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Role and Scope Coverage of Speech-Related Professionals Linked to Neuro-Advancements within the Academic Literature and Canadian Newspapers

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Abstract: Speech-related professionals such as speech language pathologists (SLPs) and audiologists make use of neuro-advancements including neurotechnologies such as cochlear implants (CIs), brain-computer interfaces, and deep brain stimulation. Speech-related professionals could occupy many roles in relation to their interaction with neuro-advancements reflecting the roles expected of them by their professional organizations. These roles include: service provider, promoter of neuro-products such as CIs, educator of others, neuro-related knowledge producer and researcher, advocates for their fields and their clients in relation to neuro-advancements, and influencers of neuro-policy, neuroethics and neuro-governance discussions. Lifelong learning, also known as professional development, is used as a mechanism to keep professionals up to date on knowledge needed to perform their work and could be used to support the fulfillment of all the roles in relation to neuro-advancements. Using 300 English language Canadian newspapers and academic articles from SCOPUS and the 70 databases of EBSCO-Host as sources, we found that the neuro-advancement content linked to speech-related professionals centered around CIs and brain computer interfaces, with other neuro-technologies being mentioned much less. Speech-related professionals were mostly mentioned in roles linked to clinical service provision, but rarely to not at all in other roles such as advocate, researcher or influencer of neuroethics and neuro-governance discussions. Furthermore, lifelong learning was not engaged with as a topic. The findings suggest that the mentioning of and engagement with roles of speech-related professionals linked to neuro-advancements falls short given the expectations of roles of speech-related professionals for example. We submit that these findings have implications for the education of speech-related professionals, how others perceive the role and identity of speech-related professionals, and how speech-related professionals perceive their own role.

Keywords: speech-language pathologist; audiologist; speech therapist; speech language therapist; neuro-advancements; lifelong learning; stakeholder; ethics; governance

1. Introduction

Knowledge around neuroscience is advancing, as is the development of neurotechnologies [1–3] (the term neuro-advancement will be used for both areas from now on). Neuro-ethics emerged as a field to discuss the social, legal, and ethical issues that arise with neuro-advancements [4]. Neuro-governance is another discourse focusing on how to best advance neuro-related products and processes [5]. Stakeholder involvement is identified within neuroethics and neurotechnology governance discussions as an essential aspect of dealing with neuro-advancements [4–6]. Given that

speech-related professionals such as speech-language pathologists (SLPs) and audiologists are exposed through their work to various neuro-advancements, they have a stake in neuro-advancements, including the ethics and governance discussions focusing on neuro-advancements. Newspapers are one source of information for the public communicating knowledge, including on topics of scientific and technological advancements [7–9], in ways that influences readers [10,11]. As such, it was investigated how the neuro-advancement linked content in Canadian newspapers engaged with speech-related professions and the roles of speech-related professionals. Academic data influences policy decision and the academic neuro-governance and neuroethics literature asks for stakeholder engagement. As speech-related professionals are stakeholders, it was also investigated how the academic literature engaged with the role of speech-related professionals in relation to neuro-advancements.

1.1. Role of SLPs and Audiologists

SLPs are trained professionals who focus on the treatment and assessment of communication and swallowing disorders [12]. Audiologists specialize in the prevention and identification of hearing and balance disorders [12]. According to the organization Speech-Language & Audiology Canada (SAC), the role of these practitioners is very similar, and the scope of practice can be subdivided into three categories: (1) clinical services, (2) advocacy and promotion and (3) education and research [13]. Clinical services include (a) screening of hearing, communication, and swallowing, (b) intervention for communication and swallowing disorders including treatment, rehabilitation, and management, and (c) consultation with other professionals. According to SAC, under the advocacy and promotion sub-category, SLPs are expected to be "advocates on behalf of individuals with communication and swallowing disorders that are at risk" [13]. Audiologists have a similar scope of practice, with an emphasis on the assessment, rehabilitation, treatment, and consultation of individuals, as well as advocacy of those with a hearing disorder [14]. Advocacy is linked to the belief that communication is a human right [15] and can be used to influence organizations such as the World Health Organization, the United Nations and World Bank [15]. At the same time, it is stated that more is needed from SLPs to fulfill the human rights language they use [16]. No studies exist that looked at role narratives of speech-related professionals within content in academic literature and media that deals with neuro-advancements.

1.2. Neuro-Advancements and Neuroethics

Neuroethics was coined as a term and developed as a field to investigate various ethical, social and legal issues raised by the advancement of the neuro-field including the areas of neuroscience, neuro-technologies and neuro-engineering [17–23], as well as individual neuro-applications such as brain-computer interfaces [24,25], cochlear implants (CIs) [26] and deep brain stimulation [27]. Roskies subdivides neuroethics into two groups: ethical issues raised when defining neuroscientific studies, and the evaluation that results from those studies [17]. The first subdivision includes issues such as privacy rights, autonomy, and informed consent. The second subdivision focuses more on the aftermath; how will the use of that knowledge shape society? For example, what will people now determine to be right or wrong in occasions where the use of brain imaging helps to discover that inmates have damaged brain cells. In other words, the issues in this subdivision consider if new knowledge will redefine what normal is. Levy (2008) further highlights the above findings with the conclusion that neuroethics has a heavy focus on how people should pursue knowledge [19]. With the increasing need to create ethical frameworks due to the advancement of neuro-technologies, there is a heightened need for stakeholder engagement to get a range of social and ethical perspectives [28]. Stakeholder engagements exist around neuroethics discourses related to various neuro-advancements [24,29,30]. Media coverage impacts how neuroethical issues are perceived and can influence stakeholder engagement with neuroscience [4,31]. Speech-related professionals have a stake in which neuro-advancements are pursued and how, and as such should play a role in neuroethics and neuro-governance discussions. Given the roles outlined for speech-related professionals by their professional organizations mentioned before, the roles could

include influencer of neuroethics and neuro-governance discussions, advocate for their field and their clients in general and within neuroethics and neuro-governance discussions and other neuro-policy discourses, and knowledge producer (researcher) on topics related to SLP and audiology in general and linked to neuroethics, neuro-governance and other neuro-policy discussions.

