at the same time. Te'eni (2001) identifies three areas of communication complexity arising from this usage: **cognitive complexity**, **dynamic complexity** and **affective complexity**.

The **cognitive complexity** problem is influenced in several ways by the availability of both media. It describes the complexity caused by the intensity of information exchange, multiplicity of points of view and the requirement to translate information into a supported medium. With an increase in the number of available media, there is also an increase in the intensity of information exchange. The users can select their favourite medium or even use both media in parallel. Also, the media are partially incompatible regarding their information representation. Audio communication cannot be reused in the chat communication and chat history has to be verbalized to be of use in the audio channel. Two factors of the cognitive complexity problem are thus negatively influenced by the availability of two media at the same time.

Dynamic complexity arises from time constraints, problems with the feedback speed and unpredictable user behaviour. This complexity issue might happen when users switch from audio to chat. Key characteristics of audio communication, such as immediate feedback, is missing from chat communication. This will require the group members to adapt to the new media features.

Affective complexity, which is the complexity arising from changes in the disposition of the group members to each other, will be of limited consequence in the short-term experiment.

Furthermore, the users have to compensate an increasing cognitive load caused by the communication process. The cognitive load theory by Sweller (1988; 1989; Chandler & Sweller, 1991) shows that the combination of information from different sources significantly increases the cognitive load. The sequential usage of audio and chat would require a distinct cognitive effort by the user to unify both the audio and chat communication into a coherent understanding. A parallel usage of both media would require even further, constant effort because of the two distinct communication channels.

In the last years several studies have researched the effects of multiple, concurrent media usage. This research topic is defined as polychromic communication (Woerner et al., 2004). The current research

is limited to case studies on media usage and perceived effects of media combinations. According to Belanger and Watson-Mannheim (2006; 2007), the usage of both chat and audio at the same time is typical for subgroup interaction. While the whole group is talking in the audio channel, subgroups discuss topics using the chat channel. Woerner et al. (2004) describe similar findings in their case study of a computer manufacturing company. During meetings group members used their computer to engage in instant messaging communication with other group members. Rennecker et al. (2006) show in their case study that instant messaging is used to clarify open questions arising during oral communication. Cameron and Webster (2005) identify three types of polychronicity in their case study:

- usage of two media: the users exchange persistent information via chat to augment oral discussion
- communication with several persons at the same time
- queue jumping with instant messaging to circumvent the waiting line for a face-to-face talk

In combination, these studies show that audio and chat are used in the same communication task. The studies suggest that this might be perceived as a useful and productive method of communication by users. But the ongoing research is currently limited to case studies and interviews without any quantitative data of the actual effects on the productivity. Thus, there is a need to confirm whether or not polychromic usage of audio and chat is productive.

3 RESEARCH MODEL AND HYPOTHESES

In this study we want to observe the effects of polychronical media choice on productivity. We focus on larger groups with seven members and compare the polychronical usage of both audio and chat against groups using either audio or chat. Figure 1 represents the research model used. We observe the direct effect of the media choice on productivity, and also analyse the influence of the media choice on the assumed positive and negative side effects of the polychronical media usage. We then observe whether these side-effects influence the productivity in any way.

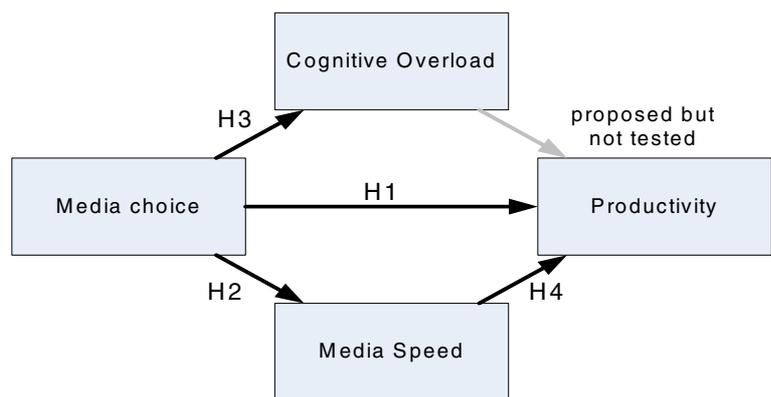


Figure 1: Research design

From our previous research we know that the selection of one medium over another can influence the collaborative productivity. The media synchronicity theory postulates that the sequential selection of appropriate media will improve productivity. The availability of appropriate media for both conveyance and convergence communication processes should lead to a higher productivity. For tasks of equivocality, this would mean that the chat communication medium could be used for the conveyance of information. The high parallelism and low immediacy of feedback should be appropriate.

