Reflection

Learning in Deaf Adults. The Importance of Understanding Deaf Culture in Contemporary Methods*

[English version]

El aprendizaje en adultos sordos. La importancia de la comprensión de la cultura sorda en los métodos contemporáneos

Aprendizagem em adultos surdos. A importância de compreender a cultura surda nos métodos contemporâneos

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Abstract

Objective: Learning is a constant process in human beings. This paper reviews the relationship between learning methods of deaf adults and the respect held for their culture in several countries of the world. **Methodology**: Scientific papers in Spanish and English over the last five years were reviewed. From 244 articles, 19 were chosen for their relevance to the research goal. **Results**: Results were grouped by topics of interest in deaf adult learning. Five neural methods were found, four validated in hearing people and tested in deaf adults, five serious games, three methods using technology, and two learning methods according to participants' cognitive abilities. **Conclusions**: Nineteen papers observed that there are professionals from all areas interested in this issue; in addition, there is a growing interest in learning about the deaf culture. There is a need to research further on the results of the methods in social and/or working contexts to improve the inclusion of this population.

Keywords: Learning method; adult learning; cultural minority; deaf; culture (obtained from the UNESCO thesaurus).

Resumen

Objetivo: el aprendizaje es un proceso constante en el ser humano. En este artículo se hace una reflexión sobre la relación entre los métodos que se han propuesto para el aprendizaje de los adultos sordos, y el respeto por su cultura en diversos países del mundo. **Metodología**: se revisaron textos científicos en los idiomas español e inglés de los últimos cinco años. En la búsqueda de información se localizaron 244 estudios, y 19 fueron seleccionados por su relevancia para el objetivo del estudio. **Resultados**: los resultados se agruparon por temas de interés respecto al aprendizaje de adultos sordos. Se encontraron cinco métodos neuronales, cuatro validados en población oyente probada en adultos sordos, cinco juegos serios, tres métodos que usan la tecnología, y dos de aprendizaje según las capacidades cognitivas de los participantes. **Conclusiones**: en los 19 escritos examinados se puede observar que en este proceso están interesados profesionales de todas las áreas de estudio; además de un creciente interés por el conocimiento de la cultura sorda. Es necesario enfatizar en la necesidad de continuar esta investigación, aplicando los resultados de los métodos en contextos sociales y/o laborales para mejorar la inclusión de la población.

Palabras clave: método de aprendizaje; aprendizaje de adultos; minoría cultural; sordo; cultura (obtenidos del tesauro UNESCO).

Resumo

Objetivo: a aprendizagem é um processo constante no ser humano. Neste artigo, reflete-se sobre a relação entre os métodos propostos para a aprendizagem de adultos surdos e o respeito por sua cultura em diversos países do mundo. **Metodologia**: foram revisados textos científicos nos idiomas espanhol e inglês dos últimos cinco anos. Na busca de informações, foram localizados 244 estudos, dos quais 19 foram selecionados por sua relevância para o objetivo do estudo. **Resultados**: os resultados foram agrupados por temas de interesse em relação à aprendizagem de adultos surdos. Encontraram-se cinco métodos neurais, quatro validados em população ouvinte testados em adultos surdos, cinco jogos sérios, três métodos que usam a tecnologia e dois de aprendizagem segundo as capacidades cognitivas dos participantes. **Conclusões**: nos 19 escritos examinados, observa-se o interesse de profissionais de todas as áreas de estudo nesse processo; além de um crescente interesse pelo conhecimento da cultura surda. É necessário enfatizar a necessidade de continuar essa pesquisa, aplicando os resultados dos métodos em contextos sociais e/ou laborais para melhorar a inclusão da população..

Palavras chaves: método de aprendizagem; aprendizagem de adultos; minoria cultural; surdo; cultura (obtidas do tesauro UNESCO).

Introduction

Currently, governments, charity organizations, and individuals spend high amounts of research funding on the development of latest treatments for deaf people (Saifan et al., 2018). However, and as expected, the research focuses on care, protection, and the ways deaf children learn. The research tests games to assess the attention level of deaf children (Kandemir & Kose, 2021), it analyzes the syntax and structure of information (Duncan & Lederberg, 2018), and identifies the differences in the development of deaf children (Hall et al., 2018). The influence of religion on the education of deaf children has even been determined (O'Connell, 2014), as well as the commitment of governments worldwide to the education and protection of this population (Khairuddin et al., 2018; Takala & Sume, 2018; Pfister, 2017; Suranata et al., 2017).

