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Dmitri Bershadskyy/Sunil Ghadwal/Jannik Greif

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Verantwortlich für diese Ausgabe:
Dmitri Bershadskyy, Sunil Ghadwal, Jannik Greif
Otto-von-Guericke-Universität Magdeburg
Fakultät für Wirtschaftswissenschaft
Postfach 4120
39016 Magdeburg
Germany

http://www.fww.ovgu.de/femm

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MTV - Magdeburg Tool for Videoconferences

Dmitri Bershadskyy[a1], Sunil Ghadwal[a], Jannik Greif[a]

Abstract

MTV is a software tool (citeware) for economic experiments facilitating researchers to gather video data from communication-based experiments in a way that these can be later used for automatic analysis through machine learning techniques. The browser-based tool comes with an easy user interface and can be easily integrated in z-Tree or oTree. It provides the experimenters control about several communication parameters (e.g., number of participants, duration), produces high-quality video data, and circumvents the Cocktail Party Problem by producing separate audio files. Using some of the recommended Voice-to-Text AI, the experimenters can transcribe individual audio files. MTV can merge these individual transcriptions to one conversation. This paper describes the underlying principles of the tool, technical requirements, possible areas of application, and current limitations.

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[1] Corresponding author.
Dmitri Bershadskyy: ORCID: 0000-0002-9856-1548
dmitri.bershadskyy@ovgu.de

Sunil Ghadwal
sunil.ghadwal@ovgu.de

Jannik Greif
jannik.greif@ovgu.de

[a] Faculty of Economics and Management, Otto-von-Guericke University Magdeburg, Germany

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1. Introduction

Experimental economics has become an established field of research looking into a variety of different topics, communication being among those. In this paper, we make the argument that communication, though been a major research topic in experimental economics for decades, can now be analyzed in economic experiments more holistically than before. We provide a browser-based communication tool (MTV – Magdeburg Tool for Videoconferences) that enables researchers to conduct their communication-based experiments easily. All required files (video, audio, transcriptions) for future analyses are stored on their own servers, thus, better protecting the data of the participants.

Communication plays an essential role in decision-making and has been a major topic of research for decades (Isaac & Walker, 1988, 1991). Still, even recent high-quality reviews discussing the implementation of communication in the laboratory do not yield unambiguous findings (Brandts et al., 2019). Instead, two insights can be made. First, if researchers are interested in one specific aspect of communication, it is valuable to restrict all parameters but the one of interest. The most prominent example of this type of research is the choice of the communication channel (Bochet et al., 2006; Brosig et al., 2003; Cason & Khan, 1999; Greiner et al., 2012, 2014; Isaac & Walker, 1988). In these experiments, communication can take place as text, audio, video conferences, or face-to-face in the same room. Other distinctions may refer to whether the communication is uni- or multidirectional (Cooper and Kühn 2014), ordered/simultaneous/unordered (Cooper et al., 1989, 1992; Ottaviani & Sørensen, 2001) or restricted in duration (Karagözoğlu & Kocher, 2016). Further, there can be content restrictions reaching from only signals to prepared statements (Brandts et al., 2014; Schram et al., 2019) or experimenters can allow free-form communication (Brosig et al., 2003).

The second insight is that, unless there are precise reasons to restrict communication, free-form communication should be preferred as it is more externally valid. However, free-form communication comes along with a set of issues. In practice, communication (for cooperation or bargaining) occurs often in face-to-face. Implementing free-form face-to-face communication in the lab is complicated and leads to the question of how to analyze it (Brandts et al., 2019). A simple alternative is to use video conferences, as in laboratory experiments these have been shown to produce almost identical results as in-person face-to-face communication (Brosig et al., 2003). While video conferences lack some possible elements of communication (e.g. physical touch, smell) the role of these elements is not clear for the majority of experimental paradigms in economics. Yet, conducting communication using video conferences has one major advantage as it allows one to record and later analyze the entire communication process. This goes beyond the typical analysis of content as it is pursued in a lot of experimental literature (Penczynski, 2019; Xiao & Houser, 2005). Instead, it includes analyzing e.g., facial expressions or voices. From an economic perspective it is established that both factors are important for research, e.g. for cooperation or charism (Antonakis et al., 2021; Centorrino et al., 2015; Hopfensitz & Mantilla, 2019).

