

Interventions That Target or Affect Voice or Speech Production during Public Speaking:

A Scoping Review

Pauline Menjot*, Lamia Bettahi*, Anne-Lise Leclercq, Nancy Durieux, and Angélique Remacle
Research Unit for a life-Course perspective on Health and Education, Faculty of Psychology, Speech
Therapy and Education Sciences, University of Liège, Belgium

* These authors contributed equally to this work

Author Note

Lamia Bettahi <https://orcid.org/0009-0006-4191-5591>

Nancy Durieux <https://orcid.org/0000-0002-4688-293X>

Anne-Lise Leclercq <https://orcid.org/0000-0003-4072-1382>

Pauline Menjot <https://orcid.org/0009-0005-6958-8433>

Angélique Remacle <https://orcid.org/0000-0001-9338-977X>

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Correspondence concerning this article should be addressed to Pauline Menjot, Department of Speech and Language Therapy, University of Liège, rue de l'Aunaie 30, 4000 Liège. Email: pauline.menjot@uliege.be. Telephone number: +32 4 3665980

Abstract

Objectives. Public speaking (PS) is frequently necessary in many professional, educational and personal settings. Mastering this communication skill is particularly important in today's society. Training techniques for PS have been described in the literature. Given that PS anxiety affects performance, especially voice characteristics and speech fluency, the purpose of this scoping review is to examine, map, and narratively summarize the available evidence on PS interventions that target or affect voice or speech. **Methods.** An extensive literature search was conducted in three bibliographic databases: Medline ALL/Ovid, PsycINFO/Ovid, and Eric/Ovid. Of the 850 studies identified, 22 met the eligibility criteria and one was added from the reference lists of the included studies. **Results.** A total of 23 studies were included. The interventions identified aim to improve speaking skills either by explicitly targeting the voice or speech (direct intervention, n=15), or by targeting the cognitive, behavioral, psychological or physical environment impacting the speaker's productions (indirect intervention, n=8). **Conclusions.** This scoping review provides the first published methodological summary of the characteristics of existing PS interventions that target or affect voice and speech. Heterogeneous characteristics were observed. Further studies are needed to determine which interventions are most effective.

Keywords: communication skills, public speaking, oral communication, voice, training, scoping review

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1. Introduction

Public speaking (PS) is an essential activity used in daily life to defend an opinion, convey an idea, convince other people, or succeed in a job interview or at school¹. These situations depend on the speaker's competence at communicating with the listener in a specific context², namely in front of an audience. PS is necessary in many professions and is even one of the core competencies for certain professionals such as teachers, trainers, lecturers, politicians and managers^{1,3}. In fact, effective PS is a skill these professionals must acquire because it can have an impact on their career success, reputation, and credibility⁴. This competence is also one that graduates of higher education institutions must acquire³. This emphasis is evident in the Dublin Descriptors (i.e., the Qualifications Framework of the European Higher Education Area), in which one of the five higher education qualifications refers to communication. In addition, 78.8% of employers consider oral communication skills to be among the five most important skills of recent college graduates⁵.

PS competence can be defined as 'the combination of knowledge, skills, and attitudes needed to speak in public in order to inform, self-express, to relate and to persuade'⁶. This ability is often considered to encompass three underlying dimensions: knowledge, motivation, and skills⁷. *Knowledge* is defined as the theoretical background a person deploys to plan and deliver a speech (e.g., knowing how to structure a speech). *Motivation* refers to the willingness to communicate and depends on self-perceived communication competence, communication apprehension and speech anxiety. A repertoire of *PS skills* is also necessary, such as visual nonverbal behavior (e.g., eye contact gestures, posture), nonverbal -auditory impressions (e.g., intonation, speech rate, pauses, speech fluency), language usage (e.g., linguistic expression, usage of rhetorical devices) and organization (e.g., structure of the speech)⁷. Therefore, to present a competent speech, the speaker must effectively combine these dimensions in a specific situation. However, many graduates, as well as students and professionals, lack oral presentation skills, which can have negative consequences for them. For example, in school and work contexts, competent speakers convey their knowledge, ideas, and opinions more successfully⁸.

Abbreviation

PCC	The JBI Population, Concept and Context eligibility criteria
PS	Public Speaking

In addition, a large proportion of the population does not feel comfortable speaking in public. For example, a study⁹ report that PS is one of the most commonly feared situations, with prevalence estimates ranging from 20% to 34% among adults. Standing in front of a crowd is a challenge for most people, particularly because of the fear it generates in speakers of being evaluated negatively by others. This is true of the general population (typical individuals)⁴, as well as of individuals with speech disorders (e.g., stuttering)¹⁰, voice disorders (e.g., dysphonia)¹¹ or anxiety disorders (e.g., social anxiety)^{12,13}. This communication apprehension can be defined as a person's level of anxiety associated with anticipated or actual communication with other people¹⁴. It refers to performance anxiety (also called stage fright)¹⁵, defined as 'anxiety while being observed or scrutinized by others'¹⁶ in performance situations (e.g., taking an oral exam).

Apprehension linked to PS objectively impacts oral communication, particularly voice and speech^{17,18}, two key concepts for this scoping review. Voice is the sound produced by vocal fold vibration and involves different processes such as breathing, phonation, articulation, and resonance. Frequency, sound pressure level, harmonic content, and temporal aspects are used to characterize voice. The literature highlights the impact of anxiety on voice production; for example, it increases the fundamental frequency or decreases its variation (reduced intonation)¹⁸⁻²¹. As a result, anxiety can induce a higher-pitched or monotonous voice. Speech, defined as human articulated language, can also be affected by anxiety. For example, disfluencies (interruptions in the flow of speech) increase; specifically, there are more interjections or filled pauses (e.g., uh) and silent pauses, and pauses become longer when the anxiety level increases^{17,18,22-24}. Accordingly, anxious speech sounds less fluent. These changes in voice or speech characteristics during discourse can influence the audience's perception of the speech and the speaker^{1,25}, especially their charisma. For example, disfluency in a politician's discourse is negatively correlated with the audience's judgements of charisma²⁶. Despite the importance of voice and speech parameters during a speech, there is little information in the literature about characteristics of interventions that allow their improvement.

