CoDAS
ISSN 2317-1782 (Online version)

Brief Communications
Comunicações Breves

Virtual audiometer: technology integrated to teaching

Audiômetro virtual: tecnologia integrada ao ensino

Deuzimar Pires de Araújo[1]
Maria Eduarda Braga de Araújo[1]
Emille Rayanne Arruda Alves[2]
Juliana Maria Rodrigues Jales[2]
Eliene Silva Araújo[1,2]

Keywords

Educational Technology
Information Technology
Education
Teaching materials
Speech, Language and Hearing Sciences
Audiology
Audiometry
Hearing Tests

ABSTRACT

Purpose: To elaborate a virtual tool, with didactic purposes, that allows the integration of technology to the teaching of Pure Tone Audiometry (PTA) and speech audiometry. **Methods:** The Interacoustics AD229b audiometer was used as a physical model to achieve the virtual tool. The Visual Basic 6 programming language was used, so that the colors, characters, and functions were similar to the real audiometer. In addition, the possibility of simulating the patient's response was added, as well as of recording the hearing thresholds in a virtual audiogram. For speech audiometry, the possibility of adjusting the VU meter and recording the number of correct and incorrect answers were implemented. **Results:** The developed tool was able to reproduce frequencies from 125 Hz to 8000 Hz, in intensities ranging from -10 to 110 dB, being possible to use different stimulus, as well as clinical masking by air and bone conduction. The microphone button can be used to facilitate the teaching of speech audiometry. **Conclusion:** The virtual version of the audiometer is similar to the model equipment, making the integration of technology into teaching feasible, with exemplify the PTA and speech audiometry.

Descritores

Tecnologia Educacional
Tecnologia da Informação
Educação
Materiais de Ensino
Fonoaudiologia
Audiologia
Audiometria
Testes Auditivos

RESUMO

Objetivo: Elaborar uma ferramenta virtual, com fins didáticos, que possibilite a integração da tecnologia ao ensino da Audiometria Tonal Limiar (ATL) e logoaudiometria. **Método:** O audiômetro da marca *Interacoustics* AD229b foi utilizado como modelo físico para a consecução da ferramenta virtual. Utilizou-se a linguagem de programação *Visual Basic 6*, de modo que as cores, os caracteres e as funções fossem similares ao audiômetro real. Além disso, acrescentou-se a possibilidade de simular a resposta do paciente, como também de registrar os limiares auditivos em um audiograma virtualizado. Para a logoaudiometria, implementou-se a possibilidade de ajuste do "*VU meter*" e o registro da quantidade de acertos e erros no exame. **Resultados:** A ferramenta desenvolvida mostrou-se capaz de reproduzir as frequências de 125 a 8000 Hz, em intensidades que variam de -10 a 110 dB, sendo possível empregar diferentes formas de apresentação do estímulo, assim como o mascaramento clínico por condução aérea e óssea. A ativação da função "microfone" pode ser aplicada para facilitar o ensino da logoaudiometria. **Conclusão:** A versão virtualizada do audiômetro mostrou-se semelhante ao equipamento modelo, tornando factível a integração da tecnologia ao ensino, com exemplificação da ATL e da logoaudiometria.

Correspondence address:
Eliene Silva Araújo
Departamento de Fonoaudiologia e Programa Associado de Pós-Graduação em Fonoaudiologia – PPgFon, Universidade Federal do Rio Grande do Norte – UFRN
Rua General Cordeiro de Faria, S/N, Petrópolis, Natal (RN), Brasil, CEP: 59012-570
E-mail: eliene.araujo@ufrn.br

Received: August 31, 2020
Accepted: November 16, 2020

Study conducted at Universidade Federal do Rio Grande do Norte – UFRN - Natal (RN), Brasil.
[1] Programa Associado de Pós-Graduação em Fonoaudiologia – PPgFon, Universidade Federal do Rio Grande do Norte – UFRN - Natal (RN), Brasil.
[2] Departamento de Fonoaudiologia, Universidade Federal do Rio Grande do Norte – UFRN - Natal (RN), Brasil.
Financial support: CAPES - Código de Financiamento 001.
Conflict of interests: nothing to declare.