1.3. The Speech-Related Field and Lifelong Learning

The utility of continual learning, lifelong learning and professional development for individuals is to enable individuals to promote and advocate for the resources needed to care for others [32], to meet the needs of clients [32] and to deal with the constant changes in the health field [32]. The scope of practice for SLPs and audiologists includes ongoing education and learning to provide safe and competent care [13], see also [16,33].

It is argued that SLPs should be given the opportunity to "seek out and be permitted to engage in continuing education experiences to update their knowledge base and hone their skill" [34]. The education of SLPs is recommended to use more problem-centered lifelong learning rather than memorizing a body of knowledge [35]. Furthermore, SLP professional organizations and employers recognize the need to build clinician expertise including continuing professional development courses and mentoring, although many question the usefulness of these approaches [35].

The framework of lifelong learning can help practitioners with different roles in audiological rehabilitation, such as audiologists and SLPs, to provide a holistic approach for individuals with hearing disabilities by updating their competencies. As one expert commented, "A hearing disability is never only the problem of an individual person but also a problem for all those living and working with these individuals. (Re)Habilitation will never be successful without keeping attention and working on the whole social context" [36] (p. 9). Linked to clinical services [37], conscientiousness is linked to a commitment to lifelong learning [38].

It is argued that audiologists should be encouraged to report unethical or morally distressing incidents, using the literature related to ethics in healthcare as a resource [39].

Due to the ongoing changes and development of speech-related fields, practitioners are encouraged and expected to continue their learning as well. As such, the purpose of this study included to investigate how and to what extent newspapers and academic literature mention lifelong learning of SLPs and audiologists in relation to neuro-advancements.

The following research questions were investigated in our study: (1) Which of the 49 neuro-terms were engaged with in relation to speech-related professionals in the literature we investigated; (2) which roles of speech-related professionals were present in relation to neuro-advancements; and (3) to what extent and how was lifelong learning engaged with in relation to neuro-advancements and speech-related professionals?

2. Materials and Methods

2.1. Study Design

2.1.1. Newspapers

It is reported that newspapers and other media influence discourses [10]. The media has a large impact on individuals and is influencing their perspective on many issues. Media set agendas in what is reported and provide an opportunity for flow of information and new perspectives [11]. Framing is one way to perform a newspaper analysis [40,41]. The aim of the study was to analyze what frames were used to describe the role of speech-related professionals in relation to neuro-advancements. Three ways of framing includes structural [42], content [43], and issue-specific framing [44,45]. The content analysis used in this study focused on how the communicator (the newspaper) frames the role of speech-related professionals as it relates to neuro-advancements.

2.1.2. Academic Literature

The objective of this study was to ascertain whether, to what extent, and how the academic literature around neuro-advancements engaged with speech-related professions especially in relation to the role of speech-related professionals. To achieve this objective, a modified scoping review drawing from [46] was chosen as the most appropriate for the study given the research questions. Scoping studies allow to "map rapidly the key concepts underpinning a research area" [46] (see also [47,48]), and to identify the extent of research present on a given topic [49–51] and the current understanding of a given topic. The following study followed in a modified way the stages outlined by [46], namely: identifying the review's research questions, identifying databases to search, generating inclusion/exclusion criteria, recording the descriptive quantitative results, selecting literature based on descriptive quantitative results for qualitative analysis, qualitative analysis of data, and reporting findings of qualitative analysis.

2.2. Data Sources and Data Collection

2.2.1. Academic Literature

To maintain a clear and feasible scope [48], eligible academic data was identified using explicit search strategies across a range of data sources [50]. On March 28th, 2018, two academic databases were searched, namely EBSCO-HOST, an umbrella database that includes over 70 other databases itself and Scopus, which incorporates the full Medline database collection, with no time restrictions. These two databases were chosen because together they contain journals that encompass a wide range of topics from areas of relevance to answer the research questions. To continue to maintain a feasible scope [48], three search strategies were employed.

Strategy 1: The abstracts of articles in EBSCO-HOST and Scopus were searched for the terms "speech language" OR "speech patholog*" OR "speech therap*" OR "audiolog*" in combination with "Neuro*" (not downloaded) OR 49 neuro-related terms (Table 1, downloaded) OR "neurosc*", "neuroen*", "neurotechn*", omitting cochlear implant (downloaded), obtaining n = 368 unique results.

Strategy 2: The abstracts of articles in EBSCO-HOST and Scopus were searched for the terms "speech language pathologist*" OR "speech therapist*" OR "audiologist*" in combination with the term "cochlear implant*" obtaining n = 251 unique results (downloaded).

Strategy 3: Scopus was used to search journals that contained "speech*" or "audiolog*" in the journal title and the following terms in the abstract: "neuro*" (not downloaded) OR the 49 neuro-related terms not containing cochlear implant (downloaded), OR the terms "neurosc*" or "neurotechn*" or "neuroen*" (downloaded) obtaining n = 353 unique results.

Additional inclusion criteria: EBSCO was only searched for scholarly peer reviewed journals, while Scopus was searched for reviews, peer reviewed articles, conference papers, and editorials.

2.2.2. Newspapers

To answer the research questions, the University of Calgary's Proquest online database *Canadian Newsstream* was used as a source, a database consisting of n = 300 English Language Canadian newspapers, for its complete time range from 1980 to March 2018. Canadian newspapers were chosen because (a) existing and potential speech-related professionals are readers of newspapers, (b) the database comprises over 300 news sources including all regions of Canada, (c) over 75% of Canadians still read newspapers [52,53], and as such are influenced by what they read and (d) parents, teachers, and career counselors who often give advice on career ideas to young adults also are readers of newspapers [54].

To maintain a clear and feasible scope [48], eligible newspaper articles were identified using explicit search strategies [50]. On March 28th, 2018 four search strategies were employed.