Different interventions have been described in the literature that focus on anxiety without analysing its consequences for voice and speech characteristics. For example, a meta-analysis¹² demonstrated the effectiveness of psychological interventions (e.g., cognitive-behavioral therapy (CBT) combining exposure and cognitive therapies) for participants with PS anxiety disorders.

Improving PS abilities is also a primary function of basic communication courses in elementary²⁷, secondary²⁸ or higher education^{29,30}. Different techniques are employed in this context. For example, in elementary school settings, storytelling activities with a collaborative approach (e.g. presenting in group using a storyboard) can improve fluent storytelling by developing knowledge (e.g., knowing how to structure a speech) and speaking skills (e.g., knowing how to use language)³¹. In secondary school, courses may focus on reducing PS anxiety with a CBT-inspired approach (e.g. shift of attentional focus, exposure)³². With university students, visual imagery activities can enhance the development of nonverbal behaviors related to oral presentations³³. All of these techniques focus primarily on improving the knowledge (theoretical background) and motivation (anxiety) dimensions⁷. The repertoire of PS skills, and especially nonverbal -auditory impressions, seems to be overlooked. The influence of the above-mentioned interventions on voice and speech parameters is not considered much. However, these parameters are key components that influence PS quality. Some PS interventions focus on voice and speech. For example, research findings suggest that awareness training is effective at reducing targeted speech disfluencies in PS⁵, as is habit reversal^{34,35}.

A common classification of voice or speech interventions distinguishes between direct and indirect methods. For voice therapy, direct interventions 'modify vocal behavior through motor execution, somatosensory feedback, and auditory feedback'³⁶, whereas indirect interventions 'include tools that modify the cognitive, behavioral, psychological, and physical environment in which voicing occurs'³⁶. The distinction between direct and indirect interventions also applies to speech therapy. For example, in stuttering treatments like the Lidcombe Program, direct interventions target speech, systematically rewarding fluent utterances and correcting stuttered ones. Indirect interventions, on the other hand, focus on the environment. For example, the Demands and Abilities Model targets the child's environment and attempts to reduce motor, linguistic, emotional, or cognitive demands while building fluency skills³⁷. The presentation and summary of the studies included in this review rely on the distinction between direct and indirect interventions.

To sum up, although studies on PS interventions exist, no review have described the characteristics of interventions that target or affect voice or speech during PS. A scoping review was therefore undertaken to address this gap and provide a robust synthesis of the evidence on this topic. Based on the definition of Munn et al.³⁸, this type of methodology was chosen to identify, map and narratively summarize all interventions. This will provide professionals interested in PS (e.g., speech

therapists, teachers, coaches, and vocologists) with an overview of the characteristics of interventions. This review prepares the ground for more specific questions that can be asked in systematic review³⁹. These questions may relate to the feasibility, appropriateness, meaningfulness or effectiveness of the interventions.

To address our research objectives, the following question was formulated: What is the extent and scope of the literature on interventions that target or affect voice or speech production in PS? In addition, this review focuses on the following sub-questions: Who is targeted by the interventions? What are the content and delivery modalities of the interventions? What outcomes related to voice or speech were reported in the selected studies?

2. Methods

2.1. Protocol and Registration

The research protocol was registered on 22 February 2022, in the Open Science Framework (OSF), see <https://osf.io/chsm9/>. This review was based on the JBI (Joanna Briggs Institute) methodological recommendations for scoping reviews⁴⁰ and was reported according to the Preferred Reporting Items for Systematics Reviews and Meta-analysis extension for Scoping Reviews (PRISMA-ScR) Checklist⁴¹.

2.2. Eligibility Criteria

The JBI Population, Concept and Context (PCC) eligibility criteria⁴² were used to develop the following inclusion criteria.

2.2.1. Population

The entire population was included, that is, participants of all ages (children, adolescents, and adults) with and without disorders (e.g., stuttering, dysphonia, social anxiety). This criterion was defined according to the objective of the scoping review, which was to identify the characteristics of all interventions that target or affect voice or speech.

2.2.2. Concept

The concept examined in this scoping review was interventions that target or affect voice or speech production. The aim of these interventions should be to improve PS skills. However, the delivery modalities of these interventions may or may not include PS in front of an audience. For example, an individual intervention in front of an empty conference room could be included if the goal of that intervention was to improve PS.

2.2.3. Context

This review examined literature about PS, which is any oral presentation made in front of an audience of more than one person (e.g., an oral presentation in front of a class, an audience, or a conference room). This numerical criterion was chosen based on McCroskey's (1997, p. 78)¹⁴ definition of communication apprehension as 'an individual's level of fear or anxiety associated with either real or anticipated communication with another person or persons'. The context of this review was based on the second part of the definition, namely the communication apprehension with more than one person.

2.2.4. Types of Sources

All peer-reviewed intervention studies published from 2000 to the present with pre and post objective (e.g., acoustic measurements, duration of silent pauses, frequencies of disfluencies) or subjective (e.g., self-assessments) measurements of voice or speech were included. The peer-reviewed criterion was established to ensure minimal quality control of studies. Therefore, randomized controlled trials, non-randomized controlled trials, before-and-after studies and case studies were eligible for inclusion. Theses, dissertations or book chapters were excluded. The date range limitation was justified by the fact that tools (e.g., software like Praat or CLAN) for analysing voice and speech have developed and become more accurate. Only studies in English and French were examined since English is the language of science and French is the authors' native language.

2.3. Information Sources and Search

Three bibliographic databases were searched between November and December 2021 to identify relevant literature: Medline ALL/Ovid (1946–2022), PsycINFO/Ovid (1806–2022) and Eric/Ovid (1965–2022). The search strategies (described in Appendix A) were run one last time in March 2022 and were executed with the help of a specialist in evidence synthesis (N.D.) and adapted for each database. Three concepts were targeted — PS, voice, and speech — and we used a set of keywords and controlled terms. These key concepts were related to the Context (PS) and Concepts (voice and speech) of the PCC canvas⁴². A limitation on publication years (from 2000 to the present) was added to the strategy. The reference lists of all articles included in the review were hand-searched for additional relevant papers (the snowball approach).