There are models that allow significant learning advances for deaf people, but due to the large quantities of information, which models are the most used and under what criteria they are effective is not clear (Hoffman et al., 2017; Rodrigues et al., 2022). Researchers have been interested in designing and testing digital platforms regarding learning in deaf adults (Pappas et al., 2018). Furthermore, researchers examined their reading comprehension practices using the translingual technique (Hoffman et al., 2017), and how it reduced access to auditory phonology and changed in visual attention during early deafness, leading to a unique neurocognitive profile for reading in deaf adults (Emmorey & Lee, 2021). Other researchers mapped the international scientific production related to music education for this population (Silva et al., 2020). Also, over the last two decades, they analyzed haptic sensory substitution technologies (Sorgini et al., 2018) and reviewed the technological innovations designed to favor people with complex communication needs (Smith, 2019).

Deaf Culture

Sensory hearing impairment (SHI) is characterized by significant limitations to hearing in a world oriented for the hearing (Malaia et al., 2020), even if the world does not decide to understand deaf culture, or the need for educational adjustments for this population to be involved productively into society (Lawyer et al., 2018).

The interest in studying deaf culture started toward the end of 20th century. The first references to this culture, according to Padden (1980) and Kyle and Woll (1985), were based on aesthetic descriptions of productions of this population and, from an anthropological approach regarding their daily lives.

Authors explain that "deaf culture" has been used as a broad term including sign language, collectivity and identity, deaf values and behavior, uses of technology by deaf people and deaf arts (Friedner & Kusters, 2020). The deaf community is also understood as having unique social, linguistic, and cultural needs (Kung et al., 2021), and is characterized by visual-gestural communication. Among contemporary disability models, the cultural model gains increasing strength and acceptance in the community of people with disabilities (CPD), especially by several theorists of deaf culture (Retief & Letšosa, 2018).

Learning forms of deaf adults became relevant when the World Health Organization (WHO) stated that there were approximately 466 million deaf people in the world; that is, 5% of the world population, 432 million adults (93%), and 34 million children (17%). It is warned that by 2050 one out of four people will have hearing problems (OMS, 2021). These results should be reflected not only in preventive measures, but also in designing communication and interaction between deaf and hearing people. Despite warning figures, there are few studies focused on the learning needs of deaf adults, which makes increasing knowledge related to the issue necessary (Bailey et al., 2021). Within the context of adult learning and deaf culture, five areas were identified based on literature review: 1) neural methods; 2) validations in hearing population tested in deaf adults, 3) serious games; 4) methods using technology; and 5) learning methods based on participants' cognitive abilities.

Methodology

According to Weiss (2003), the state of the knowledge is a long-range research technique. This technique favors "a systematic analysis and valuing knowledge regarding a field of research during a given period" (p. 4).

The methodology was a qualitative and interpretive documentary design. The selection of articles was carried out in two stages. First, the title and abstract, and the full text reading was used to define eligibility: original articles on quantitative and qualitative methodologies, cases and controls or mixed, papers related to the objectives and published between 2017 and 2023, in any language and with available abstract and full text. PubMed, Scopus and Web of Science were the browsers utilized.

In a bibliographic matrix, 19 papers were organized in Excel, analyzed and organized in Table 1 (see Annex). Only scientific articles were reviewed.

Categories emerged from reading and organizing the state of knowledge: neural methods, validated methods in hearing population tested in deaf adults, serious games, methods using technology, and learning methods based on participants' cognitive abilities.

Discussion and Results

Thematic axes were identified simultaneously with the emerging categories:

Research

Category 1: Use of Neural Methods

Four methods were grouped in this category.

1. Vibrotactile discrimination: the use of this technique showed that after a training period, quantitative measurements of electroencephalogram (EEG) registered unique neurophysiological patterns. The patterns are characterized by larger and more diffuse delta band magnitudes in deaf people. In addition, there is a general decrease in absolute power, which could mean a facilitation process linked to the learning process (Ruiz-Stovel et al., 2021).

2. Use of words/iconic signs: deaf adults find learning sign languages easier, because the signs are more rooted in a perceptive and motor experience. During the learning process, deaf adults show greater sensitivity to the visual characteristics of signs, and their phonological processing seems less automated. They focused on the more detailed phonetic properties of the signs (Malaia et al., 2020). In deaf people the upper temporal cortex (UTC) activates in response to visual stimuli revealing plausible neural pathways for auditory reorganization. In addition, correlations were observed between reorganized cortical area activations and developmental factors. They provide unique evidence to understanding the neuronal circuits involved in intermodal plasticity (Que et al., 2018).

3. Sequence memory task: The findings of this research indicate that the dorsal visuomotor neural system plays a role in verbal learning process through sign language facilitating connection with the conventional linguistic network of the left hemisphere (Kanazawa et al., 2017).

4. Socialization with another human being: according to the brain alterations found, a second language is a main requirement (Yusa et al., 2017).