On the other hand, according to the media synchronicity theory, audio communication is better suited for convergence communication processes. The high immediacy of feedback and low parallelism allow for a focused unification of interpretations. Groups with both media available could alternate usage between audio and chat in order to satisfy the communication needs of the ongoing communication process. This should, according to the media synchronicity theory, lead to a higher cooperative productivity.

Rennecker and Godwin (2003) hypothesize that with an increase in instant messenger usage, the amount of polychronic communication will increase. They further postulate that this will decrease the productivity. Individual users with polychronical chat communication are hypothesised to show a lower productivity than users without instant messaging or non-polychronical chat usage.

Rennecker and Godwin fail to formulate hypotheses about the conscious, consensual media switch described by the media synchronicity theory. They focus on the aspects of disturbance caused by spontaneous polychronicity. In our research we search for clues to understand how a deliberate offering of different media can influence the productivity. Thus, the usage of multiple media is no disturbance, but an offer to alleviate shortcomings of single media in specific communication phases.

As a summary of the literature, we can formulate that there are positive and negative factors influencing the usage effects of both audio and chat. The data gathered in the case studies presented in chapter two indicate that there is a widespread polychronical use of media. This indicates that the users feel productive using several media. Furthermore, the media synchronicity theory formulates that for different communication phases, different media offer more appropriate support. Groups with one media are forced to endure the deficiencies in either the conveyance or convergence communication phase. Groups with both audio and chat should be able to use the appropriate media at the right time. Thus, we formulate hypotheses:

H1Audio: Groups using both media are more productive than groups with audio.

H1Chat: Groups using both media are more productive than groups with chat.

According to the media synchronicity theory, audio groups can use the high immediacy of feedback in order to communicate very fast. Chat users, on the other hand, can communicate in parallel and rehearse their input prior to communication; they can also reuse and reprocess old information pieces. Both media have distinct capabilities, lacking from the other medium.

A polychronical combination of both media would offer a high feedback speed coupled with parallel communication in both media. Furthermore, the groups could change their usage preferences between both media according to the communication task requirements.

Thus, we formulate the hypotheses:

H2Audio: Groups with both media show a higher degree of media speed than groups with audio communication.

H2Chat: Groups with both media show a higher degree of media speed than groups with chat communication.

On the other hand, the groups with both media have to cope with increased cognitive effort. Not only is the speed of communication vastly increased due to the availability of both parallel and fast communication means; furthermore, the information from both media is disjointed. The user has to recombine the information from both streams in order to gain a complete understanding.

Thus, the user is assaulted by a constant stream of communication on several channels while trying to formulate a shared understanding with six other group members. This thought process is more challenging than work with only one medium. Groups with either audio or chat communication only need to monitor one communication channel which offers the whole set of information, instead of just a portion. Therefore, we formulate hypotheses H3:

H3Audio: Groups with both media show a higher degree of cognitive effort than groups with audio communication

H3Chat: Groups with both media show a higher degree of cognitive effort than groups with chat communication

The media synchronicity theory postulates that the selection of the appropriate medium with the right characteristics can increase productivity for collaborative group work. The availability of two media with very different characteristics should therefore help groups work productively. Group members can select the appropriate medium for the communication task. For this reason, the availability of more media speed should lead directly to more productivity. Thus, we postulate hypothesis H4:

H4: A higher degree of media speed should lead to higher productivity.

This paper does not formulate hypotheses on the effects of cognitive overload on productivity. Cognitive overload is a complex problem. We gather the necessary data with various questions, but the statistical consolidation of this data would require a much higher number of participants ranging in

the thousands. This is due to the fact that each data point of a group requires 7 participants. Thus, we use the research propositions by Te'eni (2001; 2006) who postulates that an increase in communication complexity hampers collaborative work. Recent research by Suh and Shin (2007) supports this insight.

4 METHODS, DESIGN AND EXPERIMENT

4.1 Selection of task

We selected the “automatic post office of the future” experiment by Olson et al. (1993) as the experimental task, which has been already used successfully in other media choice studies (Ocker et al., 1996; Hiltz & Turoff, 1993). The experimental task requires the group members to envision a design for an automated post office of the future. This design has to be described on a shared whiteboard; it must be feasible to produce within a year with 30 people. The task is characterized by a high degree of ambiguity. While basic requirements of post offices are known, the detailed specifications, features and requirements of the users are open to discussion. Thus, the group members must arrive at a shared understanding of which services should be offered by their automated post office prior to the actual specification process. The task does not focus on brainstorming, but requires the users to come to a joint understanding and priorities. Due to the constraints on manpower and time available, the groups have to weight options and generate a cohesive design. All required information is contained within the task description. Thus, the task generates a low level of uncertainty. The participants were asked to externalize their design to the shared whiteboard. The groups could spend a maximum of 45 minutes working on the task.