2.4. Selection of the Sources of Evidence

All identified records were uploaded into Covidence software (Covidence Systematic Review Software; Veritas Health Innovation, Melbourne, Australia) and duplicates were removed. Before we began to select studies, the selection process was tested using 10% of the identified articles to ensure that the reviewers agreed on the inclusion criteria. After this pilot test, titles and abstracts were screened by two independent reviewers (L.B. and P.M.) to determine their potential eligibility according to the inclusion criteria. Then, the full text of the selected papers was retrieved and screened in detail according to the inclusion criteria by the same two independent reviewers. Reasons for excluding sources of evidence at the full-text reading stage were recorded and reported by the reviewers. At both stages, discrepancies between the two reviewers' opinions during the selection process were resolved through discussion or by consulting additional reviewers (A.R. and A.-L.L.).

2.5. Data-Charting Process

Data were extracted from papers included in the scoping review by two independent reviewers (L. B. and P. M.) using Covidence software and following a data charting form developed by the two reviewers. This charting form was pretested on a small sample of studies (n = 5). During this pre-test, the definitions of extracted data were specified and some data were added to the charting form. When the data from the first five articles had been extracted, the reviewers met to ensure the consistency of their extraction. Subsequently, the data recording form was used for the remaining selected studies and described the studies' characteristics.

The data-charting form was developed based on the objectives and questions of this scoping review. Eight main topics were included: (1) study characteristics (e.g., author(s), year of publication, design); (2) participant characteristics (e.g., sample size, age, gender, presence or absence of disorders); (3) aims/purpose of the study; (4) description of the intervention's content and delivery modalities (e.g., type of intervention, characteristics of the PS task, audience's features, number of session); (5) voice and speech measures (e.g., tools used, type, number and characteristics of measurements); (6) primary outcome of the intervention; (7) key findings related to the review questions and (8) study limitations reported by the authors. If necessary, the authors of selected studies were contacted to obtain further information on the description on their intervention so we could complete the data-charting form.

2.6. Critical Appraisal of Individual Sources of Evidence

No critical appraisal of the individual sources of evidence included was done. This approach is consistent with recommendations published by the JBI ⁴².

2.7. Synthesis of Results

To examine, map, and summarize research evidence on interventions that target or affect voice or speech production during PS, a synthesis document was used. This contained different sections related to study characteristics, intervention content and delivery, participant characteristics, voice and speech measures, and relevant intervention outcomes. These will be presented in the result section below.

3. Results

3.1. Selection of Sources of Evidence

A total of 850 references were identified in the three databases, of which 167 were removed because of duplication, 533 following reading of the titles and abstracts, and 128 following the full-text reading. Thus, 22 studies that met the eligibility criteria were included in this review. Additional searches in the reference lists of these studies led to the addition of one other relevant study. At the end of the selection process, 23 studies were included. The full selection process is presented in the PRISMA flow diagram (Figure 1).

[Insert Figure 1]

3.2. Characteristics of Sources of Evidence

The studies selected for analysis were published between 2003 and 2022. The largest number of publications (18 on 23) was recorded after 2015. Of the 23 studies, 17 have a quasi-experimental design defined as ‘studies in which assignment is non-random and influenced by researchers’⁴³. More specifically, 16 are before-and-after studies and one is controlled before-and-after study*. The remaining six are randomized controlled trials (see Table 1).

[Insert Table 1]

3.3. Review Findings

3.3.1. Aims of the Interventions

This section summarizes the results of the 23 studies included in this scoping review. All of the studies sought to determine the outcomes of their intervention using PS tasks. The primary target of

* Controlled before-and-after studies (CBAs) are studies which outcomes are assessed at two time periods for several clusters. Clusters are classified into intervention and comparator groups. Before-and-after studies are similar to CBAs but without data for a control group of clusters (Reeves et al., 2017, pp. 35–36).

these interventions was PS competencies (15 out of 23), the anxiety level (3 out of 23), or both (5 out of 23).

3.3.2. Participants' Characteristics

Sample sizes ranged from 3 to 97 individuals. Almost half of the studies (11 out of 23) had a sample size less than 10. Participants ranged in age from 8 to 73 years. With regard to studies conducted in youth, participants were in elementary school^{8,27,44} or secondary school⁴⁵. Adults were undergraduates^{5,22,34,35,46–55}, graduates^{35,51,53,56} or secondary preservice teachers enrolled in a Diploma of Education program⁵⁷. Note that some studies (3 out of 23) do not provide information on participants' status. No gender predominance was observed in the analysed samples. All authors included both male and female participants.

The majority of studies were conducted in a population without disorders (17 out of 23). The existence of a disorder was mentioned in six articles, namely social anxiety disorder with a primary fear of PS^{18,46,56}, PS anxiety^{45,58} or aphasia⁵⁹.

Of the 23 studies, the predominant language spoken was English (17 out of 23). German^{8,27,34} and Turkish^{44,47} were also spoken by participants. One study¹⁸ did not specify what language participants spoke.

Five studies^{22,49,56–58} mentioned dropout rates. The rate varied from a loss of 10% to about 50% of the participants. For four out of those five studies, the impossibility of contacting the participants again was the cause of dropouts. For the other, participants dropped out because of health problems or overly high anxiety related to exposure therapy (see Appendix B).

3.3.3. Intervention Characteristics

The distinction between direct and indirect interventions on voice³⁶ or speech³⁷ was applied to describe the types of interventions used in the selected studies. Fifteen were direct interventions and eight were indirect interventions.

Direct interventions. Habit reversal therapy was used in eight studies (almost one-third of the selected studies). This therapy generally combines two components: awareness training and competing response training. Awareness training involves defining and detecting the target behavior (i.e., filled pauses, tongue clicks and/or the inappropriate use of the word 'like' or the clause 'you know') during a speech (audio, video, and/or live recording). Competing response training involves producing a concurrent response to decrease the target behavior (i.e., 3-second silent pause for filled

pauses; placing the tongue in a certain position and holding for 3 seconds for tongue clicks; beginning the sentence again without saying 'like' for the inappropriate use of 'like'). Five out of eight studies combined these two components^{34,35,51,53,54}, while three^{5,52,55} used only awareness training. Behavior modeling associated with practice and feedback was used in two studies^{8,27}. Modeling consists of appropriate speaking skill demonstrations by the instructor or via video and audio examples. Following this modeling, practical exercises are applied and feedback (i.e., peer and trainer feedbacks) is given. Practice and feedback were also used in four other studies. The first⁵⁷ used a video-based reflection intervention with four stages: (1) making a presentation (to practice and improve communication skills); (2) personal reflection (to identify communication strengths and areas for improvement); (3) peer reflection; and (4) refinement (to analyse peer feedback and self-reflection to improve PS skills). The three others used either impromptu⁴⁸ or prepared practical speaking activities^{49,50} combined with feedback to improve speech delivery. Feedback was given by the teacher, the tutor or a peer. One study used individual voice training⁴⁷ focused on breathing support, resonance, posture and articulation exercises to improve effective speaking skills.