However, going beyond content analysis leads to an issue we identified due to prior research focusing on video communication in the laboratory. Videos recorded in economic laboratories can be analyzed automatically either using proprietary software such as FaceReader (Serra-Garcia & Gneezy, 2021)) or through specially trained algorithms (Othman et al., 2019). Both approaches have different pros and cons[2]. However, what is common is that both require high-quality data. This is where Magdeburg Tool for Videoconferences (MTV) will help. Further, the tool is simple to use and easy to implement in the most commonly applied experimental software, i.e. z-Tree (Fischbacher, 2007) and o-Tree (Chen et al., 2016).

The remaining article is structured as follows. In section two, we will describe the requirements for data from video conferences such that it can be analyzed through automatic tools. In section three, we explain how MTV tackles these issues. Section four focuses on the technical requirements of the laboratory to implement the software. Section five concludes.

2. Quality of Video Data Analysis

In this section, we will briefly discuss what is required to obtain an integrated analysis of video communication. We distinguish three major factors: (i) video, (ii) audio, and (iii) content. We extend this discussion by a fourth factor – (iv) user friendliness of the tool. We consider this an important factor as it is necessary to obtain a lot of data from different experiments to achieve more stylized findings. In the following, we discuss every factor separately.

The most evident parameter of video data is the resolution. High resolution is required to obtain an appropriate level of detail, e.g. participants' facial expressions. Yet, what is appropriate is mostly unclear as even research from information science (e.g. neuroinformatic) does not provide specific benchmarks or guidelines. However, a good rule of thumb would be to say the higher the resolution the better, given that it is always possible to decrease the resolution afterwards (e.g. Dudzik et al., 2021). What is probably more important is the framerate measured in frames per second (FPS). Most common webcams used for video communication record at 30 FPS. Recording at 60 FPS provides twice the data and increases the chances of algorithms detecting some very short-lived movements. Similar to resolution, it is always possible to decrease the FPS later. Thus, we conclude that the higher the resolution and FPS, the better the quality of the video[3]. Yet, this can lead to higher requirements for data storage.

Concerning audio, there is a variety of parameters that can be measured (e.g., volume, prosody). To measure these well, it is important to establish a silent surrounding to avoid any acoustic disturbances. Given the standard practices in economic laboratories, this seems feasible, as participants take place in a single cubicle (ideally with sound insulation) and talk through headsets. The problem arises when more than one person is part of the communication, which is true for the majority of economic experiments. This concerns the so-called "Cocktail Party Problem" (Cherry, 1953) which refers to the remarkable ability of humans to identify individual sources of acoustic input (e.g. voices) in a noisy environment. At the same time, it poses problems for neural networks (Haykin & Chen, 2005) making it difficult to separate speakers

[2] The first approach applies always the same software and is easy to use. However, the software is mostly a black box and was not trained on the specific data set. The second approach, is likely to yield higher prediction rates yet requires more programming skills. It further makes it harder to reproduce the results, unless the code is published, which would be absolutely necessary. Note that we are aware of the third approach where humans code facial expression using e.g., the Facial Action Coding System (Ekman & Friesen, 1977).

[3] Please note, that we do not consider other parameters that influence the quality of recordings (e.g., lighting and the general surrounding of participants in the laboratory). Instead, we focus on the technical aspects.

solely based on audio input (Ephrat et al., 2018). Yet, if it is not possible to identify different speakers in an experiment, there is much less value for experimenters to analyze the voices.[4] Therefore, it would be useful if there was no need to separate the voices later.

