Bring the outside world into the clinic : Ecological assessment and rehabilitation of the hearing impaired







Faculté de médecine

Acknowledgements

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Ordre des orthophonistes et audiologistes du Québec





Hearing assessment





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Hearing assessment

Hearing care

(*m*) the Ordre professionnel des orthophonistes et audiologistes du Québec: assess the auditory, language, voice and speech functions, determine a treatment and intervention plan and ensure its implementation in order to improve or restore communication for a person in interaction with his environment;



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Human Development Model – Disability Creation Process (HDM-DCP) RIPPH 1998, Fougeyrollas 2010



Design an assessment procedure to measure communication improvement or restoration for a person in interaction with his environment.

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Assessment procedure

Which stimulus ?

Which condition ?

Which procedure ?

Which configuration?

Which stimulus ?

Digits

• . . .

- Non sense words
- Monosyllabic words
- Disyllabic words
- Matrix sentences
- Phonetically balanced sentences
- Common sentences



Which stimulus ?



Which stimulus ?



Which condition ?

Quiet

• . . .

- White noise
- Speech spectrum noise
- Multi-talker noise
- Everyday noises





- Adaptative
- +10 dB SNR
- + 5 dB SNR
- 0 dB SNR

• . . .



Which configuration?

- Signal at 0°
- Signal and noise at 0°
- Signal 0°, noise 45°
- Signal 0°, noise 90°
- Signal 0°, noise 180°
- Signal 0°, noise 360°
- Signal 360°, noise 360°







Human Development Model – Disability Creation Process (HDM-DCP) RIPPH 1998, Fougeyrollas 2010



In real life context

Which stimulus ?

- Pure sounds
- Syllabes
- Words
- Sentences
- Other

Which condition ?

- Quiet
- White noise
- Speech spectrum noise
- Multi-talker noise
- Everyday noises
- Other

Which procedure ?

- Adaptative
- +10 dB SNR
- + 5 dB SNR
- 0 dB SNR
- - X dB SNR
- Actual SNR

Which configuration?

- Signal at 0°
- Signal and noise at 0°
- Signal 0°, noise ± 45°
- Signal 0°, noise ± 90°
- Signal 0°, noise 180°
- Signal 0°, noise 360°
- Signal 360°, noise 360°
- Other

How to bring this everyday experience into the clinic?



Immersive Virtual Reality (VR) provides the opportunity for enhancing and modifying the learning experience of healthcare professionals through immersion in a non-real environment that closely mimics the real world.

Dalgarno, B., & Lee, M.J. (2010).

Thus, VR offers a unique opportunity to address hearing care under an ecological perspective.

Bergeron et al., (2022)

Source: Canada Western University's Brain and Mind Institute, 2019





Pilot studies



Bergeron et al., 2013

Pilot studies



Bergeron et al., 2013

Immersion 360 system

	Environment	Level (dBA peak)	Speech level (dBA peak)	S/N Ratio
THE	Car	72	76	+4
	Gymnasium	74	77	+3
	(ball game)	74		
	Gymnasium (race)	69	71	+2
	Cafeteria	64	69	+5
A A	Restaurant	68	73	+5
	Street traffic	70	73	+3
	Highway traffic	71	75	+4
	Garage	79	83	+4
	Kindergarten	77	83	+6

Psychometrics and norms

• Participants :

• 30 adults (18-30 years), hearing thresholds < 20 dB HL (250 - 8000 Hz), French speaking (15 French, 15 French-Canadian)

• Procedure:

- Two FrBio (French AzBio) lists of 20 sentences in quiet and in the 9 virtual environments
- Speech and noise levels set at the actual levels measured on the recording sites
- Presentation order of environments and FrBio lists randomly chosen
- All tests repeated one month later with half of the cohort (test-retest reliability)
- Score = percentage of correctly identified words

Psychometrics and norms

Participants spontaneously emphasized the realism of the simulated environments. *"With my eyes closed, I really feel that I am in a restaurant"*