4.2 General set-up of experiment

All experiments used groups with seven members. A description of the experiments with either audio or chat is published in Löber et al. (2007). These experiments were performed in November 2005. The experimental with polychromic media usage was conducted in November 2006 (Lustenberger 2007). As in other media studies on audio and chat, we used students as our research subjects because of their availability. To prevent a bias on computer science skills, we used students from mixed faculties, resulting in varying skills in computer-mediated-communication and typing. Usage of postal offices is widespread, thus no special knowledge or skills were required.

The participants were paid around \$20 for their effort. The experimental run with both media consisted of 70 participants. All group members were separated into different rooms to simulate the distributed group members. The equipment consisted of a notebook computer, laser mouse and a high quality headset. Chat communication and whiteboard functionality was provided by Netmeeting. A Teamspeak server was used for audio communication.

5 GATHERING OF DATA AND MEASUREMENTS

We asked five experts to rate the quality of the design. The method used was identical to the one used in the previous experiments, comparing groups using either audio or chat (Löber et al. 2007, Löber and Schwabe 2007, Grimm 2006).

The rating method was based on the established lines of creativity research (Mayer, 1999). The raters identified four major categories of features which were weighted according to their importance: critical features (8 points worth), important additional features (4 points), additional features (2 points) and marginal features (1 point). The five raters showed a high interrater agreement (Krippendorff $\alpha=0.64$), with 0 being no identical ratings at all and 1 being only identical ratings of all five raters at the same time (Krippendorff, 2003). In the original experiment by Olson et al. (1993) several raters rated a small part of the data. The person with the highest interrater agreement then judged the quality of all designs alone. We believe that rating all designs with several raters is more appropriate for the purpose of this study than the original method used by Olson et al. Furthermore, it allows evening out jittering effects of individual ratings by using the mean value of all five raters. In order to compute the productivity, we divided the quality of the design by the time required.

A questionnaire was used to gather the user input regarding the communication medium. For this purpose, we used the SUS (system usability scale) questionnaire (Brooke, 1996), which incorporates ten questions with a 5 point Likert scale. They are formulated specifically to compensate for destructive behaviour, such as marking only one side of the questionnaire. To prevent such occurrences, questions alternately give full points on the left and right side of the Likert scale. A linear algorithm transforms the results into a scale from 0 to 100, with 0 points representing an unusable and 100 points a perfect system. We use this questionnaire to understand the negative impact of the communication system on the cognitive effort.

The speed of communication is influenced directly by the immediacy of feedback and the parallelism characteristics of the media synchronicity theory. Furthermore, it is indirectly affected by the available symbol variety, rehearsability and reprocessability. A high symbol variety allows the user to express thoughts more naturally, while the rehearsability and reprocessability allow the user to communicate more efficiently (Löber et al. 2006). Thus, the speed of communication incorporates aspects of all media characteristics as defined by the media synchronicity theory. We analyse the speed of communication by transcribing one minute of communication at the 50% point of time used by the group. Afterwards the characters are counted.

Statistical methods used

We use one-way ANOVA to calculate the effects of media choice on productivity, communication speed and cognitive load. To differentiate the three media settings (audio, chat and both media), we utilize post-hoc Tukeys “honestly significant difference” (HSD) tests. To understand the effects of the communication speed, we calculate the correlation to the observed productivity. The effect of the cognitive load on productivity is calculated using linear regression with the 10 SUS questions as factors. While the number of data points (10 groups for every medium) might seem small, each data point incorporates the mean value and output of four or seven group members. Furthermore, each rating of the post office designs is also a mean value of the five raters. Therefore, we believe that the normal distribution is inherent inside the data due to the compensating effects of team work and joint rating. The meta-study by Fjermestad and Hiltz (1999) has shown that a sample size of ten for group research in the area of group support system is typically sufficient to give good results if there is a strong effect. Most experiments have used 10 or fewer groups per treatment. The assumption of a sufficient sample size is further supported by the results of a one-sample Kolmogorov-Smirnov-Test for normal distribution. Backup calculations with a non-parametric test showed the same results. For the computation of the effect size we use partial Eta-squared. All results are two-tailed.

6 RESULTS

6.1 Productivity

Groups with both media reach a mean value of 1.8 rating points per minute (SD 0.96 points per minute), while audio groups average at 1.5 points per minute (SD 0.32) as well as chat groups (1.5 points per minute SD 0.18).