Referring to content, experimental economics has established a few different approaches summarized in Brandts et al. (2019). These approaches refer to human coders as used in the majority of experiments or more automatic processes, e.g. machine learning (Penczynski, 2019). Independent of the chosen approach, the first step is to obtain the conversation as a text. This requires the experimenters to transcribe the text or to outsource it to transcription companies. Yet, currently, different speech-to-text converters can be applied in this case. Most importantly, they work more accurate if there is only one speaker as they also suffer from the Cocktail Party Problem. If, however, the problem can be solved on the audio file level, such automatic transcription tools can become a valid alternative for economic experiments.

Finally, it is important to stress some issues concerning user-friendliness. For economic experiments, it is essential to establish replicability. The easier it is to replicate an experiment the more likely is a replication. Thus, the tool used for the experiment must be free and easy to use. Further, it is important to consider the implementation of some of the most commonly used experimental software and technical requirements for the laboratory to operate the software. Finally, given that video conferences handle personalized data (e.g. faces), it is preferable not to share participants' data with other companies (e.g., Skype, Zoom). Therefore, the goal should be to provide an open-source tool with an intuitive interface that is operable for normal economic laboratories and where the data does not leave the digital space of the laboratory.

3. The structure of MTV

The goal of MTV is to address all four factors that were discussed in section 2. Doing so, we start with videos and proceed later with audio, content, and user-friendliness. However, the offered solutions are strongly interrelated.

Concerning videos, MTV offers resolutions from 640x480 to 3840x2160 and FPS from 30 to 60.[5] Thus, it enables researchers to gather high-quality videos in a range that is currently considered to be useful.

The most important feature of MTV is how it avoids the Cocktail Party Problem. As the software runs in the laboratory, the experimenters have access to all computers. This enables MTV to use a simple solution that is depicted in Figure 1. Before the audio-video signal is uploaded to the server, combining all audio-video streams into a joint communication, MTV captures a local copy of the signal that is saved as a separate file on the local computer. The separate file consists of a video of only one person. This has two implications. First, on the

[4] Please note, there are other parameters e.g., number of spoken words on group level or volume, which could still be analyzed. However, this analysis would lack the depth that MTV aims to provide.

[5] However, currently not every combination of resolution and FPS is possible. 60 FPS videos are only possible up to HD resolution (1280x720).

audio channel, there is only one speaker. This solves the speaker separation issue. Second, given that we use browser-based communication, most tools automatically adapt resolution given certain bandwidth. Guaranteeing fixed resolution and FPS is therefore complex. As the video is captured locally, the resolution and FPS stay constant - whereas the live video communication can vary slightly in resolution and FPS based on the network bandwidth. Therefore, this approach does not only solves the Cocktail Party Problem but further increases the quality of the video files.

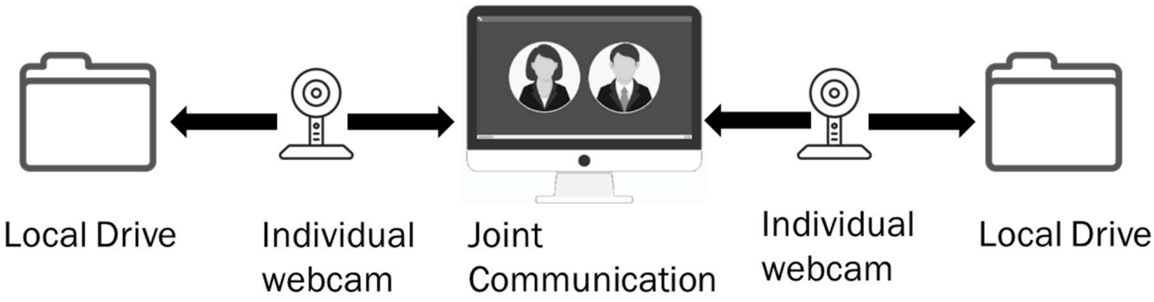

Figure 1. Structure of MTV during a two-person communication.