INTRODUCTION

In March 2020, the World Health Organization (WHO) declared the novel coronavirus (COVID-19) outbreak a pandemic. Since then, guidelines for the practice of social distancing have been issued in different locations in Brazil and around the world. Thus, teachers and educational institutions needed to adapt their didactic-pedagogical planning using technological tools to maintain their class teaching routines and remote activities in an interactive and advantageous way. In this context, permeated by technological advances, information, and communication technologies (ICTs) have been introduced in educational practices [(1)].

ICTs can be used as didactic tools to optimize the teaching and learning process, favoring the interaction of students among themselves, as well as with their teachers, stimulating moments of knowledge sharing [(2)].

The choice of tools used during in-person or remote classes should consider the content taught and the real needs of the students. Therefore, teachers need to be acquainted with the teaching resources available, learn how to use them, and question themselves how these resources could assist them in achieving their desired goals [(2)].

Even before the COVID-19 pandemic, technology-mediated educational objects were already aimed at enhancing motivation for learning and student engagement in classes, encouraging the posture of active, critical, autonomous, and reflective agents in the construction of knowledge [(3-7).]

The use of dynamic interventions, which are opposed to the non-participatory teaching model, assists in remembering contents, individually and collectively, as they require reflection on what was seen and facilitate memorization of concepts [(4,7).]

As for Speech-Language Pathology and Audiology, the use of active methodologies can improve the process of learning basic contents, as well as stimulate the practice of clinical reasoning, as they can simulate situations that undergraduates may face in their future professional practice [(7,8)]. Virtual resources have also been applied in the therapeutic process, as in the case of the prototype Q-Voz application, which was developed to help patients with dysphonia [(9)].

Two interactive teaching methods mediated by technology were successfully used for training in Orofacial Motricity: a computer model with 3D images and a 2D computer game in quiz format provided greater motivation compared with the traditional teaching model [(3).]

Previous studies have highlighted the importance of motivation in the learning process, especially when the concepts discussed are complex and thus require proactivity and personal commitment [(3,9)]. Regarding Audiology, a cybertutor assisted in learning the discipline Personal Sound Amplification Device (PSAD), improving student performance in the subject contents [(10).]

Despite the importance of integrating ICTs into didactic-pedagogical planning to optimize learning as well as into theoretical-practical reasoning, there are still few studies addressing the use of technological tools in Speech-Language Pathology and Audiology teaching [(11, 12)], especially cost-free tools with emphasis on audiological diagnosis.

Pure-tone Audiometry (PTA) and speech audiometry are part of the basic hearing assessment. They are extremely important and present complex teaching and learning procedures. A theoretical class on PTA becomes tedious and uninteresting, especially when there is restriction for handling the real audiometer.

Face-to-face class practices require difficult logistics, as there are usually fewer pieces of equipment compared with the number of students present. In addition, audiometers are expensive and fragile to be transported to the classroom. With the use of assistive computer technology in teaching, there is the possibility of creating interactive tools to be used during the classes, thus providing them with greater dynamism.

In this context, this study aimed at developing a virtual tool, with didactic purposes, which enables the integration of technology to the teaching of PTA and speech audiometry.

METHODS

The virtual audiometer was designed to optimize teaching focusing on undergraduate Speech-Language Pathology and Audiology students. Thus, the AD229b audiometer [Interacoustics], which is a common equipment in several clinical schools offering Speech-language Pathology courses, was selected as the physical model to implement this tool. This is the development of a virtual tool with waiver from the Research Ethics Committee, considering that it does not involve the participation of human beings as research subjects, as provided for in Resolution 466/2012, chapter II.

Visual Basic 6 (VB6) was the programming language used, but it was necessary to redesign the virtual tools functions to make them more similar to the buttons of the real equipment.

The display colors and characters were chosen in such a way as to be similar to the model audiometer buttons. The intensity selector switch function for both pure tone and masking was rotational, which hindered virtualization. This problem was solved by using a picture with the shape of the rotating key and two small signs at lower part: one on the left with the "-" sign to decrease the intensity, and another on the right with the "+" sign to increase the intensity.

A search for source codes made in VB6 available on the Internet was conducted aiming to create the sound stimuli, and which could generate waveforms that serve as examples in the presentation of pure tone at the frequencies and intensities required by the virtual audiometer.

The virtual tool was designed for installation on both desktop or notebook computers, compatible with Windows (tested versions: XP, Vista, 7, and 8) and Linux, installed inside the Wine application in compatibility mode, tested on ArchLinux, Debian, Ubuntu, and Mint distributions. It is worth noting that there were compatibility issues in Windows 10, and the tool did not work properly. Once installed, the tool can be used offline to exemplify the performance of PTA and speech audiometry procedures in different types, degrees, and configurations of hearing loss.