There is no overall significant difference in the productivity of the media ($F(2, 27) = 0.847$; $p = 0.440$). **Thus, hypothesis H1Audio has to be rejected.** There is also no difference between audio groups and groups with both media ($HSD = 0.301$; $p = 0.499$) or chat groups and groups with both media ($HSD = 0.294$; $p = 0.513$). **Thus hypothesis H1Chat also has to be rejected.** Further analysis reveals that the high standard deviation of the groups with both media was caused by one group. This group showed outstanding productivity, while the other 9 groups showed similar values as the groups using chat communication. The special group reached 2-3 times the average productivity of the other groups. Removing the outlying group does not change the overall results. The average productivity of the polychronical groups is dropped to 1.5 points per minute. This is the same productivity as shown by groups using either audio or chat.

6.2 Effect of media choice on media speed

Users with both media communicated 50 characters per minute (SD 12 cpm/user), while audio users communicated 90 characters per minute (SD 30 cpm/user) and chat users transmitted 35 characters per minute (SD 16 cpm/user).

This difference is significant ($F(2,27)=15$; $p<0.01$). The difference between groups with both media and audio groups is significant ($HSD=-40.3$; $p<0.01$). **Thus, hypothesis H2Audio is completely rejected. Instead of the assumed higher communication speed of polychronical groups, the audio groups show a significantly higher communication speed.** The difference between groups with both media and chat groups is not significant ($HSD=14.7$; $p=0.35$). **Thus, hypothesis H2Chat has to be rejected.** Furthermore, additional analysis have shown that groups use predominantly either audio or chat, but seldom both ($\text{pearson}(10)=-0.865$; $p<0.01$).

6.3 Effect of media choice on cognitive overload

There were two significant differences in the rating of the system between groups with both media and groups with either audio or chat. The users rated question 6 and 9 significantly different.

Users with both media rated the question “*I thought there was too much inconsistency in this system*” with 2.9 points (SD 0.66), while audio users rated their system with 2.42 (SD 0.42) and chat users their system with 2.3 points (SD 0.48). This difference is significant ($F(2,27)=4.217$; $p=0.025$; $HSD\ \text{Both/Audio}=0.516$; $p=0.096$; $HSD\ \text{Both/Chat}=0.658$; $p=0.027$).

Users with both media rated the question “*I felt very confident using the system*” with 2.9 points (SD 0.66), while audio users rated their system with 2.42 (SD 0.42) and chat users their system with 2.3 points (SD 0.48). This difference is significant ($F(2,27)=5.323$; $p=0.011$; $HSD\ \text{Both/Audio}=0.17$; $p=0.687$; $HSD\ \text{Both/Chat}=0.473$; $p=0.071$). **Thus, hypotheses H3Audio and H3Chat are tentatively supported by the data.**

6.4 Effect of the usage media speed on productivity

There is no indication, that communication speed is correlated with the productivity ($\text{pearson}(30)=-0.102$; $p=0.592$). **Thus, hypothesis H4 has to be rejected.**

7 DISCUSSION

There is no significant difference in the productivity of groups with both media and groups using either audio or chat. For the groups of seven, the groups with both media show the highest average productivity of all three media settings. But there is no statistical evidence that this difference is inherently caused by the media choice. Regarding the research question, we now know that the availability of both audio and chat does not offer a significant improvement in productivity in comparison to groups with either audio or chat. The results of the additional analysis become important in order to understand why there is no significant improvement in productivity.

First of all, there is no significant difference in communication speed between chat groups and groups using chat and audio at the same time. There is even clear evidence that audio only groups reach a higher communication speed than groups with audio and chat. The availability of two distinct communication systems does not support a speedy communication. The data clearly shows that groups tend to either use audio or chat exclusively. Eight out of ten groups used one medium nearly exclusively (>90%). Thus, this study has clearly shown that polychronic, parallel media usage severely limits the possible communication speed. Furthermore, most groups prefer to use only one medium.

The SUS questionnaire helps understand why the groups show no significant increase in communication speed. The users are overwhelmed by the information coming from different communication channels. Accordingly, they complain about the high inconsistency of the communication system. This feeling of inadequate integration of communication channels could be responsible for the limited productivity. Also, chat users rated their slow communication medium to be more consistent than users with both media. The addition of audio as a second medium seems to break

the coherent media usage. This is a clear indication that the groups with both media suffered from too much cognitive effort. It seems that even for media-savvy teens, the possible negative side effects from cognitive overload hamper the possibilities offered by the combined media characteristics.