Category 2: Use of Validated Methods in Hearing Population

1. Administration of Performance Validity Test (PVT): Memory Simulation Test (TOMM), a widely validated method in hearing populations was used to evaluate its effectiveness in deaf people communicating through sign language. The aim was to determine whether there were differences associated with use of semantic knowledge and remembrance of signs instead of spoken phonemes. The results showed that non-verbal intelligence of this population was within the average skill range. No participant scored under the standard cutoff score for the trial. These findings support the applicability of the same standard cutoff score established for hearing people in culturally deaf people using sign language (Chovaz et al., 2021).

2. Statistical Learning Mechanisms (SLM): Studies conducted with hearing people indicate that this technique supports the development of reading and writing skills (Giustolisi & Emmorey, 2018). Conducting similar research with an adapted version of the test in deaf people showed that humans can effectively develop sequencing skills, even in situations without sound.

3. Reading understanding practices using translingual techniques: Hoffman et al. (2017) identified seven key aspects: (a) family background/history; (b) communication/language; (c) education; (d) reading/historical experience; (e) bilingualism; (f) translation; and (g) professional/school experiences (in a translingual context), as key factors in language learning process in adults with hearing impairment.

4. Interactive dictionaries: TERC, Inc. conducted research at the Boston Museum of Science in 2017 to analyze the usefulness of a Dictionary of Science with Mobile Sign Language. The results showed that the visual features of these dictionaries make them valuable learning tools for deaf or hearing-impaired people who visit science museums. They provide users with effective access to the content of the exhibitions.

Category 3: Use of Serious Games with Specific Topics

1. Animation: high-quality videos with American sign language were created for administering math tests. They present one version with human interpreters and another with avatars. Deaf adults showed a remarkable preference for the first option, perhaps to higher expressiveness and fluency in human interpretation (Hansen et al., 2018).

2. Virtual Reality: to address the time processing difficulties encountered by deaf people when learning the "Code of Traffic," a program that exposes deaf adults to four driving scenarios (advancing, negotiating roundabouts, highways and intersections) was designed to ask them to make decisions regarding whether to proceed or not. There was better performance in animated condition compared to static as deaf participants made better decisions (Laurent et al., 2019).

3. In addition, Serious Games (SG) were introduced to bridge the communication gap between hearing and deaf people. It offers a tool to facilitate sign language learning for adults. Quantitative data support the effectiveness of SG in supporting the learning of a sign language. However, the qualitative data suggest possible improvements in SG design, on refining the movement in the environment, improving interactivity, and optimizing the game mechanics to a more memorable experience (Economou et al., 2020).

4. Interactive games: *MatLIBRAS Racing* is an educational game tested and evaluated to determine its impact on the process of learning of Brazilian sign language. In gameplay, all participants rated this variable as "good." They highlight the presence, participation, and fluidity promoted by the game during its execution. The graphical interface of the game

was rated as good for 89.5% of students while 10.5% rated it as "fair." The evaluation of the controller design with touch screen devices was positive; 97.4% of students rated it as suitable.

5. The level of difficulty of MatLIBRAS Racing was evaluated differently by participants: 65.8% rated it as "fair," 28.9% as "easy," and 5.3% as "weak." In addition, 89.5% of participants rated motivation to learn sign language thanks to MatLIBRAS Racing as "good." Most of the students (97.4%) recognized gaming as a "good" learning tool for sign language, although 2.6% disagreed. A total of 71.1% of students learned five or more signs, representing half of the total signs in the game (Paiva et al., 2020).

6. Artistic media: participants perceived the narration of life stories of deaf people as an educational process to obtain new knowledge regarding their lives through art. These specific learning modalities and participation in the creation of life stories of deaf people must be contextualized considering the barriers in education and society. This helps enrich the theoretical understanding of this approach, as an innovative biographical intervention that drives broad concepts and therapies, culturally sensitive and related to the well-being of deaf people (De Clerck, 2019).

Category 4: Use of Technologies

1. Movement Recognition: Professors at the Faculty of Engineering at Al-Azhar University in Cairo, Egypt, introduced a dynamic system to recognize Arabic sign language using Microsoft Kinect. After that, the Ada-Boosting technique was used to improve system recognition. The approach evaluated 42 medical-related Arab gestures, and the experimental results revealed recognition rates of 93.7% after applying Ada-Boosting (Hisham & Hamouda, 2019).