Indirect interventions. Exposure therapy was used in five out of eight indirect interventions. Two of these studies^{46,56} used psychoeducation about social anxiety disorder (i.e., self-focused attention, perceptions of self and others, perceptions of emotional control, rumination). One⁵⁸ applied pre-exposure verbalization strategies (i.e., affect labelling, positive coping statements or neutral statements). Another utilized repeated practice of speaking tasks²². The fifth relied on participation by a PS club⁵⁹ to give participants the possibility to speak in a supportive environment and develop confidence. Four of these five studies^{22,46,56,58} had a primary objective of reducing speech anxiety. A pharmacological treatment (i.e., a selective serotonin-reuptake inhibitor antidepressant)¹⁸ was also administered with the primary objective of reducing anxiety. A self-modeling intervention⁴⁵ was used by one study. It involves viewing one's own PS videos, which have been stripped of disfluencies and other behavioral manifestations of anxiety. In one study⁴⁴ specific educational games were played to improve speaking skills.

3.3.4. Delivery modalities

The number of intervention sessions was reported in 16 studies. This number was generally about 10 sessions. However, three studies reported a larger number of sessions: 20 sessions⁵¹, 30 sessions⁵⁹ or 45 sessions⁴⁸. Session duration was mentioned in nine studies. Sessions generally

lasted 60 minutes^{5,35,49,52,53} but could also be shorter (i.e., 30 min or 50 min)^{48,56} or longer (i.e., 90 min)^{8,27}. The total duration of the intervention was reported in most studies (16 out of 23). The reported duration was heterogeneous. Some studies mentioned in weeks, ranging from 3 weeks to 20 weeks^{5,18,44–48,52,53,59}; others measured duration in hours, ranging from 2 to 18 hours^{27,35,49,53,56}, minutes (i.e., 38 min)⁵⁵ or years (i.e., one academic year)⁵⁷ (see Appendix C).

Eight studies specified the profile of the trainers providing the intervention. Trainers were usually one or more of the authors^{8,27,44,49–51,53,56} from the field of psychology or educational sciences. A doctoral student and a licensed psychologist were involved in one study⁵⁶.

3.3.5. Audience

The audience size was mentioned for 12 of these direct and indirect interventions. The audience consisted of either one person (i.e., the researcher)^{35,45,51–53,55} or several people^{5,46,50,54,56,58}. Audience size ranged from 2 to 100 members. Some studies also used virtual reality (e.g., a virtual classroom with approximately 35 members or a virtual auditorium with 100 members)^{46,56} or pre-recorded video footage of a classroom audience⁵⁸. Three of the remaining studies did not give a numerical value for the size of the audience^{27,48,59} and eight^{8,18,22,34,44,47,49,57} provided no information about audience size (see Appendix D).

3.3.6. Speech Characteristics

The speech topic used in the intervention was specified in 13 studies. Participants were asked to speak about a general (e.g., school uniforms, telephones)^{48,50,58,59}, personal (e.g., self-introduction, past trip)^{35,51,54,55,57}, or scientific topic (e.g. description of a scientist's day)^{46,56} or one related to their academic field (e.g. a topic in applied behavior analysis)⁵¹. The speech could also concern a specific book⁴⁴ or text⁴⁷. The speech duration was controlled in 11 of 23 studies. The duration imposed on the participants might be specific (e.g., 1 min, 3 min, 5 min) or a value within a time range of one to six minutes (e.g., 1 to 3 min, 3 to 5 min, 4 to 6 min).

The speech preparation time during the intervention was controlled in eight studies. The allowable preparation time ranged from a just few minutes (e.g., 3 min, 5 min)^{5,48,52,54,58} to several minutes (e.g., 10 min)^{35,55} to one week⁵⁷. The speech preparation method was mentioned in nine studies. Several of them allowed participants to make an outline or prepare notes without scripting their speech^{5,35,48,50,52,54,55,58}. Collaborative preparation was also permitted with peers⁵⁰ or family members⁵⁹ (for more details, see Appendix D).

3.4. Reported Outcomes of Interventions

3.4.1. Terms Used for Voice and Speech Characteristics

Because the included studies come from diverse research fields (e.g., psychology, education), they used different terms to label voice and speech characteristics. These terms are listed in Table 2 and grouped under a single dedicated appellation that we will use to describe the interventions' outcomes.

[Insert Table 2]

3.4.2. Characteristics of Pre- and Post-Intervention Conditions

In line with one of the inclusion criteria of this scoping review, all of the selected studies included pre- and post-intervention voice or speech measurements that can be considered as baseline measures. To obtain these measures, participants were asked to give a speech. The speech topic was reported by the majority of studies (20 out of 23) and was quite similar in pre- and post-intervention sessions (except for studies three studies)^{22,48,50}. As it was the case for speech topics during intervention (see section 3.3.6), the thematic speeches focused on a personal presentation^{22,48,57}, experience^{18,51,55} or opinion^{35,45,54,55}. The topic could also be general^{5,44,52,58}, academic^{34,51}, political⁴⁷, controversial^{46,56} or scientific^{8,27}.

The audience size was mentioned in 16 studies, ranging from one person (i.e., the researcher)^{8,27,35,51,53,55} to a few (e.g., 2 persons) or several people with a maximum of 25 persons⁴⁵. The audience size was similar in pre- and post-intervention conditions.

The speech duration was monitored in the pre- and post-intervention conditions by 17 studies. A specific duration (e.g., 1 min, 2 min, 3 min) or a measure included in a time interval (e.g., 1 to 3 min, 3 to 5 min) was imposed on some participants, who were therefore characterized by similar pre- and post-intervention duration. One study controlled only the post-intervention speech time⁴⁸ and five others did not report any information on duration^{8,27,47,49,50}.