	Quiet	Car	Street traffic	Garage	Gymnasium Race	Gymnasium Ball	Kinder- garten	Road traffic	Cafeteria	Restaurant
Mean	99,42	98,06	99,10	98,51	97,79	98,60	98,86	98,70	98,53	98,99
SD	0,61	2,37	0,81	1,80	2,45	1,99	1,07	1,28	1,36	0,88
	99,13	97,18	98,79	97,82	96,88	97,86	98,45	98,22	98,02	98,67
95% interval	99,70	98,95	99,41	99,19	98,71	99,34	99,27	99,17	99,04	99,32
p test-retest	0,91	0,19	0,89	0,62	0,09	0,03	0,19	0,31	0,85	0.37
SE	0,11	0,30	0,27	0,56	0,27	0,33	0,42	0,52	0,41	0,40

- Mean speech perception score = 97,8% to 99,4%
- Narrow standard deviation
- Standard Error < 1%
- Normal limits [95% conf interval] = 97,2% 100%

Averages and 95% confidence intervals for the FrBio administered to 28 hearing impaired French Canadian and French-French individuals in different test conditions (gray = quiet, red = speech noise, blue = multitalker noise, green = Immersion's environments).



















































HA-owner, n=673

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Efficacité des pré-traitements automatiques proposés par défaut par Cochlear avec les processeurs Nucleus 6 et 7 Marzin C, Piron JP



Figure (4): Graphique présentant les scores en pourcentage aux listes FrBio en fonction des conditions testées dans le bruit "Restaurant" avec le système i360°.



Cochlear Implant + CROS





Efficacy of the signal improving technologies for unilateral recipients of ABC Naida CI Q90 sound processor

Bergeron F, Agrawal S, Lemolton A, Demers D



40.00 30.00 20.00 10.00 0.00 non-Cl side non-Cl side Front Cl side 45 Cl side 90 90 45

Noise, CROS OFF Noise, CROS ON

UltraZoom Outcomes





Hearables are intended as a solution for situational hearing issues, especially in difficult listening situations.



Effectiveness of Hearables in Enhancing Speech Recognition in Normal-Hearing Individuals: First results. Sadi S, Beaulieu A, Boudreau M, Bergeron F, Hotton M



Poster 177



Speech recognition

Listening effort









<u>Hyperacusis</u>

When everyday sounds are too loud, annoying and painful

(Salvi, 1992)



A new individualized, ecological and immersive approach to measuring noise-related annoyance: feasibility study Pierre H. Bourez, Guillaume T. Vallet, Nathalie Gosselin, François Bergeron, and Philippe Fournier



FP2: Hearing assessment and hearing aids contributed talks session



Environments



Sound localization

Precision of sound source localization depends primarily on the type of sound source, the listener's familiarity with the source, and the type of acoustic environment

(Sacharine & Letowski, 2005)







Auditory training

To hear speech, we usually need to pick it out against background noise... Auditory training aims to improve the ability to filter out distractions.

(Ehrenfeld, 2021)







Environmental sound perception

Environmental sounds are a key component of the human experience as they carry meanings and contextual information, together with providing situational awareness. The experience of acoustic environments is related to security, well-being and quality of life.

Environmental sounds perception in a virtual space in cochlear implanted adults

Berland A, Bergeron F, Tremblay G, Beaumont I.



Virtual Reality: The Next Frontier of Audiology

The Hearing Journal, September 2017

Virtual Reality Technology Opens New Doors of (Spatial) Perception Audiology Online, July 2018

The Role of Virtual Reality in Hearing Instrument Hearing Review, 2006

Understanding Hearing Loss With Virtual Reality Sonus Hearing Care, 2018

Virtual Reality Experience Replicates Life as a Child With Hearing Loss The Shepherd Centre, 2018

Immersive education: virtual reality in clinical audiology University of Canterbury, 2012

Is virtual reality the future of vestibular rehabilitation? ENT & Audiology news, 2019

Conclusion

- It is possible, and highly desirable, to reliably reproduce everyday soundscapes experience in a clinical setting.
- Assessment and care of auditory perception, with or without technological hearing devices, can (should ?) be done ecologically in conditions similar to daily life.

Thank you !



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