Strategy 1, The newspaper database was searched for the terms "speech language" OR "speech patholog*" OR "speech therap*" OR "audiolog*" in combination with "neurosc*" OR" "neurotechn*" OR "neuroen*" or "neuro*" obtaining n = 403 unique results articles,

Strategy 2, The newspaper database was searched for the terms "speech language" OR "speech patholog*" OR "speech therap*" OR "audiolog*" with 49 neuro-related terms (Table 3) omitting cochlear implant obtaining n = 83 unique results,

Strategy 3, The newspaper database was searched for the term "speech technolog*" obtaining n = 438 unique results, and

Strategy 4, The newspaper database was searched for the terms "speech language" OR "speech patholog*" OR "speech therap*" OR "audiolog*" with the term "cochlear implant*" obtaining n = 321 unique results.

The newspaper articles found for each of the four search strategies were downloaded as individual PDFs and imported into Atlas.TI8™, a qualitative data analysis software application for qualitative, thematic content analysis.

2.3. Data Analysis

2.3.1. Newspapers and Academic Newspapers Together

A descriptive quantitative and thematic qualitative content approach was employed to answer the research questions using the software's ATLAS.Ti8™ Adobe Acrobat. For the descriptive quantitative data analysis, hit counts were generated for the presence of terms representing various speech-related fields and professionals in relation to neuro-related terms. For the qualitative content analysis both authors read the content of academic abstracts and newspaper articles. While reading the content, both authors generated codes using a term or phrase reflecting a given role seen as evident in a given content. The coding was deductive in the sense that the top-level theme examined (role) was predefined by the scope of the study [55,56]. The actual roles found, however, that emerged from reading the academic abstracts and the full-text of the newspaper articles were not pre-set and as such could be seen as an inductive approach [55,56].

2.3.2. Trustworthiness Measures: Newspapers and Academic Literature

Trustworthiness measures include confirmability, credibility, dependability, and transferability [57–59]. Differences in codes and theme suggestions of the qualitative data were few, discussed between the authors, and revised as needed to ensure credibility and dependability. Confirmability is also evident in the audit trail made possible by using the Memo and coding functions within ATLAS.Ti8™ and the sticky note function in Adobe Acrobat. As for transferability [57–59], the methods description gives all required information for others to decide whether they want to apply these keyword searches on other data sources such as other newspapers, or social media such as twitter or other academic databases or want to expand on the keywords used.

2.4. Limitations

2.4.1. Academic Literature

The search was limited to two academic databases and English language literature. As such, the findings are not to be generalized to the whole academic literature, non-academic literature, or non-English literature. These findings, however, allow conclusions to be made within the parameters of the searches. Furthermore, the 49 neuro-related terms we used are not the only ones present in the literature but reflect terms we came across in our research for the grant listed below that we obtained. However, the data based on the existing terms used allow for some conclusions around the terms used.

2.4.2. Newspapers

The focus of this study was on Canadian newspapers. Sources such as social media or online-only news content (e.g., the Canadian Broadcast Corporation) were not the focus, and therefore were not included. Furthermore, the focus was on English-language newspapers only. Therefore, the results cannot be generalized for media in general, newspapers in Canada, and media including newspapers from other countries. Furthermore, the 49 neuro-related terms we used are not the only ones that could be present in the newspapers but reflect terms we came across in our research for the grant listed below that we obtained. However, the data based on the existing terms used allow for some conclusions around the terms used.

3. Results

3.1. Descriptive Quantitative Data

As the first step, abstract counts for all search terms were generated and used to obtain abstracts for manifest and latent thematic content analysis. First, the focus was on searching the abstracts in Scopus and EBSCO ALL for different neuro-related terms in conjunction with "speech therap*", "speech patholog*", "speech language" or "audiolog*" OR the term "speech" (Table 1).

Table 1. Hit count results for abstracts mentioning different neuro-related terms in conjunction with "speech therap*", "speech patholog*", "speech language" or "audiolog*".

First Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract
	Speech	"Speech Therap*"	"speech Patholog*"	"speech Language"	"Audiolog*"
N/A	N/D	9156	4772	26326	25604
Neuro*	17,073	948	466	2138	1350
Neurosc*	925	12	15	58	18
Neurote*	5	0	0	4	1
Neuroen*	96	0	0	0	0
Artificial brain	N/D	0	0	0	0
Auditory brainstem implant	N/D	0	0	7	39
Bionic eye	N/D	0	0	0	0
Brain imaging	N/D	8	3	29	0
Brain to speech	N/D	0	0	5	0
Brain stimulation	N/D	37	5	98	0
Brain-computer interface	N/D	0	0	6	2
Brain-to-text	N/D	0	0	0	0
Cochlear implant	N/D	49	22	542	1556
Cognitive stimulation	N/D	5	1	0	0
Collaborative cognitive simulations	N/D	0	0	0	0
Cortical modem	N/D	0	0	0	0
Cranial electrotherapy stimulation	N/D	0	0	0	0
Darpa Ram senor	N/D	0	0	0	0
Deep brain stimulation	N/D	13	4	14	0
Direct acoustic cochlear implant	N/D	0	0	0	0
Ear-EEG	N/D	0	0	0	1
Electrocorticography	N/D	3	1	0	0