The speech preparation time during pre- and post-intervention sessions was controlled in 18 studies and was similar in both conditions. The preparation duration ranged from a few seconds (e.g., 30 s)⁴⁴ to a few minutes (e.g., 2 min, 3 min, 5 min)^{5,45,46,52–54,56,58} or several minutes (e.g., 10 min, 15 min, 20 min)^{8,18,27,34,35,51,55} up to one week of preparation (e.g., 1 week)⁵⁷. The amount of time spent on speech preparation was fairly similar to that for the intervention sessions (see section 3.3.6). For one study²², participants were allowed a time interval ranging from 15 to 120 minutes.

Concerning speech preparation methods, 20 studies provided information on pre- and post-intervention preparation conditions and one study⁵⁰ provided only post-intervention information. During preparation, participants were allowed to individually prepare their speech, for example: make an outline or prepare notes^{5,35,45,46,48,50-56}, take time to think⁴⁴ or practice a few times (i.e., at least 10 times)⁴⁸. The help of external resources was also accepted, such as using a chapter from a reference book and consulting the Web^{34,51}, or using a page with questions and answers to guide the preparation of the speech⁵⁸. Collaborative preparation was also allowed with peers^{8,27} or family members⁵⁹.

3.4.3. Voice and Speech Measures in Pre- and Post-Intervention

To observe the PS intervention's outcomes for voice or speech, the authors took different measurements in pre- and post-intervention condition. The majority of the selected studies (18 out of 23) evaluated both speech and voice. Only five^{34,35,46,56,59} focused solely on speech. More qualitative measures than quantitative measures were used.

Qualitative evaluations were based on the completion of a self-report^{22,27,49-55} or hetero-assessed (e.g., assessment by audience members)^{8,22,27,44,47-49,57-59} questionnaire. These questionnaires targeted both speech and voice. They may have been created specifically for the study^{8,22,27,44,51,57,58} or previously developed by other researchers^{47-55,59}. When created for the study, these questionnaires used Likert scales to assess PS through the observation of target behaviors related to voice (intonation, SPL, breath support, f_0 , others), speech (disfluencies, speech rate, length of speech, quality of articulation) or other components (e.g., body movements, eye contact). These target behaviors (related to voice, speech and other components) were also assessed with validated questionnaires developed prior to the studies. Five of the studies selected⁵¹⁻⁵⁵ used the *Public Speaking Ability Questionnaire*⁵¹, which examines behaviors related to voice and speech such as SPL, disfluencies and speech rate. The quality of PS was also evaluated with other questionnaires focusing on some voice or speech target components. The *Public Speaking Competence Rubric* (PSCR)⁶⁰ assesses intonation, disfluencies, speech rate and quality of articulation⁴⁸. A revised version of the *Speech Efficacy Questionnaire*⁶¹ was used; this questionnaire focuses on intonation, SPL, speech rate and quality of articulation⁵⁰. The *Behavior observation form*⁶² evaluates intonation, breath support and speech rate⁴⁷. The *Oral communication Assessment Rubric* (OCR, The University of

Southern Mississippi) rates intonation, SPL, disfluencies and speech rate⁴⁹. The *Linguistic Communication Measure*⁶³ is a more specific questionnaire to assess PS in people with aphasia⁵⁹.

Quantitative evaluations relied on listening to audio or video recordings to measure a target behavior related to speech^{5,22,34,35,46,51–56,58,59}, namely disfluencies (e.g. percentage of interjections based on the total number of syllables, rate of filled pauses/min), speech rate (e.g., number of spoken words/min) or length of speech (e.g. length of speech/min). Finally, specific software (Praat, 1998) was used in two studies^{18,22} to obtain objective voice measures such as f_0 (e.g., mean f_0), intonation (f_0 max, f_0 SD), SPL (e.g. intensity mean in decibels) and speech measures such as speech rate (e.g. syllables/second, number of syllables/total duration of speech produced).

3.4.4. Other Pre- and Post-Intervention Measures

For 21 out of 23 studies, other measures (other than voice and speech) were taken in the pre- and post-intervention conditions. These measures could be qualitative or quantitative.

For qualitative measures, half of the studies (11 out of 23) assessed anxiety with standardized questionnaires or instruments developed for the study. Among standardized questionnaires, participants' trait -anxiety was assessed with the Personal Report of Confidence as a Speaker (PRCS)⁶⁴, Personal Report of Communication Apprehension (PRCA)⁶⁵, Personal Report of Public Speaking Anxiety (PRPSA)⁶⁶, Brief Fear of Negative Evaluation (BFNE)⁶⁷, or Behavioral Assessment of Speech Anxiety (BASA)⁶⁸. State -anxiety was measured using the State-Trait Anxiety Inventory (STAI)⁶⁹ or Subjective Units of Distress Scale (SUDS)⁷⁰. Performance anxiety was also measured with the Performance Anxiety Questionnaire (PQ)⁷¹. The questionnaires created by the authors measured state -anxiety with visual scales^{22,44} or a closed-ended questionnaire⁵⁰. The participants' impressions (confidence, comfort level, perception of changes), motivation, expectations or capabilities were also taken into account by several studies^{5,22,34,35,45,47,51,52,54,57}. The questionnaires used to assess these components were usually the same ones used to qualitatively assess voice or speech. Indeed, more than half of the studies^{5,8,22,27,35,45,49,51–55,57} used a questionnaire that combines analyses of voice, speech, and other measures.

As for quantitative measures, only one⁵⁸ study assessed heart rate with a tracker worn on the wrist of participant's non-dominant hand.

These qualitative and quantitative measures of voice, speech and other factors during pre- and post-intervention conditions enabled the authors to highlight, the PS intervention's outcomes. The

outcomes of direct interventions will be presented first, followed by those of indirect interventions. Note that a purely narrative summary will be provided in relation to the objective of a scoping review.

3.4.5. Outcomes of Direct interventions for Voice, Speech and Other Measures

Eight studies^{5,34,35,51-55} used habit reversal therapy to improve their participants' PS skills. Following this type of intervention (which might or might not combine awareness training and competing response), all studies reported a reduction in the rate of targeted disfluencies (e.g., filled pauses such as 'ums', 'uhs' or inappropriate use of 'like'). In six of those studies^{5,51-55}, an improvement in the overall self-measured score for general PS skills was also observed, including the evaluation of voice (e.g., SPL), speech (e.g., disfluencies, speech rate) and other measures (e.g., eye contact, confidence, and comfort level). However, it should be noted that one study⁵ observed an idiosyncratic increase in untargeted disfluencies (e.g. repetitions) in parallel to the decrease in targeted disfluencies.

