SPRAAKLAB: a mobile laboratory for collecting speech production data

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ABSTRACT

In this paper, we discuss the specifications of a mobile laboratory, dubbed SPRAAKLAB, and how we use it for acquiring research-grade acoustic and articulatory data in the field, thereby providing access to participant populations which are otherwise hard to study. In addition, we illustrate how the mobile laboratory supports public engagement activities in combination with research data acquisition, allowing us to entertain and inform an interested audience about speech research, while simultaneously collecting speech production data from dozens of participants in a matter of days.

Keywords: Mobile speech laboratory, large-scale data collection, public engagement.

1. INTRODUCTION

In two of the research lines in our lab, we focus on (1) investigating regional language variation and (2) investigating disordered speech (articulation). Both lines require collecting high-quality acoustic and articulatory research data in populations that are more difficult to reach than undergraduate university students. Unfortunately, university-based facilities for collecting acoustic and articulatory data are less convenient when the goal is to study populations (such as dialect speakers, elderly speakers, or individuals with a speech disorder) which are relatively dispersed and do not always live close to the university, nor have a particular reason to regularly visit one.

As collecting acoustic and articulatory data is very hard to do remotely, one option (see [5]) is to use portable acoustic and articulatory recording equipment to visit participants at their homes or a nearby location (e.g., [6]). However, there are two disadvantages to this. The first is that setting up and packing the equipment when leaving is rather involved, especially when using costly equipment with many components such as a portable electromagnetic articulograph (EMA; e.g., [3]). The second disadvantage is that the locations where the equipment may be set up are variable, which may affect the quality of the recordings. For example, usually there is no sound-dampened room, which often results in background noise being present in acoustic recordings. Consequently, data cannot be obtained in a controlled manner, thereby negatively affecting the quality of the acquired data.

In this paper, we illustrate how using a custom-made mobile laboratory alleviates both issues. In addition, we explain how it lowers the threshold for potential participants to participate and how it enables us to inform a broader audience about speech research.

2. MOBILE LABORATORY SPECIFICATIONS

After a successful funding request in the beginning of 2020, our university board provided us with a grant of €150,000 to purchase a custom-made mobile laboratory. We spent an additional €35,000 for all additional hardware and equipment inside (excluding our EMA and ultrasound systems). Our faculty board additionally committed to paying the variable costs of operating the mobile laboratory (i.e., the diesel fuel, insurance, road tax, roadside assistance, the alarm system subscription, and yearly maintenance costs) which are estimated at about €15,000 per year. We found a coach work company (Carrosserie Akkermans B.V. in Oud Gastel, the Netherlands; the chassis was made by Coxx Mobile Systems B.V. in Rijen, the Netherlands) that constructed the laboratory according to our specifications. The whole process from the initiation of the design until delivery of the vehicle lasted about nine months (April 2020 to January 2021).

2.1. Outside: dimensions, safety, power and design

The mobile laboratory (SPRAAKLAB: SPeech Recorded Acoustically And Kinematically LABoratory) was constructed on the basis of a custom-made chassis with air suspension attached to a Fiat Ducato 3.5T Heavy Chassis Cabin. The air suspension allows the chassis to be lowered to facilitate the entrance of people with reduced mobility. This is additionally aided by an extendable step and a security handrail. Stabilizer legs (manually extendable) allow the van to be stabilized when parked. The total dimensions of the mobile laboratory are 7 meters in length, 2.20 meters in width (2.75 meters including the mirrors of the cabin), and 2.95 meters in height. The length of the laboratory area itself is about 4.50 meters. The inside floor-to-ceiling height is about 2.10 meters, which is comfortable. The weight of the van is just below 3,500 kilograms,

which means that it can be driven with a regular EU class B driving license. A 360-degree bird-eye camera system, a digital rear-view mirror, a rear cross-traffic collision warning system (for detecting objects when driving in reverse), as well as a loud beeping noise clearly audible at the outside of the van while driving in reverse, were installed to help with safely navigating. The mobile laboratory is furthermore secured with a Class-5 alarm system with a vehicle tracking system.

The van obtains its electricity by plugging in its power cable in an available external power socket (rated 230V, 16A). A 50-meter extension cable is present to allow for flexibility in placing the mobile laboratory. For emergency power, a Honda EU22i generator is stored in the van. The (locked) storage area for the generator and extension cable is only accessible from the outside of the van and also contains two power sockets. These sockets can be used to plug in two cable extension reels (also stored in the storage area), each of which has multiple power sockets. When electricity is needed outside, a cable extension reel can be positioned outside where needed (usually close to the entrance of the mobile laboratory), while the connecting cable of the cable box can be guided below the van, through a closable hatch, into one of the power sockets in the storage area.