Table 1. *Cont.*

First Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract	+Second Search Term in: Abstract
	Speech	**"Speech Therap*"**	**"speech Patholog*"**	**"speech Language"**	**"Audiolog*"**
Emotive	N/D	0	0	3	0
Exocortex	N/D	0	0	0	0
Facial electromyography	N/D	0	0	2	1
God Helmet	N/D	0	0	0	0
Hemoencephalography	N/D	0	0	0	0
Hippocampus prosthesis	N/D	0	0	0	0
Human Computer	N/D	6	1	2	0
Intracranial electroencephalography	N/D	0	0	0	0
Muse headband	N/D	0	0	0	0
Neural stem cell	N/D	1	0	0	0
Neuralink	N/D	0	0	0	0
Neurochip	N/D	0	0	0	0
Neurofeedback	N/D	1	0	0	2
Neuroimaging	N/D	13	6	127	61
Neuroinformatics	N/D	0	0	3	0
Neuromodulation	N/D	1	11	6	3
Neurostimulation	N/D	3	0	3	4
Nootropics	N/D	1	0	0	0
Optogenetics	N/D	0	0	0	0
Prosthetic memory device	N/D	0	0	0	0
Pulsed electromagnetic field therapy	N/D	0	0	0	0
Responsive neurostimulation	N/D	0	0	0	0
Sacral nerve stimulation	N/D	0	0	0	0
Speech BCI	N/D	0	0	0	0
Spinal cord stimulator	N/D	0	0	0	0
Subvocal speech device	N/D	0	0	0	0
THync mood altering headset	N/D	0	0	0	0
Transcranial direct current stimulation	N/D	23	1	16	4
Transcranial magnetic stimulation	N/D	29	3	17	16
Virtual reality	N/D	4	2	11	16
Whole brain emulation	N/D	0	0	0	0

Hit counts were also done in Scopus to search "speech" and "audiolog*" in the journal title and different neuro-related terms in the abstract (Table 2). The results are as follows:

Table 2. Hit count results for abstracts mentioning different neuro-related terms within "speech" and "audiolog*" journals.

Search Term in: Abstract	In Journals That Contain "Speech*" in the Title	In Journals That Contain "Audiolog*" in the Title
Neuro*	1172	757
Neurosc*	77	13
Neurote*	3	0
Neuroen*	2	2
Artificial brain	0	0
Auditory brainstem implant	1	11
Bionic eye	0	0
Brain imaging	16	6
Brain to speech	0	0
Brain stimulation	22	2
Brain-computer interface	72	1
Brain-to-text	1	0
Cochlear implant	352	764
Cognitive stimulation	3	2
Collaborative cognitive simulations	0	0
Cortical modem	0	0
Cranial electrotherapy stimulation	0	0
Darpa Ram senor	0	0
Deep brain stimulation	18	2
Direct acoustic cochlear implant	0	1
Ear-EEG	0	0
Electrocorticography	9	0
Emotive	18	0
Exocortex	0	0
Facial electromyography	0	0
God Helmet	0	0
Hemoencephalography	0	0
Hippocampus prosthesis	0	0
Human Computer	152	0
Intracranial electroencephalography	0	0
Muse headband	0	0
Neural stem cell	0	0
Neuralink	0	0
Neurochip	0	0
Neurofeedback	0	1
Neuroimaging	36	15
Neuroinformatics	0	0
Neuromodulation	3	0
Neurostimulation	3	4
Nootropics	0	0
Optogenetics	0	0
Prosthetic memory device	0	0
Pulsed electromagnetic field therapy	0	0

Table 2. *Cont.*

Search Term in: Abstract	In Journals That Contain "Speech*" in the Title	In Journals That Contain "Audiolog*" in the Title
Responsive neurostimulation	0	0
Sacral nerve stimulation	0	0
Speech BCI	0	0
Spinal cord stimulator	1	0
Subvocal speech device	4	0
THync mood altering headset	0	0
Transcranial direct current stimulation	3	1
Transcranial magnetic stimulation	10	5
Virtual reality	26	3
Whole brain emulation	0	0

Finally, the full texts of Canadian newspaper articles were searched in the database Canadian *Newsstream* for different neuro-related terms in conjunction with "speech therap*", "speech patholog*", "speech language" or "audiolog*" (Table 3) and downloaded for manifest and latent thematic content analysis.

Table 3. Mentioning of the terms "speech therap*", "speech patholog*", "speech language" or "audiolog*" in conjunction with terms indicating neuro-advancements within Canadian Newspapers.

First Set of Search Terms	Second Search Term	Article Count Total
"speech therap*" OR "audiolog*" OR "speech patholog*" OR "speech language"	Neuro Terms	19,216
	Neuro*	433
	Ethic*	234
	Neurosc*	87
	Speech technolog*	3
	Neurote*	0
	Neuroen*	0
	Neurotechnology	
	Artificial brain	0
	auditory brainstem implant	2
	Bionic eye	0
	brain computer	0
	Brain stimulation	15
	Brain to speech	2
	Brain-computer	0
	Brain-to-text	0
	Cochlear implant*	314
	Collaborative cognitive simulations	0
	Cortical modem	0
	Cranial electrotherapy stimulation	0
	Darpa Ram senor	0
	Deep brain stimulation	8
	direct acoustic cochlear implant	0
	Ear-EEG	0
	electrocorticography	0
	Emotive	5
	Exocortex	0
	Facial electromyography	0
	God Helmet	0
	Hemoencephalography	0
	Hippocampus prosthesis	0
	Human computer	1
	Intracranial electroencephalography	0

Table 3. *Cont.*

First Set of Search Terms	Second Search Term	Article Count Total
	Muse headband	0
	Nerve stimulation	6
	Neural stem cell*	1
	Neuralink	0
	Neurochip	0
	Neurofeedback	0
	Neuroimaging	5
	Neuroinformatics	0
	Neuromodulation	0
	Neurostimulation	0
	Nootropic*	0
	Optogenetics	0
	Prosthetic memory device	0
	Pulsed electromagnetic field therapy	0
	Responsive neurostimulation	0
	Sacral nerve stimulation	0
	Speech BCI	0
	Spinal cord stimulator	0
	Subvocal	0
	THync mood altering headset	0
	Transcranial direct current stimulation	0
	Transcranial magnetic stimulation	6
	Virtual reality	12
	Whole brain emulation	0

All three tables indicate that "neuro*", which can include words such as neurotoxicity and other terms that one would not link to speech-related professionals, and "cochlear implant*" are the only terms leading to substantial hits. The terms "neurosc*" for neuroscience, "neurote*", and "neuroen*" and most of the 49 neuro-related terms did not generate many hits, if any. Phrases containing the term "brain" and "human–computer" had some hits in the academic literature we investigated but not in the newspapers.

In a second step, manifest and latent content coding was performed on the academic abstracts and newspaper articles downloaded. The below is separated into two main parts: academic abstract content analysis and Canadian newspaper full text article content analysis.