Behavior modeling associated with practice and feedback^{8,27} had a positive influence on the appropriateness of overall performance (measured by external evaluators). In addition, this training had positive outcomes on the participants' self-perceived PS skills. Regarding voice, breath support did not improve⁸ or even deteriorated²⁷. These two studies presented contradictory results. One study²⁷ highlighted an improvement in speech fluency and visual nonverbal behavior (posture, gesture, eye contact, proxemics) while the other⁸ did not.

Four studies^{48-50,57} used only practice and feedback. This type of intervention had a positive impact on PS competence. The different questionnaires these studies administered highlighted an improvement in voice (measured with items targeting intonation and SPL), speech (measured with items focusing on disfluencies, speech rate, and quality of articulation) and other components of PS (such as body language, confidence, congruence between voice, words and body).

The individual voice training employed in one study⁴⁷ resulted in an improvement in voice, more specifically intonation, breath support and resonance. This training also improved speech, namely speech rate and quality of articulation (for more descriptive details, see Appendix E).

3.4.6. Outcomes of Indirect Intervention for Voice, Speech and Other Measures

Four studies^{22,46,56,58} applied exposure therapy with the primary objective of reducing speech anxiety. Three of them^{46,56,58} looked at length of speech (time spent speaking by participants) and found conflicting results, either an increase in speech duration following the intervention^{46,56} or a

decrease⁵⁸. One of them²² focused on other voice- (i.e., intonation, SPL, f_0) and speech-related features (i.e., disfluencies and speech rate). It highlighted a decrease in excessive pitch variations (intonation) and disfluencies and an increase in speech rate. It also showed that, when participants had more time to practice before delivering their speech, they experienced fewer total disfluencies and less excessive intonation variation. A reduction in self-reported anxiety^{56,58} and self-reported social anxiety disorder symptoms (measured by the BFNE)⁴⁶ was observed. An improvement in personal reports of confidence as a speaker (measured by the PRCS)⁵⁶ was also observed. An intervention for people with aphasia⁵⁹ used exposure therapy in a PS club. This type of intervention increased the length of speech (number of words produced during speaking time) and facilitated improved language skills.

One study¹⁸ applied a pharmacological treatment that decreased the level of anxiety experienced (measured by the SUDS) and had positive results on voice and speech; a decrease in the average f_0 and in the maximum value of f_0 was observed, along with an increase in the speech rate (linked to a decrease in silent pauses during the speech).

A self-modeling intervention (i.e., viewing one's own PS stripped of disfluencies and other behavioral manifestations of anxiety) was used in one study⁴⁵. Its results showed a decrease in the total score on the BASA including measures of voice (intonation, stress of mouth and throat), speech (disfluencies) and other measures (facial expression, body movement, anxiety). A reduction in self-reported PS anxiety (measured by the PRPSA) and self-reported state anxiety (measured by the STAI-S) was also reported.

Another study⁴⁴ used specific educational games to improve speaking skills. The results showed an improvement in two variables; style (which the authors defined as sound, speed, self-confidence, repeating words, prolonging the ends of words, and making sounds like 'eee/aaa/hmmm' in pauses) and speaking sounds (consisting audibility and significance). However, little information is given on the influence of the subcomponents contained under each of these rubrics (for more descriptive details, see Appendix F).

3.5. Generalization phase and follow-up

In addition to these pre- and post-intervention measures, five studies^{35,52-55} included generalization measures. The generalization phase is characterized by a change in condition from the pre- and to the post-intervention period, such as a new presentation topic, a new presentation context

or the presence of an audience. Only two^{53,55} made voice and speech measurements during these generalization phases. These studies showed that intervention outcomes (i.e., reduction in disfluencies) generalized to a new context for a portion of their sample.

Seven studies^{5,34,45,51–53,58} provided follow-up measures obtained by the production of a speech in conditions similar to those conducted in the baseline sessions. Measures of speech or other measures were taken after a few days, a few weeks or a few months. All of these studies observed the maintenance of a low rate of target disfluencies, as observed in the post-intervention session. Some found that a reduction in speech rate⁵ or length⁵⁸ was maintained. For the other measures, the decrease in state -anxiety was maintained at follow-up⁴⁵.

3.6. Limitations Reported in Selected Studies

A small sample size is the most common limitation reported by the authors (13 out of 23). Almost half of the studies had fewer than 10 participants (11 out of 23). Moreover, limits regarding the representativeness of the sample (i.e., the likelihood that the sample accurately reflects the characteristics of the general population) are mentioned^{5,18,22,27,45,49,56,57}, which decreases the probability that the results can be generalized. For example, in one study⁵⁶, participants had a lower rate of comorbidity than is typically found in individuals with social anxiety disorder. In other words, only 33% of the study sample had a secondary diagnosis such as specific phobia, depression or generalized anxiety disorder. Study authors also indicate limits related to study design, such as the lack of a control group^{46,59} or generalization phase^{53,57}. Variability in pre-intervention measures^{5,8,18,22,34,35,53,58}, dose of exposure between experimental conditions⁵⁶ and topic of PS task^{27,55,58} are also reported as limits. For instance, the difficulty of the self-chosen PS tasks should have been evaluated prior to presentation in order to include only topics of equal difficulty³⁵. A short implementation time for the intervention or the presence of confounding variables might also be considered as limitations^{27,44,57}. For example, in one study⁵⁷, participants were exposed to concurrent classroom experiences throughout the year, which might have impacted the conclusions drawn from this intervention. Finally, the small size audience or the lack of any audience are mentioned in several studies^{5,52,53,57}. For example, the authors of one study⁵³ advise future researchers to examine the effects of interventions in the presence of larger or different audiences (e.g., potential employer or professor), during longer speeches and in different contexts (e.g., conferences, class presentation).

4. Discussion

The primary objective of this scoping review was to identify, map and narratively summarize all interventions that target or affect voice and speech production in PS. To meet this objective, 23 studies with pre- and post-intervention measures were selected. We will now discuss some aspects related to the main research question and the three sub-questions, and potential limitations.