2. A year later, the same team of researchers introduced another Arabic Sign Language (ArSL) recognition system using a *Leap Motion Controller* and *Latte Panda*. Ada-Boosting technique was implemented to improve precision, followed by DTW (Dynamic Time Wrapping) technique compared to AdaBoost. The system was applied to 30 hand gestures

and included 20 one-handed and 10 two-handed gestures. Experimental results showed that DTW achieved an accuracy of 88% for one handed, and 86% for two-handed gestures. In general, the recognition rate of the proposed model reached 92.3% for one-handed, and 93% for two-handed gestures when applying Ada-Boosting. Finally, a prototype of the model was implemented on a single board (Latte Panda) to improve the reliability and mobility of the system (Hisham & Hamouda, 2021).

3. Performance and ease of use of a voice-to-sign translation assist device: the real-time performance assessment revealed that the inclusion of attention-based feedback led to a 16% reduction in translation error rates (measured by the sign error rate), and a 5.4% increase in the accuracy of translation (bilingual assessment), compared with a reference system without these real time features. The findings of usability indicated that the assist device was pleasant and satisfactory for deaf users (Otoom & Alzubaidi, 2018).

Category 5: Cognitive Analysis for the Development of Learning Methods

1. E-learning platforms: deaf adults still face social exclusion, especially as they experience difficulties during the transition from school to work. Thus, the cognitive characteristics of deaf adults, as well as their learning preferences, were examined to design innovative, easy-to-use e-learning platforms according to their educational needs. Participants preferred e-learning modules that maintain consistency in content, provide questions of understanding during sessions, and offer practical exercises at the end. In addition, participants expressed positive attitudes toward the incorporation of special graphics and explanatory videos (Pappas et al., 2018).

2. Phrase repetition test: Manual and non-manual aspects of sentences were examined to determine whether, and to what extent, they could be distinguished between three groups of deaf people using sign language, namely native, beginner, and late signing deaf people. Statistical analyses reveal that test scores based on the precise repetition of the manual gestures of each sentence, are significantly negatively correlated with the

age at which the signs were acquired. Incorporating accurate repetition of non-manual elements into the score is suggested to increase the reliability of the evaluation process (Sze et al., 2020).

Malaia et al. (2020) examined the neuronal responses of a group of deaf signers who learned sign language at different ages. The order of marked words was found to be negatively correlated with the age of acquisition of syntax and information structure, indicating that the older the learning age, the higher the cognitive load during this process. For this reason, the use of cognitive, technological methods or serious games are an interesting option for this population to socially interact (Glezer et al., 2018), and develop representations closed to the written word with its visual form.

These reasons support that the learning process of adult deaf people must have special characteristics, because reading demands a high possibility of errors in understanding the message, and a cognitive load expressed through procrastination and abandonment of the process. Understanding deaf culture improves the cognitive and emotional processes of deaf adults by allowing the individuals to feel more relaxed during interactions.

Challenges in early oral language acquisition in individuals with deep deafness and the impact of those challenges on cognitive neurodevelopment were also studied (Ruiz-Stovel et al., 2021). Studies concluded that portable technology can be very useful for all users, especially for deaf people. It helps them in their daily lives by reducing problems in effective communication with others (Tang et al., 2018). Other methods, such as observational learning, appear to be more suitable for learning in children than in deaf adults (Van de Weijer et al., 2019).

Learning techniques in deaf adults have a number of features that can be used in several educational contexts. The repetition technique is used for sign learning by Sze et al. (2020), and described by Silva et al. (2020) for learning melodies, as well as detailed by Pappas et al. (2018) for the cognitive assessment for the adjustment of learning technique. However, only Silva et al. show that family support during learning processes is crucial to achieving goals.

Sorgini et al. (2018) reviewed the literature on aptic assistance technologies for sensory hearing and vision impairments, and provided evidence that sensory replacement aids can mitigate deficits in learning of language, communication and movement of deaf, and blind and deaf people. They also showed that touching can be a means of communication for providing certain information to people with

sensory disabilities. Ruiz-Stovel et al. (2021) evaluated the temporal perception of stimuli (pure tones, trumpet sounds and vocal sounds) by means of vibration in deaf adults.

Smith (2019) aimed to determine the impact of technological innovations by evaluating the extent to which they improved social interaction. The author classified the innovation as: (a) Innovations in Communication Tools - Hardware; (b) Innovation in Input/Access Methods; and (c) Innovations in Voice Broadcasting Technologies. These innovations, developed by learning techniques used in this research, provide opportunities to support full participation of deaf people in society.

Conclusions

Over the last five years, the inclusion of technology has been very important in all aspects of life. Technology has been a constant through the use of avatars, digital platforms, virtual reality, animations, etc. However, for the achievement of the desired learning in each research study, interaction among human beings showed higher results, indicating that work should be done regarding raising the awareness of hearing people for the interest of communication with individuals in deaf cultures.