The academic abstract part is subdivided into 3 sub-parts: the role of speech-related professionals (a) evident in abstracts containing the terms "neurosc*", or "neuroen*" or "neurote*" or 49 neuro-related terms and speech-related terms; (b) evident in abstracts containing the terms "neurosc*", or "neuroen*" or "neurote*"or 49 neuro-related terms and the terms speech* or audiolog* in the title of the journal; and (c) in relation to CIs.

The Canadian newspaper part is also subdivided into 3 sub-parts: the role of speech-related professionals (a) evident within the context of neuro-advancements (not CI), (b) evident within the CI of neuro-advancement, and (c) evident outside context of neuro-advancements. In all sections, content linked to "speech" is first examined and then content linked to "audiolog*".

3.2. Qualitative Data

3.2.1. Academic Literature

Roles of Speech-Related Professionals Evident in Abstracts Containing the Terms "Neurosc*", or "Neuroen*" or "Neurote*", or 49 Neuro-Related Terms Omitting CIs (Search Strategy 1)

In total, n = 368 academic abstracts were downloaded and looked at. Within the downloaded abstracts, it is made explicit that neurology has an interest in and influences areas that are also of interest to speech-related professions such as speech therapy [60], audiology [61] and speech language pathology [62], and that cooperation between neuro- and speech-related professionals is warranted [63].

To give one quote: "The analysis of aphasia as a matter of fact is a crucial question not only for neurology and related clinical areas, but also for linguistics, neuropsychology, psychology, and speech therapy" [60] (p. 267). It is seen as important that speech language pathology students learn about the "neuro-anatomy and neurophysiology of the normal speech, language, swallowing, and hearing systems" [64] (p. 27).

Neurotechnologies mentioned within abstracts containing the terms "neurosc*" include EEG, neurostimulation, neuro-pharmaceuticals, imaging technology, neuro-scans, rTMS, tDCS and MRI. The terms "neuroen*" and "neurote*" did not mention any neurotechnologies. Instead, "neuroen*" was used to describe individuals with neuroendocrine dysfunctions and their possible vocal symptoms; however, the role of SLPs and audiologists was not mentioned. Furthermore, there was no relationship with the keyword "neurote*" and speech-related professionals. Two abstracts mentioned that transcranial brain stimulation (TMS and tDCS) might be worthwhile as a complimentary method to speech therapies and useful for SLPs [65,66].

As to the role of speech-related professionals, it was noted that neurotechnologies such as Neuroimaging Techniques, Magnetoencephalography Imaging, diffusion Tensor MRI, Transcranial Magnetic Stimulation, Transcranial Direct Current Stimulation, Laryngeal Imaging and biofeedback for Acquired Apraxia will impact the practice of SLPs and audiologists [67]. SLPs were mentioned as evaluators in $n = 6$ abstracts and as a clinical service provider in $n = 5$ abstracts. The role of researcher was evident in $n = 4$ abstracts, of which $n = 3$ were linked to providing grouping/classification of research subjects. The role of knowledge consumer was evident in $n = 3$ abstracts. The role of producer of best practice guidelines, knowledge producers (refining communication disorder phenotypes) [68] (p. 245), advocate, and preventing worsening of a condition were mentioned once. Furthermore, audiologists were mentioned in their role of evaluator in $n = 4$ abstracts and as programmers in $n = 2$ abstracts.

The keyword "neuroethics" had $n = 0$ results in the downloaded academic abstracts and only one mentioned ethics but not in relation to SLP. Essentially, SLPs and audiologists were not mentioned as influencers of neuro-governance or neuroethics discourses. Furthermore, lifelong learning was not mentioned as a mechanism or tool for SLPs and audiologists to update their knowledge.

Roles of Speech-Related Professionals Evident Containing the Terms "Neurosc*", or "Neuroen*" or "Neurote*" or 49 Neuro-Related Terms in the Abstracts and the Terms "Speech*" or "Audiolog*" in the Title of the Journal (Search Strategy 3)

In this section, the findings of $n = 353$ downloaded academic abstracts are reported on. As to the role of speech-related professionals, none mentioned a role using the terms "audiologist*" or "therapist*". Using the word "pathologist*", one abstract of an article reported on the results of a systematic literature review that investigated the involvement of SLPs in communication interventions of people with dementia, whereby it is concluded that cognitive stimulation approaches might be useful, and that the findings of the literature review might have implications for clinical services of SLPs [69] thereby indicating the role of knowledge consumer. One abstract listed challenges for SLP practice such as "preparation of future speech-language pathologists, reimbursement for services, availability of appropriate technology, and widespread connectivity" [70] (p. 189). These challenges were all linked to clinical services, although one could envision that the role of advocate and educator might also fit to face the challenges. Another abstract mentioned SLPs in the role of evaluator of a patient in a clinical trial. SLPs as knowledge consumers, researchers, clinical service providers and evaluators were mentioned once. SLPs and audiologists were not mentioned as influencers of neuroethics and neuro-governance discussions. They were also not mentioned as lifelong learners of neuro-advancements and the implications that can arise with the use of such advancements. Ethics was not mentioned in the abstracts.

Roles of Speech-Related Professionals in Relation to CIs (Search Strategy 2)

Regarding CIs $n = 251$ academic abstracts were downloaded and analyzed for the roles linked to speech-related professionals in relation to CIs (Table 4).

Table 4. Role narrative of speech-related professionals linked to CIs.

Role	Frequency of the Found Roles
Evaluator of clients and CI	69
Programmer of CI	20
Promoter/Referrer of CI	12
Rehab	11
Educator of others	8
Expert	6
Knowledge provider	5
Counsellor	4
Fitting device	4
Service provider	4
Knowledge consumer	4
Support parents/family	3
Knowledge producer	3
Researcher	3
Stakeholder	3
Integrate into Hearing World	1
Compliance Role	1
Help User	1
Trainer of client	1
Supporter of social life	1
Designer of device	1

As is evident from Table 4, the main role of speech-related professionals was linked to providing a service to a client with the main role being to evaluate the usability of CIs and the applicability of a CI for a potential user. The role of programming CIs was linked mostly to audiologists. Other researchers discussed SLPs' important role in pretreatment counseling [71].