4.1. Main Research Question: Extent and Scope of the Literature on Interventions That Target or Affect Voice and Speech Production in PS

Twenty-three studies were examined. Most of them featured a quasi-experimental design in which assignment is non-random and researcher-influenced. The remainder (about a quarter) used an experimental design, namely a randomized controlled trial. The greater prevalence of quasi-experimental designs may be explained by their methodological ease. According to a review⁷², a quasi-experimental design is faster, less expensive and has more external validity. However, this type of design provides a lower level of evidence than experimental design. Indeed, their internal validity (defined as a measure of strength of the cause-and-effect relationship between the intervention and its outcome) is lower, leading to a greater risk of bias in their results⁷³.

In most of the studies included, the objective was to improve speaking skills. However, some studies had the primary goal of reducing anxiety levels, while considering the consequences of this reduction on voice or speech. And some studies combined the two objectives of improving PS skills and reducing perceived anxiety. Combining anxiety and voice or speech in a PS intervention is not surprising in the light of the literature. The selected databases (Medline ALL/Ovid, PsycINFO/Ovid, and Eric/Ovid) have research areas close to these topics. A search of other databases such as Scopus (a multidisciplinary database) or Linguistic and Language Behavior Abstracts (LLBA, a linguistic database) may be recommended in future to provide further studies combining anxiety and voice or speech.

To achieve their objective, the authors employed direct or indirect interventions. Direct intervention was used in the majority of the studies selected in this scoping review. Such interventions often have the objective of improving PS. When the primary goal is anxiety reduction, interventions are generally indirect. This is consistent with the distinction made in the literature^{36,37} that direct interventions explicitly target the voice or speech, while indirect interventions target the cognitive, behavioral, psychological or physical environment impacting the speaker's productions. This type of intervention is therefore more implicit at the level of voice or speech.

4.2. First Sub-Question: Individuals Targeted by the Interventions

The age range of the participants included in the studies is broad (from 8 to 73 years old). This is consistent with literature^{1,3,5}, which emphasizes that PS is useful at any age and important in daily and educational or professional life. However, each study selected in this scoping review focuses on a specific age range to allow adequate comparisons among voice and speech measures. According to a study⁷⁴, the rate of disfluencies varies with age. Repetitions of words, revisions and interjections are more frequent in older than in younger adults due to age-related cognitive, perceptual and motor modifications⁷⁴. Regarding voice, it is well-known that mean f_0 depends on the speaker's age, among other components⁷⁵. From a mean f_0 of 500 Hz at birth, voice pitch drops at puberty to 258 Hz for females and 166 Hz for males⁷⁶. These considerations justify the authors focusing on a specific age range when conducting PS interventions that target voice or speech.

There was no predominant gender among participants. All authors included both males and females to analyse the consequences of intervention without distinguishing between their results. However, the literature points out that gender can impact voice or speech. For example, some studies have found a greater rate of disfluencies in males⁷⁴ while others do not report any differences in fluency between genders^{77,78}. Voice intonation may also differ between males and females^{79,80}. Consequently, it would probably be relevant to consider this variable in future studies.

Most studies enrolled undergraduate or graduate students recruited from the authors' own university. The predominance of university students can be explained by the need for graduates of higher education to acquire the PS skills necessary in many professions^{1,3,5}. However this may constitute a bias due to this population's specific cognitive abilities and compliance⁸¹. Conducting studies on participants less familiar with PS would probably be useful.

Regarding the language spoken by the participants, the majority of the studies were conducted in English. However, speech fluency can differ from one language to another⁷⁸. For example, a study⁸² showed that, among adults, filled pauses occurred more frequently in French than in English. Moreover, they suggest that such disfluencies could be less stigmatized in French since they also occur in formal contexts. Another study⁸³ found a higher rate of within-word disfluencies in Swedish than in English. Based on these findings, the results obtained by English-language studies on voice or speech should be considered with caution when planning interventions for other languages.

4.3. Second Sub-Question: Content and Delivery Modalities of the Interventions

The content of the interventions was heterogeneous. Among direct interventions, habit reversal therapy (HRT) was the most commonly used therapy; it aims to improve PS skills by reducing speakers' disfluencies (called target behavior). In the literature, HRT is considered an effective multicomponent behavioral intervention designed to reduce the manifestations of disorders related to habits (e.g., nail biting, thumb sucking), tics (e.g., Tourette's syndrome) or pathologies (e.g., stuttering)⁸⁴. It generally consists of three phases: (1) awareness training, (2) competing response training, and (3) generalization. In this scoping review, half of the studies using HRT combined all these phases. The other half used two of the three phases, namely awareness training combined with concurrent response training or generalization. This reduction in the number of phases is consistent with the fact that HRT is a lengthy and very comprehensive procedure⁸⁴. The reduction in the number of phases presented to the participants does not seem to have had an impact on their achievement of the objective defined before the beginning of the intervention (i.e., the reduction of a target behavior). In this scoping review, no HRT-type interventions targeting voice in a PS context were identified. It would therefore be interesting to investigate this type of intervention for PS in future studies.

Behavior modeling was another indirect intervention identified in this scoping review. One of the most widely used and studied interventions in psychology⁸⁵ is behavioral modeling training. This approach combines (1) learning strategies through the presentation of models that demonstrate the effective use of behaviors, and (2) opportunities to practice these behaviors by receiving feedback and social reinforcement.

Opportunities to practice by receiving feedback without modeling are also provided in other studies. Feedback plays a central role in learning and instruction. However, in the studies included in this scoping review, little information is provided about the type, dosage and reactivity of feedback given, even though these characteristics have an impact on learning⁸⁶.

A fourth type of direct intervention was also applied in some studies: individual voice training. The exercises proposed in this therapy are quite similar to those used in other studies⁸⁷, in which vocal self-knowledge, breathing, vocal expressiveness, etc., are developed.

As for indirect interventions, exposure therapy (ET) is the most frequently used technique among the studies reviewed in this scoping. Its primary objective is to reduce anxiety. The observation of this type of intervention in a PS context is consistent with the literature. Indeed, ET is part of CBT for anxiety-based disorders. It aims to associate a new memory with feared situations through repeated,

progressive and controlled exposure in order to reduce the associated anxiety^{88,89}. In the literature, ET, or repeated approaches toward fear-provoking stimuli, has been a mainstay of CBT for anxiety disorders⁸⁸. It has been proven to be an effective treatment strategy for such disorders^{88,90} and specifically for PS anxiety disorder⁹¹. In addition, studies^{92,93} have shown that affect labelling enhances the effectiveness of exposure. This affect verbalization technique associated with ET was applied in one of the studies identified in this scoping review⁵⁸. Virtual reality associated with ET is also used. The literature⁵⁶ highlights its clinical interest (e.g., treatment acceptability) and its methodological interest (e.g., control of the proposed environment).