Throughout development, the virtual tool was analyzed and assessed by the research team in comparison with the selected physical model. The team was composed of an audiologist developer, a professor with a Ph.D. in Audiology, a graduate Speech-Language Pathology and Audiology student, and two undergraduate Speech-Language Pathology and Audiology students. The assessment was based on the following items: (1) Visual similarity: colors, buttons, size, location; (2) Functional similarity: stimuli, frequencies, intensities, masking, Vu-meter, activation of light indicator on the panel; (3) Usability and additional resources: audiogram, symbology, possibility of recording speech audiometry results, patient illustration, and representation of transducers, in addition to the possibility of patient response. To this end, responses were analyzed using a Likert scale [13] with five levels: strongly agree, agree, indifferent, disagree, strongly disagree. The final version of the tool was defined by obtaining unanimous appreciation with "strongly agree" or "agree" for all items.

RESULTS

The developed virtual audiometer was similar to the physical model in terms of aptitude and functionality (Figures 1 and 2). Modifications have been made since the first version based on suggestions by the research team in each assessed item.

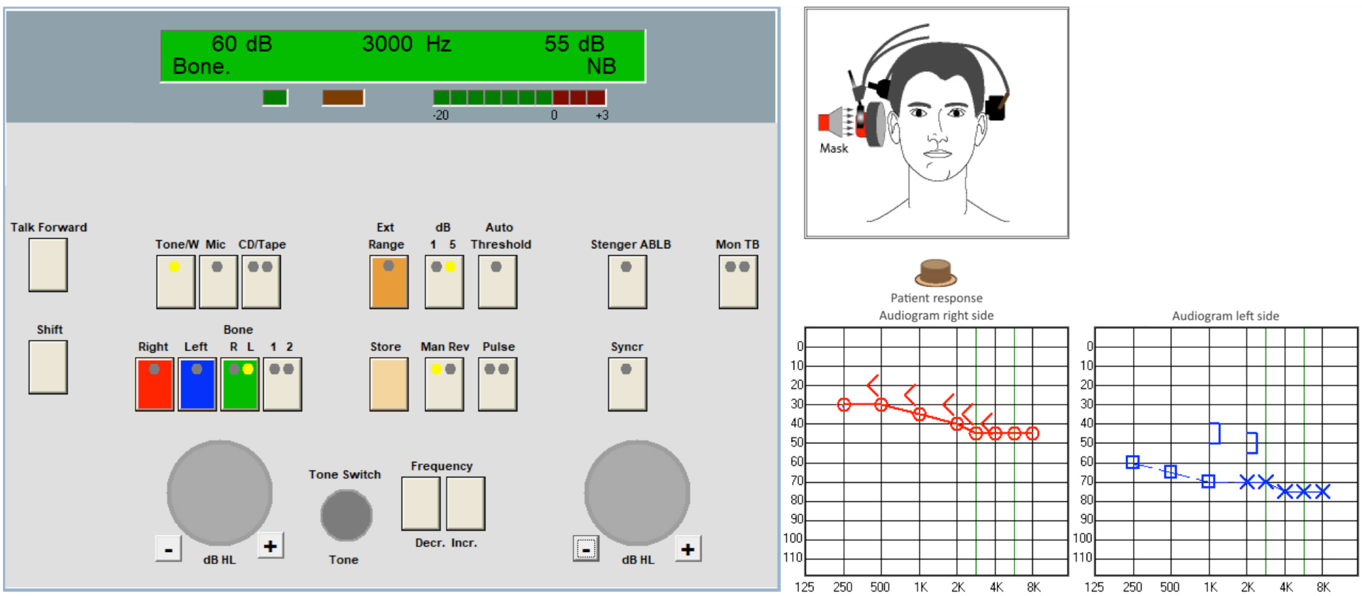

Figure 1. Virtual audiometer interface with representation of the bone conduction threshold survey using contralateral masking and annotation of hearing thresholds in the audiogram.