The outside design of the van (designed by the last author; see Figures 1 and 5) includes photos showing the different techniques we use for our research, which allow us to explain those techniques to a general audience. In the summer, a large awning above the door provides shade during public engagement activities in front of the van (see also Section 3.2).

Figure 1: The outside of SPRAAKLAB. See Figure 5 for a photo of the other side.

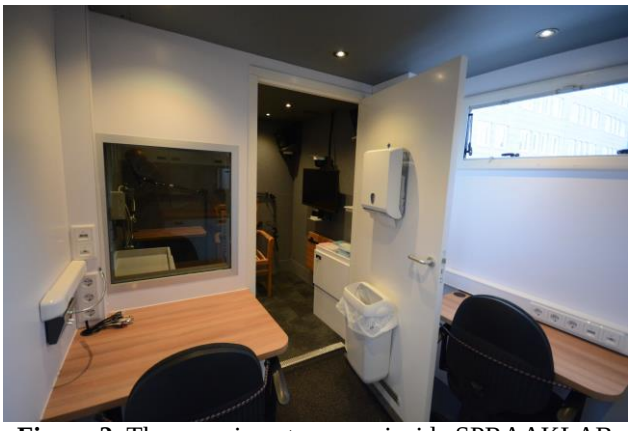

Figure 2: The experimenter room inside SPRAAKLAB (fixed desk on the left, foldable desk on the right).

2.2. Inside: laboratory rooms

SPRAAKLAB contains two separate rooms, separated by a (soundproof) door. In addition to a control room (of 2 x 2.50 meters) for at most two researchers, the mobile laboratory contains a separate sound-dampened (approx. -40 dB) room of about 1.90 x 1.90 meters. Since we use EMA for our data collection, bitumen (as opposed to metal) was used for sound-dampening the room. A (soundproof) window allows the researcher to look inside the sound-dampened room. While the setup of the mobile laboratory has been chosen to optimally support speech (articulation) research, it is flexible enough to also be suitable for running reaction time, eye-tracking and EEG experiments for up to two participants simultaneously.

2.3.1. Experimenter room

The experimenter room contains two desks (with multiple power plugs and UTP ports close by) to allow two researcher(s) to be present simultaneously (see Figure 2). One of the desks is fixed, and the other is foldable (but can be secured while driving). The desk chairs can be securely attached to the two desks. Below the fixed desk, a cupboard contains two small high-performance PCs from which all audio, video and articulatory recording equipment can be controlled. Sound recording equipment (sound cards and sound processors) is on top of the fixed desk and connected to the PCs below. A network attached storage (NAS) system with several terabytes of hard drive storage, connected to a 16-port switch and an uninterruptible power supply, provides a robust storage system for all acquired research data.

In addition, the experimenter room contains a small kitchen with a sink and a cold-water tap (see Figure 3), a small refrigerator (as the glue we use for EMA studies needs to be stored at a low temperature), a heater, an air-conditioning system, and a small

portable toilet for emergencies stored in a cupboard. In addition, an intercom system is available to communicate with the participant inside the sound-dampened room. Finally, there is a large number of cupboards available to store equipment and supplies. The lights in the room are dimmable.

Figure 3: The kitchen of the experimenter room inside SPRAAKLAB.

2.2.2. Sound-dampened room

The sound-dampened room (see Figure 4) contains two foldable desks (to allow for dyadic experiments) and two chairs, all of which can be secured while driving. A 32" computer monitor is attached to a flexible arm to optimally position it in front of participants of different heights (including children). There are three pan-tilt-zoom IP cameras, placed above and below the monitor, as well as in the outer top corner of the room. These cameras allow the researcher to observe (and optionally record) the participant during an experiment. The camera below the monitor is useful for checking the stability of an ultrasound probe, for example, whereas the camera above the monitor is useful for checking whether EMA sensors remain attached to the tongue throughout the duration of the experiment. The camera in the top corner provides a clear overview of the entire room and is useful for checking in on the participant(s) during the experiment.