The categorization of methods provides significant knowledge regarding innovative and effective strategies in the education of adults with hearing loss. The exploration of e-learning platforms, adapted to the cognitive needs and learning preferences of deaf adults, highlights the importance of personalizing educational methods especially for this demographic group. The successful introduction of technologies such as Microsoft Kinect and Leap Motion Controller has proven to be a promising pathway that provides practical solutions for sign language recognition, and improves communication. Furthermore, a conscious attention to visual features and real-time spectator-based feedback has led to substantial improvements in accuracy and reduction of errors in sign language interpretation.

The reflection on the transition from education to work for deaf adults highlights the need to address social challenges and improve inclusion in professional environments. The detailed evaluation of learning preferences, assessment of cognitive skills, and implementation of results-oriented e-learning systems

highlight the importance of adapting pedagogical strategies to optimize learning and skills development.

This project enriched the understanding of educational needs of deaf adults, and also provided practical and technological approaches to significantly improve their learning experiences. This path to contemporary methods and adaptive technologies lays the foundations for a more inclusive and effective educational future for the deaf community.

Understanding the identity, customs and communication methods of deaf people allows for better interaction. The use of signs makes deaf people feel respected, and facilitates learning of academic and/or work tasks.

Limitations

No comparative articles were chosen between hearing and deaf learning modes that did not provide solutions.

Recommendations for Further Research

Neural methods provide results applied to objects, machines, tools and spaces that facilitate the process of working and social inclusion of deaf culture individuals.

References

Bailey, N., Kaarto, P., Burkey, J., Bright, D., & Sohn, M. (2021). Evaluation of an American Sign Language Co-Curricular Training for Pharmacy Students. *Currents in Pharmacy Teaching and Learning*, *13*(1), 68-72. https://doi.org/10.1016/j.cptl.2020.08.002

Chovaz, C., Rennison, V., & Chorostecki, D. (2021). The Validity of the Test of Memory Malingering (TOMM) with Deaf Individuals. *The Clinical Neuropsychologist*, *35*(3), 597-614. https://doi.org/10.1080/13854046.2019.1696408

De Clerck, A. (2019). Creative Biographical Responses to Epistemological and Methodological Challenges in Generating a Deaf Life Story Telling Instrument. *Contemporary Social Science*, *14*(3-4), 475-499. https://doi.org/10.1080/21582041.2018.1448940

Duncan, M., & Lederberg, A. (2018). Relations Between Teacher Talk Characteristics and Child Language in Spoken-Language Deaf and Hard-of-Hearing Classrooms. *Journal of Speech, Language, and Hearing Research*, *61*(12), 2977-2995. https://doi.org/10.1044/2018_JSLHR-L-17-0475

Economou, D., Gonzalez Russi, M., Doumanis, I., Mentzelopoulos, M., Bouki, V., & Ferguson, J. (2020). Using Serious Games for Learning British Sign Language Combining Video, Enhanced Interactivity, and VR Technology. *Journal of Universal Computer Science*, *26*(8), 996-1016. https://lib.jucs.org/article/24100/

Emmorey, K., & Lee, B. (2021). Teaching & Learning Guide for: The Neurocognitive Basis of Skilled Reading in Prelingually and Profoundly Deaf Adults. *Language and Linguistics Compass*, *15*(4), 1-7. https://doi.org/10.1111/lnc3.12410

Friedner, M., & Kusters, A. (2020). Deaf Anthropology. *Annual Review of Anthropology*, *49*(2), 31-47. https://doi.org/10.1146/annurev-anthro-010220-034545

Giustolisi, B., & Emmorey, K. (2018). Visual Statistical Learning with Stimuli Presented Sequentially Across Space and Time in Deaf and Hearing Adults. *Cognitive Science*, *42*(8), 3177-3190. https://doi.org/10.1111/cogs.12691

Glezer, L., Weisberg, J., O'Grady, C., McCullough, S., Midgley, K., Holcomb, P., & Emmorey, K. (2018). Orthographic and Phonological Selectivity Across the Reading System in Deaf Skilled Readers. *Neuropsychologia*, *117*, 500-512. https://doi.org/10.1016/j.neuropsychologia.2018.07.010

Hall, W., Smith, S., Sutter, E., DeWindt, L., & Dye, T. (2018). Considering Parental Hearing Status as a Social Determinant of Deaf Population Health: Insights from Experiences of the "Dinner Table Syndrome". *PLOS ONE*, *13*(9), 1-8. https://doi.org/10.1371/journal.pone.0202169

Hansen, E., Loew, R., Laitusis, C., Kushalnagar, P., Pagliaro, C., & Kurz, C. (2018). Usability of American Sign Language Videos for Presenting Mathematics

Assessment Content. *Journal of Deaf Studies and Deaf Education*, *23*(3), 284-294 https://academic.oup.com/jdsde/article/23/3/284/4969363