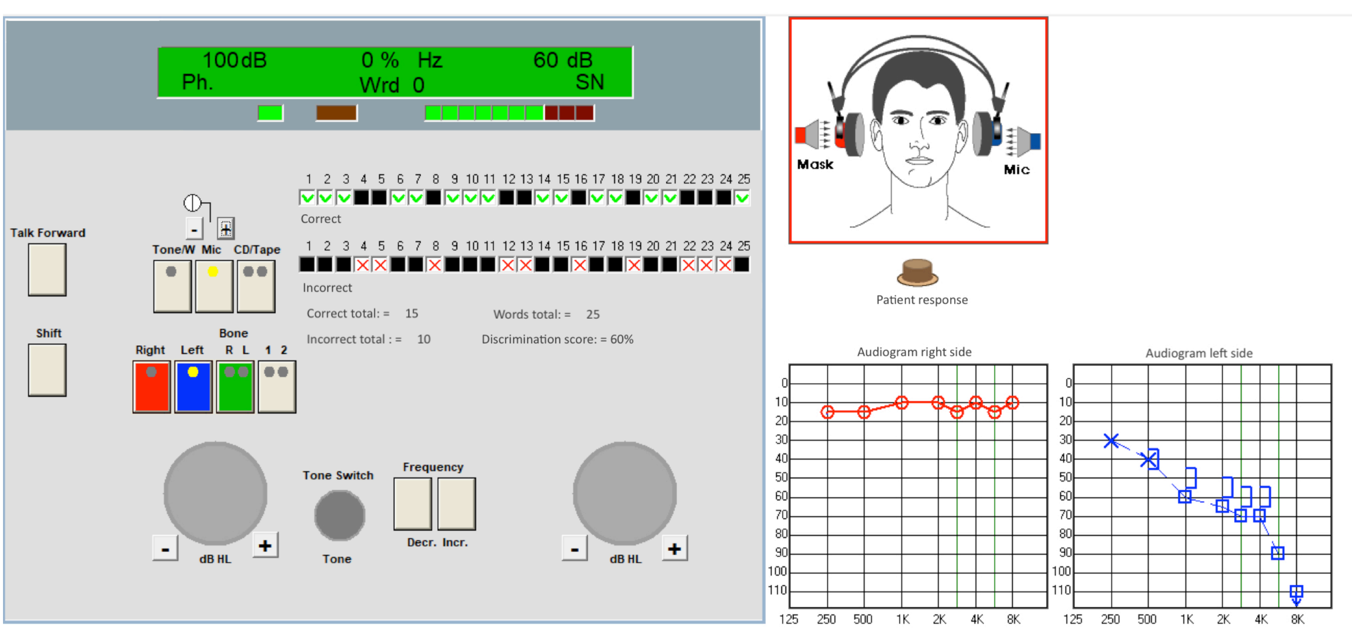

Figure 2. Virtual audiometer interface with representation of speech audiometry with the use of contralateral masking and annotation of hearing thresholds in the audiogram.

The first software displayed only one audiogram at a time, did not accept the marking of hearing thresholds below zero dB, and presented larger symbols that caused some visual pollution.

The device was programmed to reproduce pure tones at frequencies between 125 and 8000 Hz at intensities from -10dB to 110dB, and allowed the use continuous, pulsatile and warble pure tone stimuli by means of Man Rev and Pulse functions. In the final version, there is no precision between the frequencies generated by the program and the real audiometer; however, they maintain similarities in such a way that it is not possible to audibly identify such differences.

When starting the program, as in the real audiometer, the initial frequency is 1000 Hz, and the intensity is 30 dB. Another characteristic inherited from the AD229b is the intensity limit of 100 dB, and activation of the extended range feature is required to use higher intensities.

As the purpose of the tool is to provide a practical simulation of PTA and speech audiometry, the virtual audiometer enables activation of masking noise and selection of the ear to which the stimulus is directed. For noise, the stimulus produced is similar to the white noise of the real audiometer and, for didactic purposes, the virtual audiometer panel shows "SN" (speech noise) or "NB" (narrow band) when selecting the microphone and the pure tone, respectively.

In addition to the similarity of the frequency and intensity functions, the virtual tool offers the possibility for students to record the hearing thresholds in an audiogram shown on the virtual audiometer screen, with the appropriate symbology for air- and bone-conducted stimuli, with or without masking, so that the symbols are equivalent to the procedures performed and the color of the ear tested (Figures 1 and 2). Moreover, it is possible to note the present or absent thresholds.