In addition, the sound-dampened room contains two high-quality microphones (Sennheiser SE66) attached to flexible arms that can reach all places where participants can sit. Other microphones (such as headset microphones) can be attached to the flexible arms if necessary. One of the walls of the room has a shelf to which our NDI Vox-EMA field generator can be attached. The room furthermore contains ample power sockets and UTP sockets, a stereo speaker system, and two headphone connections, as well as cupboard space for the EMA and ultrasound tongue imaging (UTI) equipment. All equipment is connected to and can be controlled from the fixed desk in the experimenter room (using audio, video, and UTP cables guided through sound-isolated ports). The lights in the room are dimmable (controlled separately from the dimmable lights in the experimenter room).

Figure 4: The sound-dampened room inside SPRAAKLAB.

3. SPRAAKLAB USE

3.1. Bringing the laboratory to the participant

When investigating the speech articulation of (for example) people with Parkinson's disease, it is often more convenient for them if data can be collected at their homes. However, recording participants in their own homes may negatively affect the quality of the data as there is a great deal of variability in the environment where the data is recorded. Using SPRAAKLAB, we are now not only able to travel to the participants' homes but also able to collect high-quality research data due to the constant, optimal environment. Rather than bringing our recording equipment into the field [5], we now bring an entire laboratory *setting*. In doing so, we do not only improve the quality and consistency of the collected data, but the data collection itself is also more efficient, as the time needed to set up and store equipment is reduced to a minimum (about 15-20 minutes for even the most complicated experiments). In addition, the use of SPRAAKLAB significantly lowers the participation threshold for our participants, as they do not have to travel to us, nor do they have to host us at their home. A disadvantage of using the mobile laboratory is that researchers first need to get used to driving a vehicle of this size (to prevent damaging it while driving), and need sufficient training to be able to use all equipment inside before data collection can start.

3.2. Public engagement

Besides using SPRAAKLAB to collect research data, we also employ it to participate in public engagement

Figure 5: SPRAAKLAB during a public engagement activity in 2021.

events. For these events, usually organized during the summer, we place a few tables and chairs in front of the mobile laboratory, underneath the awning (see Figure 5). At the tables, we then set up various activities for children and adults to learn about their speech in general, and our speech research in particular. For example, we usually show people the movement of their tongue using UTI (and also give them a printout of the ultrasound image as a keepsake) while explaining the basics of speech motor control. We promote regional language appreciation and use by demonstrating an app for learning the regional language, and an app which can predict where someone is from on the basis of the dialectal variants they use (similar to [2]). We additionally provide a short speech quiz (on a tablet), and some puzzles. Finally, we explain the workings of the speech production system using a physical model of the vocal tract, and by generating vowel sounds using an electrolarynx in combination with a sliding vocal tract model [1].

3.3. Combining public engagement and data collection

During most events we visit with our mobile laboratory, we also collect experimental data in the sound-dampened room. Visitors to the events are usually very interested in participating in a relatively short experiment (lasting up to 20 minutes; while people are enthusiastic to participate, being recruited on the spot also means they usually have limited time available), despite us not providing a monetary reimbursement for their time. This approach allows us to collect high-quality data from a substantial number of people in a relatively short time span.

For example, in three days we collected formant perturbation data for 30 Dutch children in a very short (five-minute) experiment during *Zwarte Cross* [4], which is the largest music festival in the Netherlands. At the cultural festival *Noorderzon* in Groningen (the Netherlands), we collected UTI data (likewise in a five-minute experiment) on the production of liquids in a sample of 70 adult participants during only six days. Finally, at the *Festival della Scienza* in Genoa (Italy) in October 2022, we collected formant perturbation data in a 15-minute experiment for over 90 Italian native speakers in the span of a week. For all experiments, ethical approval is always obtained beforehand, and people (in the case of children: their parents) give informed consent before participating.

While collecting data at an outreach event does result in less data per participant than in a regular experimental setup, it has the benefit of not only attracting many participants but also ensuring that we are more likely to get a diverse group of participants regarding age and educational background.

4. CONCLUSION

In this paper, we have illustrated how we have literally "take[n] the laboratory into the field" [5]. Our approach using SPRAAKLAB has the benefit of being able to easily access hard-to-reach populations while maintaining a strictly controlled laboratory environment in which sophisticated experimental speech production techniques can be employed. A further advantage of having access to SPRAAKLAB is that it can be used for combining public engagement activities and data collection. In this way, we can collect sufficient research-grade data with minimal effort in a span of only a few days.

5. ACKNOWLEDGEMENTS

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