Hisham, B., & Hamouda, A. (2019). Supervised Learning Classifiers for Arabic Gestures Recognition Using Kinect V2. *SN Applied Sciences*, *1*, 1-21. https://doi.org/10.1007/s42452-019-0771-2

Hisham, B., & Hamouda, A. (2021). Arabic Sign Language Recognition Using Ada-Boosting Based on a Leap Motion Controller. *Int. j. inf. tecnol.*, *13*, 1221–1234. https://doi.org/10.1007/s41870-020-00518-5

Hoffman, D., Wolsey, J., Andrews, J., & Clark, D. (2017). Translanguaging Supports Reading with Deaf Adult Bilinguals: A Qualitative Approach. *The Qualitative Report*, *22*(7), 1925-1944. https://doi.org/10.46743/2160-3715/2017.2760

Kanazawa, Y., Nakamura, K., Ishii, T., Aso, T., Yamazaki, H., & Omori, K. (2017). Phonological Memory in Sign Language Relies on the Visuomotor Neural System Outside the Left Hemisphere Language Network. *PLOS ONE*, *13(*9), 1-15. https://doi.org/10.1371/journal.pone.0177599

Kandemir, H., & Kose, H. (2021). Development of Adaptive Human–Computer Interaction Games to Evaluate Attention. *Robotica*, *40*(1), 56-76. https://doi.org/10.1017/S0263574721000370

Khairuddin, K., Miles, S., & McCracken, W. (2018). Deaf Learners' Experiences in Malaysian Schools: Access, Equality and Communication. *Social Inclusion*, *6*(2), 46-55. https://doi.org/10.17645/si.v6i2.1345

Kung, M., Lozano, A., Covas, V., Rivera-González, L., Hernández-Blanco, Y., Diaz-Algorri, Y., & Chinapen, S. (2021). Assessing Medical Students' Knowledge of the Deaf Culture and Community in Puerto Rico: A Descriptive Study. *Journal of Medical Education and Curricular Development*, *8*, 1-5. https://doi.org/10.1177/2382120521992326

Kyle, J. & Woll, B. (1985). *Sign Language: The Study of Deaf People d their Language*. Cambridge.

Laurent, S., Boucheix, J., Argon, S., Hidalgo-Muñoz, A., & Paire-Ficout, L. (2019). Can Animation Compensate for Temporal Processing Difficulties in Deaf

People? *Appl Cognit Psychol*, *34*(2), 308-317. https://doi.org/10.1002/acp.3617

Lawyer, G., de García, B. G., & Karnopp, L. (2018). Deaf Education and Deaf Culture: Lessons from Latin America. *American Annals of the Deaf*, *162*(5), 486–488. https://doi.org/10.1353/aad.2018.0006

Malaia, E., Krebs, J., Roehm, D., & Wilbur, R. (2020). Age of Acquisition Effects Differ Across Linguistic Domains in Sign Language: EEG Evidence. *Neuropsychologia*, *200*, 1-10. https://doi.org/10.1016/j.bandl.2019.104708

O'Connell, N. (2014). "Confessing to Wilful Disobedience": An Ethnographic Study of Deaf People's Experience of Catholic Religious Schooling in the Republic of Ireland. *British Journal of Religious Education*, *33*(3), 229-247. https://doi.org/10.1080/03323315.2014.940683

Organización Mundial de la Salud [OMS]. (2 de marzo de 2021). *La OMS advierte que, según las previsiones, una de cada cuatro personas presentará problemas auditivos en 2050.* https://www.who.int/es/news/item/02-03-2021-who-1-in-4-people-projected-to-have-hearing-problems-by-2050

Otoom, M., & Alzubaidi, M. (2018). Ambient Intelligence Framework for Real-Time Speech-to-Sign Translation. *Assistive Technology*, *30*(3), 119-132. https://doi.org/10.1080/10400435.2016.1268218

Padden, C. (1980). The Deaf Community and the Culture of Deaf People. In C. Baker, & R. Pattison (Eds.) *Sign Language and the Deaf Community* (pp. 89-103). Silver Spring: National Association of the Deaf.