To be part of a team was mentioned as being important for SLPs and audiologists. Teagle and Moore (2002) outlined the pivotal role SLPs have in the CI team [72]. This role was described as the "need to recognize symptoms and make prompt recommendations for quick intervention". Researchers in another abstract outlined that audiologists have a role in the CI team, particularly in the rehabilitation phase [73].

Some abstracts linked with the "educator" role of speech-related practitioners, whereby the education role was linked to educating individuals on the clinical benefits and uses of CIs [74].

The term "educational audiologist" was present in $n = 7$ abstracts, whereby this role was linked to the role of ensuring compliance [75], ensuring the benefits of CIs [76], that special education teachers benefit from CIs [77], having a role in the school of the deaf [78], providing education that increases auditory learning of children [79,80], and providing good devices to students [81]. A study from 2009 called "*Preparation and perceptions of speech-language pathologists working with children with cochlear implants*" "examined the level of preparedness of North Carolina speech-language pathologists (SLPs) who serve school-aged children with cochlear implants (CIs)" [82] (p. 142). The study concluded that SLPs and audiologists need "to engage in continuing education to update their knowledge of emerging innovations in CI technology and habilitation" [82] (p. 142). Another study argued that audiologists should educate pediatricians [83]. One abstract indicated that providing "specialty training for SLPs working with deaf and hard of hearing children" [84] (p. 297) improves the ability "to work with culturally diverse children who are deaf or hard of hearing and in particular, those who use cochlear implants and have differing experiences with spoken language" [84] (p. 297).

Berg (2007) highlighted the idea that audiologists should be trained and increase their knowledge of educational audiology and deaf culture perspective to gain better discussions with clients on CI [85]. Researchers in another abstract concluded that the role of an audiologist is not only to provide assessment, but also to provide information and knowledge of speech and CIs to families so parents "can continue to respond to their child" [86]. This role is reflected in the quotes, "the role of the audiologist is therefore not just to assess the child's auditory thresholds and provide effective amplification, but perhaps more importantly, to support parents through the stages of grief by fine-tuning the amplification so that parents can see their infant's early responses to sounds" and "By more closely fulfilling the needs and expectations of parents, audiologists are better placed to achieve improved speech, language, and social outcomes for children with early identified hearing loss" [86] (p. 3).

There were $n = 3$ abstracts that mentioned speech-related professionals as stakeholders in relation to CIs, with one abstract describing their role as "stakeholders in the adoption process" [87]. The second abstract discussed the importance of the support of all stakeholders, including speech therapists, for commencement of a CI program [88]. The third abstract indicated audiologists as stakeholders by stating that audiologists see themselves in the role of providing sensory management, but that aural rehabilitation is done by others [89].

Some abstracts suggest the role of knowledge consumer by indicating gaps of knowledge within speech-related professionals. One study from the UK suggested that "audiologists support cochlear implantation, but due to a lack of training and familiarity, not all are confident in discussing CIs with patients and making an appropriate referral" [90] (p. 213). A study from Brazil concluded that audiologists and other involved professionals do not have enough knowledge of CIs [91]. A 2018 abstract "*Awareness and Knowledge of Cochlear Implants among Speech-Language Pathologists*" concluded that SLP in Mississippi lack CI related knowledge and skills to work with CI clients [92].

In one abstract, "*Exploring the Identities of Hearing Parents Who Chose Cochlear Implantation for Their Children with Hearing Loss*", four identities of parents were identified: advocates, resilient parents, obedient worriers, and matter-of-fact narrators. Identifying and understanding these parent identities was seen as useful knowledge to "improve audiologists' abilities to help families seek out, implement, and follow-through with family centered hearing healthcare" [93] (p. 131).

As to lifelong learning, one abstract mentioned the use of technology to advance professional development [94]. Another abstract made the case that "experts in their respective fields, including neuroscience, speech-language pathology, and educational psychology" do not know enough about the literacy field and the case is made in the abstract for these experts to "attend professional development sessions concerning big picture perspectives and make observations in schools where these perspectives have been effectively implemented" [95] (p. 1).

3.2.2. Canadian Newspapers

In the final step of our analysis, we investigated the full text of Canadian newspaper articles (Table 5). Although an article might mention speech-related professionals and neuro-advancements it is not a given that these two areas are mentioned in relation to each other. They might be linked to totally different stories and as such could be classified as non-relevant or false-positives. Therefore, we report in Table 5 the roles of speech-related professionals in relation to neuro-advancements and in relation to non neuro-advancements (search strategy 1–3). As to the articles containing CIs (search strategy 4), not one mentioned SLPs or audiologists in a non-relevant fashion. All mentions were linked to some aspects of CI whether technical aspects or mentioning of social discussions around CI. As such, Table 5 has only one column for CIs (search strategy 4).

Table 5. Role narrative of speech-related professionals linked to neuro-advancements vs linked to neuro-advancements and linked to CIs.

Role	Search Strategy 1–3 n = 924 Articles		Search Strategy 4 Cochlear Implant n = 321 Articles
	Not Linked to Neuro-Advancement	Linked to Neuro-Advancements	All Linked to the Neuro-Advancement of Cochlear Implant
Facilitator of Therapeutic Interventions	71	3	6
Expert (indicated by being quoted)	30	4	16
Advocate for their field	9	0	6
Educator (of others)	5	0	8
Researcher	4	1	1
Therapeutic evaluator of clients and devices	4	0	2
Influencer of policy, ethics and governance discourses	2	0	0
Learner (obtaining new knowledge)	1	0	1
Promoter of CI	0	0	5
Programmer of CI	0	0	2
Advocate for others such as clients	0	0	1

Table 5 indicates that for the non-CI content, roles of speech-related professionals were mentioned much less in relation to neuro-advancements than outside of neuro-advancements. However, between the two non-CI columns which roles were mentioned most, and which roles were rarely or not mentioned were mostly the same.