These individual audio files can now be transcribed using a variety of different voice-to-text AI models (e.g. Whisper, VOSK[6]). The quality of transcription does not depend on MTV but on the audio quality (e.g. used headphones, background noises) and the model itself. The transcription accuracy can vary between different languages. We provide one possible solution within our tool, yet stress that researchers could try different models and foremost should recheck the transcriptions manually[7]. Still, even if transcribing individual voices worked out well, there remains one issue. As an example, consider a simple Ultimatum Game where the sender and receiver communicated. Then, the experimenter would obtain two separate text files - one transcription for each participant. This makes it more difficult to read and analyze. However, MTV can merge the text files into one conversation. This works as follows. While transcribing the audio files, it is possible to time stamp each word. After the transcription files are merged, these timestamps can be used to sort the spoken words by time. Finally, this gives the experimenter a chat protocol of the spoken conversation. Please note that this is only possible if communication is synchronized. This issue, however, is solved within MTV, too. MTV only allows communication to start, after all participants joined the conversation. Otherwise, there is a waiting screen. From an experimental perspective, we consider this useful, as it avoids that some participants can start talking to each other before others have joined.

Summing up, consider again the example of a typical two-person Ultimatum Game with communication using MTV. Since MTV stores the joint and individual files, at the end of the experiment, the experimenter would obtain three video files, three audio files, and three texts.[8]

[6] VOSK: https://alphacephei.com/vosk/models ; Whisper: https://github.com/openai/whisper
[7] This implies that there still has to be a human involved. Yet, we argue that simply checking whether the transcription is accurate requires much less time than actually transcribing the discussion.
[8] In more general for a n-Person communication, MTV generates n+1 files (n individual files and 1 joint file).

Now, given that MTV can address most of the discussed problems, the fourth question remains: is it user-friendly? Strictly, we distinguish between three types of users: experimenters, laboratory managers, and participants. We consider the experimenters to be the central group and start with these. We discuss the usability for laboratory managers and participants afterwards.

A very important feature for experimenters is how they can create and manage communication. For this problem, MTV comes with a simple user interface (UI). This UI enables experimenters to create a room with a few simple clicks and provides a variety of different features. These include the name of the experiment, number of participants, duration of the meeting, resolution, frame rate, type of communication, and recording mode. This gives the experimenter enough freedom for the majority of research questions that are usually investigated in experimental economics. After the communication room is created, the experimenter receives a simple link that can now be implemented into the experiment. In o-Tree this will start a new browser tab and in z-Tree it will start a new browser window. Since the rooms can be reused, there is no need to change anything between the sessions. If the experimenters need several rooms for one session, they can create the desired number of rooms and implement those links in the experiment accordingly.

We now turn to laboratory managers as the second group of users. Laboratory managers would have to install MTV on their servers. MTV comes along with documentation that explains how to do so. In a nutshell, the installation is straightforward and the technical requirements for the laboratory are discussed in Section 4. Laboratory managers become administrators of MTV on their local server and guide the experimenters on how to register an account. MTV provides a simple registration procedure where the experimenters create their accounts using e-mail and password. After confirmation, the experimenter can log in and create their experiments. The laboratory manager as the administrator is permitted access to all accounts, enabling them to support novice experimenters.

Finally, we consider the participants as a user group. Participants see a waiting screen as long as the predetermined group size is not reached. The communication starts once every participant has joined the room. The tab can be closed automatically using zTree or oTree without the need of participants' engagement.

Altogether, MTV is easy to use for all three possible groups of users and yields the experimenters a standardized set of communication data that can be analyzed. This leads to the remaining question of whether the technological benchmark for the laboratories is sufficiently low.

4. Technical Requirements and License

In our discussion of the technical requirements of MTV, we focus on three parts: Meetings App (UI), Video App, and Transcription Utility. We stress that the requirements for the first ones are moderate yet can be high for the last ones. The next paragraphs shall discuss these issues in more detail.