Paiva, H., Furlan, J., & Pinheiro, P. (2020). An Educational Game to teach Numbers in Brazilian Sign Language while having Fun. *Neuropsychologia*, *107*, 1-51. https://doi.org/10.1016/j.chb.2018.12.003

Pappas, M., Demertzi, E., Papagerasimou, Y., Koukianakis, L., Kouremenos, D., Loukidis, I., & Drigas, A. (2018). E-Learning for Deaf Adults from a User-Centered Perspective. *Education Sciences*, *8*(4), 1-15. https://doi.org/10.3390/educsci8040206

Pfister, A. (2017). Forbidden Signs: Deafness and Language Socialization in Mexico City. *ETHOS*, *45*(1), 139–161. https://doi.org/10.1111/etho.12151

Que, M., Jiang, X., Yi, C., Gui, P., Jiang, Y., Zhou, Y., & Wang, L. (2018). Language and Sensory Neural Plasticity in the Superior Temporal Cortex of the Deaf. *Neural Plasticity*, *2018*, 1-18. https://doi.org/10.1155/2018/9456891

Retief, M. & Letšosa, R. (2018). "Models of Disability: A Brief Overview," *HTS Teologiese Studies/ Theological Studies*, *74*(1), 1-8. https://doi.org/10.4102/hts.v74i1.4738

Rodrigues, F., Rato, J., Mineiro, A., & Holmström, I. (2022). Unveiling Teachers' Beliefs on Visual Cognition and Learning Styles of Deaf and Hard of Hearing Students: A Portuguese-Swedish Study. *PLOS ONE*, *13(*9), 1-20. https://doi.org/10.1371/journal.pone.0263216

Ruiz-Stovel, V., González-Garrido, A., Gómez-Velázquez, F., Alvarado-Rodríguez, F. J., & Gallardo-Moreno, G. (2021). Quantitative EEG Measures in Profoundly Deaf and Normal Hearing Individuals while Performing a Vibrotactile Temporal Discrimination Task. *Neuropsychologia*, *166*, 71-82. https://doi.org/10.1016/j.ijpsycho.2021.05.007

Saifan, R., Dweik, W., & Abdel-Majeed, M. (2018). A Machine Learning Based Deaf Assistance Digital System. *Comput Appl Eng Educ*, *26*(4), 1008-1019. https://doi.org/10.1002/cae.21952

Silva, N., Alves, J., Castro, A., & Varela, J. (2020). Music Education for the Deaf: Characteristics, Barriers and Successful Practices. *Educação e Pesquisa*, 46, 1-17. https://doi.org/10.1590/S1678-4634202046221995

Smith, M. (2019). Innovations for Supporting Communication: Opportunities and Challenges for People with Complex Communication Needs. *Folia Phoniatrica et Logopaedica*, *71*(4), 156–167. https://doi.org/10.1159/000496729

Sorgini, F., Caliò, R., Chiara, M., & Oddo, C. (2018). Haptic-Assistive Technologies for Audition and Vision Sensory Disabilities. *Disability and Rehabilitation: Assistive Technology*, *30*(3), 394-421. https://doi.org/10.1080/17483107.2017.1385100

Suranata, K., Atmoko, A., Bolo Rangka, I., & Ifdil, I. (2017). Risks and Resilience of Students with Hearing Impairment in An Inclusive School at Bengkala, Bali, Indonesia. *Special Education*, *2*(37), 165-214. https://doi.org/10.15388/SE.2017.4

Sze, F., Xiao Wei, M., & Lam, D. (2020). Development of the Hong Kong Sign Language Sentence Repetition Test. Journal of Deaf Studies and Deaf Education, *23*(3), 298–317 https://doi.org/10.1093/deafed/enaa001

Takala, M., & Sume, H. (2018). Hearing-Impaired Pupils in Mainstream Education in Finland: Teachers' Experiences of Inclusion and Support. *European Journal of Special Needs Education*, *33*(1), 134-147. https://doi.org/10.1080/08856257.2017.1306965

Tang, J., Cheng, H., Zhao, Y., & Guo, H. (2018). Structured Dynamic Time Warping for Continuous Hand Trajectory Gesture Recognition. *Pattern Recognition*, *80*, 21-31. https://doi.org/10.1016/j.patcog.2018.02.011

Van de Weijer, J., Åkerlund, V., Johansson, V., & Sahlén, B. (2019). Writing Intervention in University Students with Normal Hearing and in Those with Hearing Impairment: Can Observational Learning Improve Argumentative Text Writing? *Logopedics Phoniatrics Vocology*, *44*(3), 115-123. https://doi.org/10.1080/14015439.2017.1418427

Vesel, J., & Robillard, T. (2017). Accessing Science Museum Exhibits with Interactive Signing Dictionaries. *Journal of Visual Literacy*, *36*(3-4), 125-141. https://doi.org/10.1080/1051144X.2017.1397310

Weiss, E. (2003). *La investigación educativa en México 1992-2002*. Grupo Ideograma Editores.