The Frequency Decr. and Frequency Incr. functions are used to decrease and increase the frequency, respectively. The stimulus is shown through the Tone Switch function, with the possibility of intensity increments of 1 and 5 dB, with activation of the LED on the "dB 1 5" function, indicating the type of increment in effect.

The output function offers four possible configurations that determine how the stimuli, pure tone, and masking, will be presented: when activating the "Right" or "Left" functions, the contralateral noise will be activated for the opposite ear. The same is true for activating bone conduction using the "Bone" function.

Indication that the sound stimulus is being presented to the left or right ear was implemented through the illustration of a patient. Such illustration is visible on the examination screen, with the patient wearing a supra-aural earphone or bone vibrator, or even their combined use for researching bone conduction thresholds with masking (Figure 1).

When presenting pure tone and/or masking, signaling information in the stimulated ear appears in the patient's illustration, showing which stimulus is being presented to each ear (Figure 1).

The item "additional resources" also included the possibility of simulating the patient's response by activating the function that represents the "ear" of the real equipment. When this function is activated, a red signal light goes on the audiometer panel, indicating that the sound has been detected.

For audiometry, the virtual audiometer can be used to explain the performance of the test by voice, including the appropriate adjustment of the "VU Meter", intensity variation, and even the recording of responses (Figure 2). As in the physical model, the procedure is activated through the microphone key "Mic". Adjusting the "VU meter" regulates the intensity of the audiometer microphone, using the "+" and "-" buttons. Performance of the three tests that compose the speech audiometry can thus be exemplified: Speech Recognition Threshold (SRT), Speech Detection Threshold (SDT) and Speech Recognition Percentage Index (SRPI). As a differential, for the SRPI, a table with 25 dialog boxes appears on the screen of the audiometer so that the examiner can mark the correct and incorrect responses and, subsequently, calculate their percentages (Figure 2).

DISCUSSION

Considering that there were already logistical difficulties related to audiological practices and that the return to in-person activities after the pandemic will be gradual and with caution, the virtual audiometer can optimize the teaching and learning of techniques associated with PTA and speech audiometry, providing students with greater familiarity when in the presence of a physical audiometer.

Aiming to provide similarity, an initial screen resembling that of the model audiometer was created, and is capable of reproducing most of its functions, since the design and features of the virtual tool need to be thought according to their purpose [8,9].

As an example of the creation of the auxiliary prototype Q-Voz application [9], VB6 was the programming language used in the virtual audiometer.

A virtual audiometer developed in the United States of America [8] also allows the simulation of hearing tests, such as PTA and speech audiometry, including research on air- and bone-conducted stimuli, different transducers, and the use of clinical masking. It is presented in two versions: one for teachers and another for students. The virtual audiometer of the present study has a single version; however, this can be made available to students through the sharing of an installation link, enabling the practice of procedures and recording of audiometric thresholds.

Technological resources aimed at teaching and therapy can be developed as applications [9] or software [3,8]. The virtual tool described here corresponds to a program whose use requires prior installation on a desktop or notebook computer, which can be pointed out as a limitation of access when outside of classes in comparison with applications; however, students are able to install the software on their personal computers. In contrast, an advantage of the virtual audiometer compared with other technology-mediated educational objects [3] is the fact that, once installed, it does not require Internet connection.

Regarding remote teaching, in addition to having the option of providing the tool link, the teacher can use a screen-sharing feature during remote classes, which facilitates the explanation of examinations and visualization of mentioned examples.

In the context of face-to-face teaching, it is proposed that the program be installed on computers at the institution itself, as some students may have difficulty accessing a desktop or notebook computer outside the university.

Application of a tool considered innovative in the learning process lightens the feeling of constant evaluation [7]. Furthermore, enabling the use of this tool in extra class hours is important, as the ability to organize a study routine according to the students' availability and preference influences intrinsic motivation [3].

Considering the importance of motivation and reflection for the teaching and learning process [3,4,7,9], the virtual tool was designed to enable the simulation of different audiometric configurations, expressing different degrees of difficulty. Thus, it is up to the teacher to perceive the potential and difficulties of the class, providing examples that keep students motivated.

It should be noted that the purpose of the virtual audiometer is not to replace the clinical practice supervised by the teacher, as this is considered crucial for the training process. What is proposed is the use of the program as an additional resource for teaching, with the teacher as a mediator [3,9]. Therefore, it is suggested that the teacher and/or monitors of the discipline be available to clarify doubts associated with the handling of this tool and the execution of examinations.