First, the UI consists of an app created in Python with the Django framework. Both can be considered very common components and do not impose major challenges on a typical experimental laboratory. The same is true for the MySQL server used to store and retrieve the data. Second, the video app consists of an express js server created and ran using Node js, and an Openvidu instance running on a separate server to handle video streams. The Meetings App and the Video App connect to the same MySQL server to store and retrieve data.

Finally, the largest technical requirement comes from the transcription tool. The first step consists of a python module Pydub (FFMPEG) to convert video files to wav files. In the second step, it applies a predefined transcription model. These models, however, can impose more or less requirements. For instance, Whisper requires up to 10GB VRAM while a VOSK models requires up to 4.4 GB for the German language model. We stress, that researchers can implement the model of their choice. Finally, the script that puts the separate texts together depends on the filenames that are generated implying that these shall not be changed.

MTV is open-source, licensed under an adaptation of the MIT license[9]. We ask researchers to cite this paper when using MTV for academic or other publications. The source code for MTV can be downloaded for free from GitHub. Contributions and improvements to the source code are welcome and should be submitted using GitHub, too.

5. Limitations

As of the first published version (MTV 1.0), the tool has several limitations, which we will present in this chapter. It is our goal to improve on these. We refer to the GitHub project[10] for possible updates and pull requests.

While MTV supports resolution up to 3840x2160 and 60FPS it is currently not possible to combine both. Recording with 60 FPS is only possible for HD resolution and lower. Further, our approach to implement audio-only communication is improvable. Current implementation means, that participants communicate "as if" through video conference, yet only with black screens. This implies, that in the end there are no simple audio files but video files. However, MTV enables the experimenters to extract the audio channel from the video file.

The recordings are saved in WebM format. Compared to MP4, this format is less typical for the common user and can cause issues with some media players. In some of the common players, winding forwards and backward of the locally recorded videos does not work. However, we refer to a common player (i.e., Media Player Classic) which can operate with our files.

Further, it is more recommendable for the experimenter to watch the joint communication videos, which do not suffer from this issue. In addition, this issue does not matter for the automatic analysis as the algorithms analyze individual frames and no rewinding is required.

[9] https://github.com/MaXLab-OVGU/MeetingsApp

[10] https://github.com/MaXLab-OVGU/

However, using the WebM format has a few advantages, too. It is the standard format for browser-based communication. Since it is our future goal to upgrade the tool such that it can be used for online experiments, it is valuable to use such a widely spread format.

Still, the current solution works only within laboratories. The individual files have to be collected manually. Further, due to our solution to the Cocktail Party Problem, there is more demand for storage. However, our assessment is that storage will not become a major bottleneck for laboratories.

Finally, we stress again that the quality of the transcription does not depend on MTV but the actual model chosen. We highlight that whatever model is chosen, it has to produce time stamps, so MTV can merge the individual text files into one.

MTV is currently only tested using the Chrome Browser. We are aware that some browsers can cause certain types of problems with synchronization. We further strongly advice to set the configuration of the browser in such a way that the application of the web-cam does not need further acceptance from the user. Otherwise some participants join the conversation but cannot be seen by the others.

6. Conclusion

All in all, the goal of MTV is to enable experimenters to gather communication data from experiments with video-conferences in an integrated approach. The tool is easily implementable in z-Tree and oTree. It saves high-quality videos with respect to resolution and FPS. Further, applying a simple trick, it avoids the Cocktail Party Problem and enables a more sophisticated analysis of the voices. MTV comes along with a simple user interface for the experimenter and comparatively low technical requirements for the laboratory. The tool is open-source (citeware) and can easily be adapted on local servers of any laboratory. Doing so, enables researchers to keep subjects' data on private servers and strengthens local data protection regulations.

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Otto von Guericke University Magdeburg
Faculty of Economics and Management
P.O. Box 4120 | 39016 Magdeburg | Germany

Tel.: +49 (0) 3 91 / 67-1 85 84
Fax: +49 (0) 3 91 / 67-1 21 20

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