Yusa, N., Kim, J., Koizumi, M., Sugiura, M., & Kawashima, R. (2017). Social Interaction Affects Neural Outcomes of Sign Language Learning as a Foreign Language in Adults. *Frontiers in Human Neuroscience*, *11*, 1-11. https://doi.org/10.3389/fnhum.2017.00115

Annex

Table 1. *List of Texts Consulted in the State of the Knowledge.*

Author	Title	Year	Location
(Ruiz-Stovel, González-Garrido, Gómez-Velázquez, Alvarado-Rodríguez, & Gallardo-Moreno)	Quantitative EEG Measures in Profoundly Deaf and Normal Hearing Individuals while Performing a Vibrotactile Temporal Discrimination Task	2021	https://www.sciencedirect.com/science/article/abs/pii/S0167876021001653
(Laurent, Boucheix, Argon, Hidalgo-Muñoz, & Paire-Ficout)	Can Animation Compensate for Temporal Processing Difficulties in Deaf People?	2019	https://onlinelibrary.wiley.com/doi/abs/10.1002/acp.3617
(Economou , et al.)	Using Serious Games for Learning British Sign Language Combining Video, Enhanced Interactivity, and VR Technology.	2020	https://www.researchgate.net/publication/354596022_Using_Serious_Games_for_Learning_British_Sign_Language_Combining_Video_Enhanced_Interactivity_and_VR_Technology
(Hisham & Hamouda)	Arabic Sign Language Recognition Using Ada-Boosting Based on a Leap Motion Controller	2021	https://link.springer.com/article/10.1007/s41870-020-00518-5
(Pappas, et al.)	E-Learning for Deaf Adults from a User-Centered Perspective	2018	https://www.researchgate.net/publication/329220758_E-Learning_for_Deaf_Adults_from_a_User-Centered_Perspective
(Paiva, Furlan, & Pinheiro)	An Educational Game to teach Numbers in Brazilian Sign Language while having Fun	2020	https://www.sciencedirect.com/science/article/abs/pii/S0747563218305892

Author	Title	Year	Location
(Sze, Xiao Wei, & Lam)	Development of the Hong Kong Sign Language Sentence Repetition Test	2020	https://pubmed.ncbi.nlm.nih.gov/32427328/
(Chovaz, Rennison, & Chorostecki)	The Validity of the Test of Memory Malingering (TOMM) with Deaf Individuals.	2021	https://pubmed.ncbi.nlm.nih.gov/31797722/
(Malaia, Krebs, Roehm, & Wilbur)	Age of Acquisition Effects Differ Across Linguistic Domains in Sign Language: EEG Evidence	2020	https://pubmed.ncbi.nlm.nih.gov/31698097/
(De Clerck)	Creative Biographical Responses to Epistemological and Methodological Challenges in Generating a Deaf Life Story Telling Instrument	2019	https://www.researchgate.net/publication/323803834_Creative_biographical_responses_to_epistemological_and_methodological_challenges_in_generating_a_deaf_life_story_telling_instrument
(Hisham & Hamouda)	Supervised Learning Classifiers for Arabic Gestures Recognition Using Kinect V2	2019	https://link.springer.com/article/10.1007/s42452-019-0771-2
(Giustolisi & Emmorey)	Visual Statistical Learning with Stimuli Presented Sequentially Across Space and Time in Deaf and Hearing Adults.	2018	https://onlinelibrary.wiley.com/doi/full/10.1111/cogs.12691
(Hansen, et al.)	Usability of American Sign Language Videos for Presenting Mathematics Assessment Content	2018	https://pubmed.ncbi.nlm.nih.gov/29659894/
(Otoom & Alzubaidi)	Ambient Intelligence Framework for Real-Time Speech-to-Sign Translation.	2018	https://pubmed.ncbi.nlm.nih.gov/28152342/

Author	Title	Year	Location
(Que, et al.)	Language and Sensory Neural Plasticity in the Superior Temporal Cortex of the Deaf	2018	https://pubmed.ncbi.nlm.nih.gov/29853853/
(Vesel & Robillard)	Accessing Science Museum Exhibits with Interactive Signing Dictionaries	2017	https://www.tandfonline.com/doi/abs/10.1080/1051144X.2017.1397310
(Kanazawa, et al., 2017)	Phonological Memory in Sign Language Relies on the Visuomotor Neural System Outside the Left Hemisphere Language Network.	2017	https://pubmed.ncbi.nlm.nih.gov/28931014/
(Hoffman, Wolsey, Andrews, & Clark)	Translanguaging Supports Reading with Deaf Adult Bilinguals: A Qualitative Approach	2017	https://nsuworks.nova.edu/tqr/vol22/iss7/12/
(Yusa, Kim, Koizumi, Sugiura, & Kawashima)	Social Interaction Affects Neural Outcomes of Sign Language Learning As a Foreign Language in Adults	2017	https://pubmed.ncbi.nlm.nih.gov/28408872/