When developing materials for teaching or for therapy, it is up to the developers to define whether it is going to be cost-free or commercialized [9]. A difference of the software version described in this study is that it is intended to make it available free of charge in order to expand its use and contribute to the training of undergraduate Speech-Language Pathology and Audiology students.

Student and teacher satisfaction with the use of this virtual tool will be assessed in future research. It is noteworthy that the results shown here are partial and are aimed mainly at presenting the developed tool.

The importance of developing additional virtual resources aimed at teaching in the various areas of Speech-Language Pathology and Audiology to enhance the teaching and learning process is highlighted.

CONCLUSION

The prepared virtual audiometer proved to be similar to the model equipment, being able to reproduce the frequency ranges, intensities, masking, form of stimuli presentation, and activation of the microphone function for performing speech audiometry. Thus, it represents a potential tool for improving the quality of audiology teaching both in the remote and in-person teaching scenarios.

REFERENCES

1. Costa CHC, Dantas FF Fo, Moita FMGSC. Marvinsketch e Kahoot como ferramentas no ensino de isomeria. HOLOS. 2017;1:31-43. http://dx.doi.org/10.15628/holos.2017.4733.
2. Machado FC, Lima MFWP. O uso da tecnologia educacional: um fazer pedagógico no cotidiano escolar. Sci. Cum Ind. 2017;5(2):44-50. http://dx.doi.org/10.18226/23185279.v5iss2p44.
3. Rondon-Melo S, Andrade CRF. Computer-assisted instruction in Speech-Language and Hearing Sciences: impact on motivation for learning about the Orofacial Myofunctional System. CoDAS. 2016;28(3):269-77. http://dx.doi.org/10.1590/2317-1782/20162015143. PMid:27305632.
4. Lee J, Lim C, Kim H. Development of an instructional design model for flipped learning in higher education. Educ Technol Res Dev. 2017;65(2):427-53. http://dx.doi.org/10.1007/s11423-016-9502-1.
5. Lee K. Everyone already has their community beyond the screen: reconceptualizing online learning and expanding boundaries. Educ Technol Res Dev. 2018;66(5):1255-68. http://dx.doi.org/10.1007/s11423-018-9613-y.
6. Melo ECA, Enders BC, Basto ML. Plataforma PEnsinar®: ferramenta de aprendizagem para o ensino do processo de enfermagem. Rev Bras Enferm. 2018;71(4):1613-21. PMid:30088620.
7. Silva K, Guedes-Granzotti RB, César CPHAR, Dornelas R Gaming as a teaching and learning tool in speech, language and hearing. RIAEE. 2018;13(1):78-88. http://dx.doi.org/10.21723/riaee.v13.n1.2018.8866.
8. Lopes AC, Jacob-Corteletti LCB, Abramides DVM, Berretin-Felix G, Lopes-Herrera SA, Ferrari DV. Audiômetro virtual: ensino por meio da simulação. São Paulo: Universidade de São Paulo; 2015.
9. Lavaissiéri P, Melo PED. Prototype app for voice therapy: a peer review. CoDAS. 2017;29(1):e20150300. PMid:28300955.
10. Blasca WQ, Maximino LP, Galdino DG, Campos K, Picolini MM. New educational technologies in audiology teaching. Rev CEFAC. 2010;12(6):1017-24. http://dx.doi.org/10.1590/S1516-18462010005000021.
11. Lieberth AK, Martin DR. The instructional effectiveness of a web-based audiometry simulator. J Am Acad Audiol. 2005;16(2):79-84. http://dx.doi.org/10.3766/jaaa.16.2.3. PMid:15807047.
12. Kompis M, Steffen P, Caversaccio M, Brugger U, Oesch I. A multilingual audiometer simulator software for training purposes. Acta Otolaryngol. 2012;132(4):428-33. http://dx.doi.org/10.3109/00016489.2011.636379. PMid:22235845.
13. Likert R. A technique for the measurement of attitudes. Arch Psych. 1932;140:1-55.

Author contributions

DPA and MEBA were responsible for the study design, interpretation of results, and writing of the manuscript; ERAA and JMRJ were responsible for the interpretation of results and writing of the manuscript; ESA was responsible for the study design, analysis and interpretation of results, conceptual review, and approval of the final version of the manuscript.