Within the CI content, there were certain specific roles highlighted, such as programmer of CI, which could be seen also as service provision. However, the role of influencer of policy, ethics and governance discourses was also not mentioned as in the non-CI content.

Roles Evident within Context of Neuro-Advancements Omitting CIs

As reflected in Table 5, the role of SLPs and audiologists was rarely mentioned. Even the role of service provider the role mentioned the most was mentioned only n = 3 times. Within all the downloaded newspaper articles not one article reported on the role of SLPs or audiologists as advocates, researchers or influencers of neuro-advancements including neuro-policy, neuro-ethics and neuro-governance discussions.

Roles Evident within Context of CIs

As to the content reflected in Table 5 relating to CIs, the top roles mentioned for SLPs and audiologists were expert (n = 16 articles), educator of others (n = 8 articles), and service provider or advocates for their fields (n = 6 articles).

Beyond these roles for SLPs, one article reported on a camp run by SLPs for children to meet other implant users and learn communication skills [96]. Another article described SLPs as members of the CI team needing to provide assessment, therapy, and rehabilitation [97].

One article reported on a workshop that was held for the personal and professional development of women in the speech field, specifically on CIs [98].

As to CIs, some roles were exclusively linked to audiologists such as: promoter of CI (n = 5 articles all before the year 2000) and programmer of CI (n = 2 articles). As to the promoter of CI role, this was seen as either negative; for example, "So what does this device do? It offers false hope to the parents of deaf children. However, do parents have enough information on the alternative? Not likely: they are mobbed by the doctors or audiologists from the day deaf babies are born" [99], or as needed; for example, "However, Dr. Sipke Pijl, an audiologist at St. Paul's hospital, who does about five or six operations every year says he takes exception to the deaf community dictating what other people should do with their lives" [100]. Two articles highlighted audiologists' input on CIs, with one stating that CIs are not the only solution to hearing loss, as there is a lot of therapy and rehabilitation in the

process as well [101]. The other reported on an audiologist's opinion that CIs work best in people who could speak before being deaf [102].

Roles Evident Outside Context of Neuro-Advancements

Canadian newspapers rarely linked the role of the speech-related field to neuro-advancements including CIs. As to the roles evident without linkage to -neuro-advancements and CIs, one article from 2004 stated:

> "Speech-Language Pathologists (SLPs) and Audiologists (Auds) are highly trained professionals who can help people make their lives richer, more productive and enjoyable through improved communication skills. What we do: Identify, assess, and rehabilitate children and adults with hearing difficulties and communication disorders. We counsel clients and families and provide referrals to other professionals. We are committed to ongoing research, public education, and training of new speech-language pathologists and audiologists. What we study: Acoustics, anatomy, assessment, counseling, hearing disorders, hearing aids, language development disorders, linguistics, neurology, neurophysiology, non-vocal communication, parent training, psychology phonetics, voice, speech and voice disorders, statistics, stuttering and research methods. Where we work: Speech-language pathologists and audiologists work in private practice, child development centres, pre-schools, schools, hospitals, rehabilitation centres, government agencies, health units, industry, colleges, universities and research centres throughout the world. We are often part of teams which include physicians, psychologists, social workers, nurses, teachers, counselors, occupational therapists and physical therapists". [103]

The results are summarized in Table 5. More specifically, the role of service provider, whether in a clinical setting or in-home service, was evident in over $n = 71$ articles, while the role of being an expert was indicated $n = 30$ times by the many speech-related professionals quoted by name and the quoting of speech professional organizations and phrases such as: "audiologists say … ".

The role of being an educator was evident in $n = 5$ articles that highlighted talks given by professionals. The role of being an advocate for one's profession was present in $n = 9$ articles, whether in questioning negative consequences such as cuts in numbers or changes of status, or positive aspects such as awareness month.

Being a researcher was evident in $n = 4$ articles; for example, one article stated that audiologists are "committed to ongoing research, public education, and training of new audiologists" [103]. Being an influencer of policy decision beyond advocating for one's profession was only evident in $n = 2$ articles. To give one quote, "The Canadian Pediatric Society and the Canadian Association of Speech-Language Pathologists and Audiologists (CASLPA) recommend hearing screening for all newborns" [104]. That one has to learn was present in one article [105]. However, the issue of professional development and lifelong learning was not discussed. No article highlighted the importance of the role of the speech-related professionals to deal with neuro-advancement related policy, ethical, social and governance issues arising in relation to their fields.

4. Discussion

The purpose of this study was to investigate which of the many possible roles of speech professionals are mentioned in conjunction with neuro-advancements in academic literature and Canadian newspapers, and how speech-related fields are engaged with in relation to various neuro-advancements in the same literature. The role of user of neuro-advancements in one's clinical service provision was the role found the most. Other roles, such as educator and advocate, were much less frequently mentioned, and the role of influencer of ethics, governance and policy discourses of neuro-advancements was missing. The findings suggest a narrow and problematic role narrative of speech-related professionals in relation to neuro-advancements. In the remainder of this section

we first engage with our problematic findings through the lens of neuroethics and neurotechnology governance discussions and then look at our findings through the lens of lifelong learning.

4.1. Neuroethics and Neurotechnology Governance Discussions: Role of Speech-Related Professionals

Stakeholder engagement is one focus of discussions within neuroethics and neuro-technology governance discourses [4–6]. It is seen as important to bring stakeholders together to "provide relevant perspectives and broadly considered insights" [5] (p. 6) and to build recognition of the importance of ethical issues into the training of all of those involved in utilizing neurotechnologies [5]. Speech-related professionals use neuro-advancements in their practice. Speech-related professionals have been engaged with some neuro-related products for quite some time such as CIs and some neuro-related products that are just emerging such as speech supporting brain computer interfaces and deep brain stimulation. The use of such emerging products will increasingly become part of the scope of practice of speech-related professionals. Furthermore, there are some neuro-advancements in which the use might not become part of the scope of practice of speech-related professionals directly but still might impact the clients of speech-related professionals. As such, speech-related professionals have a stake in how neuro-advancements are discussed, including in the ethics and governance discourses. Therefore, it is problematic that not one academic abstract or newspaper article in the literature we investigated engaged with the role of speech-related professionals as influencers of and knowledge producers for policy, ethics or governance activities related to neuro-advancements.

