Challenge name	Innovative Audiometry
Challenge owner	Maastricht University Medical Center (MUMC+)
	ϒ Company x Research ϒ Student team
	Jerome Waterval, MD PhD Ear, nose & throat surgeon MUMC+
Brief summary	Since different pathology might cause hearing loss, the testing of people's hearing function – particularly in the case of conductive and sensorineural hearing loss – is difficult due to the physical characteristics of the skull and the head. To help people around the world with limited healthcare access, as well as small hospitals and hearing aid specialists, we aim to develop a mobile and semi-automated audiometry test facility for areas of need to provide basic audiometric care, but also as a screening tool at healthcare locations where staff is insufficiently trained.

About the challenge owner

We are actually not only one challenge owner, but a team of otologists and audiologists, represented by Jérôme Waterval (otologist) and Gijs Hoskam (audiologist, clinical physicst). We are a highly clinically oriented team with numerous patient contacts of patients with ear and hearing problems for doctor visits and hearing tests, varying from children who need ventilation tubes to deaf people who are implanted with cochlear implants.
We are based in the Maastricht University Medical Center at the polikliniek KNO and the Audiological Center.

Challenge description

This challenge is a follow-up of a 2020-2021 challenge. Students of this academic year are invited to elaborate this topic as it has shown to be relevant and worth developing to a higher level of implementation.

In most university departments hearing tests are performed by specially trained professionals. Hearing is tested by air conduction (headphones) and bone conduction (vibrating device on the bone behind the ears), as different pathology might cause the hearing loss. Conductive hearing loss is due to a problem in the ear canal or middle ear, whereas sensorineural hearing loss is caused by the cochlea, nerve or the brain. Testing is difficult in such cases due to the physical characteristics of the skull and the head. Noise can be used at the one side for masking purposes to test the other side.

However, this is a time consuming examination and much experience is necessary for reliable testing. A wrong technique can lead to a wrong diagnosis. In many hospitals these tests are performed by staff that are insufficiently trained, or – even worse – there is no money for the set-up that is needed for reliable testing.

What is the overall goal you aim to achieve?

We aim to develop a mobile and semi-automated audiometry test facility for areas of need to provide basic audiometric care, but also as a screening tool at healthcare locations where staff is insufficiently trained.

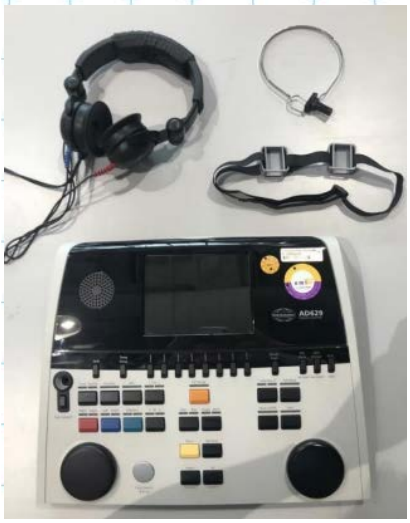
What are possible components you see fitting in the work of the project group?

- Testing the new set-up on patients (approval of the medical ethical committee has been obtained)
- Setting up an algorithm for automated audiometry
- Initiating the construction of a (webbased?) platform for (online) audiometry

Explain whether something already exists that students will build on.

Last year, one of the last-year-edition ISBEP students has developed an elastic headband entailing customised 3D-printed applicators for a bilateral bone conductor (see challenge picture, next page). Furthermore, a couple of healthy individuals have been tested with this set-up, with promising results.

Challenge Picture



Currently, three setups are needed to perform full audiometry: bone conduction (upper left) at the left and right side, air conduction (head phones upper left at the right image), and different positions of the air conduction to provide masking noise. This research aims to examine a simplified set-up which consists of a combination of regular headphones and an elastic band on which two bone transducers are fixed (lower left image). This would allow the examinator to only administer one steadier set-up instead of three. Performing the audiometry can also be automised using a mobile device (laptop) instead of the audiometer (device at the right image).

Input and involvement of challenge owner

Please indicate briefly what your involvement will be for the project group.

As we did last year, we are a highly interactive group. We have a specific vision and long-term goal with this challenge!

How would solving this challenge help your organization?

Not only our organization, but hearing aid specialists (audiciens), small hospitals and large parts of the world with limited healthcare access can potentially benefit from this type of application.

Resources

What resources are necessary for the students to work on the challenge?
Time, knowledge and patients with abnormal hearing are required at this stage.

What resources do you offer to students?

Expertise: audiological knowledge, hardware and software; patients who present at the department for hearing examination can be included.

ϒ *Materials; …*

ϒ *Workplace; …*

ϒ *Other; …*

Roles of different disciplines (only for ISBEP)

The table below describes what different disciplines of students could be doing. It is free for teams and individual students to define his/her own goals and outcomes. Please describe possible contributions you expect to see from as many disciplines as you see fit for this project.

(In the attachment you find an overview of the roles of students from different departments).

Automotive Technology	
Biomedical Engineering	
Architecture, Urbanism and Building Sciences	X
Computer Science and Engineering	The eventual goal is to perform automated hearing tests. An algorithm should be built, in order for the patient to undergo a hearing test without intervention of an audiologist. Ideally, a user-friendly interface is built.
Data Science	
Electrical Engineering	
Industrial Design	There is now a prototype device available. This device can be optimised.
Medical Sciences and Technology	All of the other descriptions apply for these students
Psychology and Technology	The difference between standard hearing tests and this innovative way of testing can be evaluated by the students. The psychological impact of hearing loss can also be assessed.
Chemical Engineering and Chemistry	
Software Science	The eventual goal is to perform automated hearing tests. An algorithm should be built, in order for the patient to undergo a hearing test without intervention of an audiologist. Ideally, a user-friendly interface is built.
Sustainable Innovation	
Industrial Engineering	
Applied Physics	
Applied Mathematics	
Web Science	The eventual goal is to perform automated hearing tests. An algorithm should be built, in order for the patient to undergo a hearing test without intervention of an audiologist. Ideally, a user-friendly interface is built.
Mechanical Engineering	

1. Huber, A.M., et al., *Evaluation of eardrum laser doppler interferometry as a diagnostic tool.* Laryngoscope, 2001. **111**(3): p. 501-7.
2. Murbe, D., et al., *Acoustic properties of different cartilage reconstruction techniques of the tympanic membrane.* Laryngoscope, 2002. **112**(10): p. 1769-76.
3. Kamrava, B., et al., *Preliminary Model for the Design of a Custom Middle Ear Prosthesis.* Otol Neurotol, 2017. **38**(6): p. 839-845.
4. Hirsch, J.D., R.L. Vincent, and D.J. Eisenman, *Surgical reconstruction of the ossicular chain with custom 3D printed ossicular prosthesis.* 3D Print Med, 2017. **3**(1): p. 7.