But one polychronical group has shown extraordinary collaborative productivity. They reached twice or three times the productivity of all other groups, regardless of the media treatment. This group has shown that with the right selection of media and a structured approach to communication, two media can be used productively. The group focused their communication on chat (70%), but also used audio communication. But while this group was able to perform their cooperative work very efficiently, 9 other groups failed to utilize the potential of their communication system.

Most users were overwhelmed by the cognitive effort required to understand the information and the complexity of using several media sequentially or even in parallel. In order to fully absorb all information, the users had to listen to the audio communication, read every chat message and maintain an awareness of the changes in the shared whiteboard space. Furthermore, information available in one media is not available in the other media. Thus, the users had to combine the two information streams into a complete set of information. According to Sweller (1988; 1989), this requires a large cognitive effort. In combination, the usage of both media proved to be too complex for the group members, even for supposedly experienced youths.

In regards to the ongoing research into polychronicity, we can augment the research framework of Rennecker and Godwin with our own findings. Our research indicates that current students are not able to instinctively use polychronical communication systems to their full potential. The coordination of the media usage of both media seems to result in both high complexity and cognitive overload. While a sequential selection of media might seem sensible to media choice researchers, this experiment indicates that normal users are not able to differentiate their communication needs sufficiently.

Furthermore, our research suggests that the media synchronicity theory has to be clarified regarding the sequential effects. While the media synchronicity theory incorporates recommendation of sequential usage of multiple media according to communication needs, it requires further detail. In our experiment, the users failed to grasp the concept of sequential media usage instinctively. It seems that prior training would be required to ensure an appropriate selection of the medium according to communication needs. Parallel, polychronical media usage is completely missing from the media synchronicity theory.

8 CONCLUSION

This work presents empirical insights into the effect of polychronical usage of both audio and chat at the same time. Our findings indicate that the theoretical benefits of using two media at the same time fail to occur in real life. The users cannot use both media at the same time while working on a complex task requiring the building of a shared understanding. The main problem hampering the productivity seems to stem from the increasing complexity of communication. The users are faced with a complex system requiring too much cognitive effort. It seems, thus, that a multitude of communication channels used at the same time overwhelm the users and thus hinder productivity. The first practical insight from our research would be: keep it simple. Limiting the number of available communication media to one system can lower the cognitive effort while leaving the productivity unchanged.

It is vital to prevent inconsistencies in the communication system; if more than one communication medium must be used at the same time, a tight integration of the different media might partially alleviate the high cognitive effort. Also, it is important to research how training of the users can lower the losses due to communication complexity. One group has shown that with the right media usage, the productivity can increase dramatically. This group used the audio medium for oral presentation of ideas and the chat medium for questions about these concepts. Further research is required to understand these two groups.

The media synchronicity theory inherently postulates a knowledgeable media user without specifying how normal users would be able to benefit from the insights. Therefore, it is important to continue

research on how ordinary users interact with communication media and what effects training would have in media choice theories. Sequential usage of the appropriate media could help alleviate the cognitive load while still offering benefits from both media. But this would require distinct communication processes and a full knowledge and understanding of media choice theories and effects by the users.

9 LIMITATIONS

There are several limitations attached to this study. The importance of the combination of both media became apparent after a thorough analysis of the available data of the previous experiments. Also, due to the limited numbers of possible experimental participants, the research experiments had to be conducted in several distinct experiments. A joint experiment would have required 210 participants.

In order to cope with this limitation, we conducted several checks. In order to prevent changes in the judgment of the designs to impact on the findings, we conducted re-ratings of old designs along with the rating of the new designs. The re-ratings showed a very high correlation to the old results (Krippendorff Alpha=0.911).

Another concern was the possibility of a change in the typing skills of the chat users over time. We therefore checked if there was any difference in the typing skills. The questionnaire showed no significant change in the ease-of-use rating of the chat medium. We furthermore prevented users to participate repeatedly in the experiment by archiving their names and prohibiting a new registration.

We originally used Skype as the audio channel for the experiments of four. Due to the lack of Skype software ability to communicate with more than 5 users, we had to switch over to Teamspeak. We used a low-latency, high-bandwidth LAN to compensate for potential echoes and then hand tuned the settings.

Finally, we acknowledge that there are several different task types in the real world apart from the ambiguous experiment chosen in our research. Our experiment should provide insight into other design-oriented, collaborative tasks. Also, our research is limited to a short duration experiment. Studies such as the work done by Kinney and Watson (1992) and the case studies referenced in section two offer complementary insight into the effects of media choice. But we believe that most business and private tasks include adhoc communication phases, such as the one used in the experiments.

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