Sherwin stated that "we [ethicists] lack the appropriate intellectual tools for promoting deep moral change in our society" [106] (p. 80). Involving people is part of promoting change in society. That the role of speech-related professionals being influencers and knowledge contributors to neuroethics and neurotechnology governance discussions is not present in the literature we investigated suggests that speech-related professionals are not seen as potential and needed change agents in society or in need to change as part of being members of society.

According to an OECD report, one of the key objectives of the BNCT project "Neurotechnology and Society" is to "pool ideas, norms, and approaches for achieving more responsible innovation in neurotechnology for health-related applications through a step-wise process of dialogue involving researchers, innovators, policy makers, health care professionals, and the publics" [5] (p. 9). Speech-related professionals are also health care professionals but are not mentioned in the document explicitly. According to SAC, the expectations in a practitioner's role are to get involved in producing research and to become knowledge producers themselves [13]. As such, one would have expected some mentioning of and engagement with that role in relation to neuro-advancements, neuroethics and neuro-governance.

According to the SAC Code of Ethics [107], respect for autonomy, beneficence, non-maleficence, and justice are the main principles to be upheld. More specifically, respect for autonomy refers to the practitioners "enabling individuals to make informed choices"; beneficence refers to "balancing the benefits of intervention against the risks and costs"; non-maleficence refers to "avoiding the causation of harm"; and justice refers to "ensuring clients in similar situations are treated in a similar manner" [107]. Such wordings as those present in the SAC code of ethics suggest that speech-related professionals should be involved in neuroethics and neuro-governance discussions. That the role of speech-related professionals includes advocacy on behalf of their clients [13,14], promotion, education and research [13] also suggests that the gap found in this study should be filled.

How newspapers portray speech-related professions and the role of speech-related professionals may influence an individual's perception of the field and its professionals. The study findings suggest that the readers do not obtain any idea that being influencers of ethics and governance discourses is one role of speech-related professionals. Furthermore, when the role of educator is mentioned, the topic of education was on the clinical services and the topic of hearing and not on ethics or governance issues. The academic literature also did not discuss the role of the speech-related professionals as educators and influencers of ethics and governance issues.

4.2. Lifelong Learning and Professional Development

Building clinician expertise for SLPs and audiologists including professional development [35] and lifelong learning fits with the scope of evidence-based practice [35]. A commitment to lifelong learning is expected [12,38], and SLPs and audiologists should be given the opportunity to update their knowledge and skills [34], including skills for working in an interdisciplinary environment [36]. An interdisciplinary competency framework was developed that is seen to enable the person to identify whether they need to update their competencies in order to be able to work in an interdisciplinary way [36]. Continual learning, lifelong learning and professional development for SLPs and audiologists enables the professionals to provide safe and competent care [13,16,33] and to advocate on behalf of their clients [13,14]. It is also noted that audiologists should have the skill to make use of ethics literature [39].

However, according to the literature we investigated, lifelong learning and professional development of speech-related professionals was not present as a topic in relation to neuro-advancements, neuroethics or neuro-governance. This gap in the literature should be filled. Indeed, the findings could be seen to be empirical evidence supporting claims that lifelong learning procedures are not effective [35]. The findings also fit with studies that focused on certain groups of health professionals (not speech-related professional) and that concluded that there is a need for better knowledge of health professionals on ethics issues [108,109]. Our findings suggest that discussions of how to make use of lifelong learning mechanisms to increase skills and knowledge needed to contribute and influence neuroethics and neuro-governance discourses have not even started. Work is needed in this area especially given that the existing system is seen as not working [35]. Others have suggested that lifelong learning is needed to be able to discuss social and technological changes [110]. Given the constant change in neuro-advancements, lifelong learning is needed as a mechanism to be up to date not only on the neuro-advancements but also on their impact, if speech-related professionals are to fulfill their roles of providing safe and competent care [13] and to advocate on behalf of their clients [13,14].

5. Conclusions and Future Research

The findings from this study suggest that the role narrative of speech-related practitioners linked to neuro-advancements focuses on clinical practices such as the assessment, therapy, and rehabilitation of clients and not on influencer of and knowledge contributor to neuroethics and neuro-governance discussions. Lifelong learning and professional development are not discussed as tools to obtain the skills and knowledge to contribute in a meaningful way to neuroethics and neuro-governance discourses. The findings of the study are problematic given the role understanding of speech-related professionals [12,13] and the focus of neuroethics and neuro-governance on stakeholder engagement. Given the results of the study, future research could be conducted in two main areas. One area could investigate in detail the views of speech-related professionals on their role in relation to and outside of neuro-advancements in order to obtain a better understanding whether our role narrative findings reflect the role understanding of speech-related professionals or not. More concretely, such research could obtain the views of speech-related professionals on specific roles such as being influencers of neuro-advancement discourses including ethics, policy, and governance discussions and being educators of the public on neuro-advancements including ethics and governance aspects of neuro-advancements. Linked to this focus, speech-related professionals could be asked about their views of the importance of neuroethics and neuro-governance and their own involvement in neuroethics and neuro-governance discussions. A second focus of research given our findings could be on the utility of lifelong learning to empower speech-related professionals in fulfilling all of their potential roles. More concretely, such research could obtain the views of speech-related professionals on whether lifelong learning and professional development could and should be used to (a) give them the knowledge and skills needed so they can in a meaningful way contribute to the neuro-advancement discourses including ethics, policy, and governance discussions, and (b) increase

their role of being educators of the public on neuro-advancements including ethics and governance aspects of neuro-advancements. Furthermore, an analysis of the current lifelong learning programs for the speech-related field with a focus on which roles they enable might be warranted.

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