One study applied a self-modeling intervention. According to the literature⁹⁴, self-modeling is an effective technique. However, care must be taken with the content of the videos used by removing unwanted behaviors (e.g., the production of disfluencies during a speech). The aim of self-modeling is to focus on positive aspects that lead to a cognitive change, improving participants' skills⁹⁵. Unwanted behaviors were in fact suppressed in the study identified in this scoping review. Pharmacological treatment and specific educational games were other interventions applied.

4.4. Third Sub-Question: Reported Outcomes

In this sample of studies, both qualitative and quantitative measures of voice or speech were used in pre- and post-intervention conditions to observe interventions' outcomes. However, qualitative measures were employed more often than quantitative measures. Nevertheless, an evaluation combining both types of measures can provide a more in-depth description of voice or speech production⁹⁶. In future studies, it would be interesting to observe the relationship between quantitatively observed speech behaviors (e.g., intonation or disfluencies) and the speaker's or audience's qualitative perception of them.

Qualitative measures were based either on questionnaires created for the studies or on existing questionnaires (norm-referenced tests). When questionnaires were created, a complete psychometric evaluation was not performed in any of the studies. The authors mention some psychometric criteria such as face validity, convergent validity, criterion validity, inter-rater reliability, or internal consistency. But some mandatory criteria⁹⁷ for constructing a questionnaire are not mentioned: assessment of construct validity, criterion validity and reliability, or internal consistency. A lack of precision in the psychometric criteria considered when constructing a questionnaire affects its validity.

Quantitative measures were based on audio or video recordings to assess voice or speech. The selected studies provide little information on the recording materials and methods. However, the literature highlights the influence of the material on recording quality. Future studies should follow the recommendations made in some reviews^{98,99}. In addition, the use of specific software (i.e., Praat) to obtain objective voice measures is infrequent in the selected studies. None of the authors mention using specific software for speech analysis; for example, the tool used to count disfluencies is not described. However, some have been mentioned in the literature (e.g. CLAN software)¹⁰⁰. The specific software used should be mentioned in the methodology of future studies.

As for the interventions' outcomes for voice or speech, the proposed interventions and the related measures are heterogeneous, as another study¹⁰¹ also noted concerning the interventions offered during voice training for healthy individuals. This heterogeneity makes it harder to draw general conclusions related to interventions' effects on voice and speech. From a purely descriptive point of view, all the interventions identified in this scoping review seem to have had an improvement in general PS competence regardless of their type (direct or indirect) or primary target (speech, voice or anxiety). However, some studies using the same type of intervention obtained conflicting or unexpected results (e.g., an increase in untargeted disfluencies after HRT), which will need to be resolved by future studies. Note that this review did not carry out any statistical or critical analyses of the interventions' outcomes, as this is not the purpose of a scoping review. The results reported in this review should be regarded as indicative. Following this scoping review, a systematic review is recommended to statistically analyse the interventions' effects. This paper offers an initial methodological synthesis that will serve as a basis for further research. Future investigations of the effectiveness of these interventions using statistical analysis (e.g., in a systematic review or meta-analysis) should help generate clear guidelines for clinical and educational practice.

4.5. Limits

The limits of this scoping review are twofold. The first one concerns the search strategy. Broad terms for the Context (PS) and Concepts (voice and speech) of the PCC framework were used in relation to this review's exploratory purpose. However, references indexed with more specific terms related to voice (e.g., pitch) and speech (e.g., pauses) may not have been retrieved. Furthermore, during our searches, we found that some authors considered the term 'Oral Presentation' to be synonymous with PS. Because this term is very broad, it would have resulted in too many references

not specifically related to our research question. However, it could be used in the search strategy of a systematic review to assess the effectiveness of interventions. With this objective, an additional search in a general database (e.g., Scopus, LLBA), a register of interventional studies (e.g., ClinicalTrials.gov) or the grey literature may be recommended.

The second limitation concerns the characteristics of the studies identified: because of the exploratory objective of this review, a certain heterogeneity in the characteristics of participants, interventions and measures was observed. The formulation of more specific questions with a less exploratory aim seems valuable following the inventory carried out in this scoping review.

4.6. Conclusions and Prospects for Future Research

This scoping review identified 23 studies on interventions targeting or affecting voice or speech in a PS context. The results reveal heterogeneity in the types of interventions, the measurements of voice or speech, and other components involved in PS (e.g., level of state -anxiety). Habit reversal therapy is the most common direct intervention, while exposure therapy is the most common indirect intervention. In a purely descriptive way (without statistical analysis), this review reveals that the interventions reported on in all the selected studies had positive impacts on PS skills. However, further studies should be conducted to determine whether these outcomes are significant and which interventions are most effective, taking into account the speaker's profile (e.g., gender, age, status, disorder, etc.) and the PS context (e.g., audience size, speech topic, length of speech, etc.).

This scoping review constitutes the first published methodological summary of PS interventions targeting or affecting voice or speech. Recommendations for further studies can be made. Firstly, voice and speech should be more thoroughly assessed via qualitative and quantitative measures. In qualitative assessment, consideration of the psychometric characteristics of the questionnaire selected or developed for the study is recommended. Currently, these questionnaires provide an overall score that includes measures of voice, speech and other components related to PS competence. Analysis of this global score shows that, in general, PS skills have improved. However, it does not indicate which specific components have improved. The use and analysis of sub-scores would be relevant. For quantitative evaluation, a description of the recording material (e.g., microphone) and the acoustic characteristics of the environment (e.g., background noise) is recommended, as these factors influence the quality of sound recordings. Secondly, based on the distinction between direct and indirect voice and speech interventions made in this scoping review, it

would be interesting to identify current clinical practices, i.e., the use and prevalence of direct, indirect or mixed interventions, and the facilitators and barriers to each, through a practice survey.

To conclude, this scoping review has enabled us to answer the main research question and the three sub-questions. It could also serve as a basis for other studies of PS.

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Author contributions

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Declaration of competing interest

The authors declare no conflict of interest.

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Tables

Table 1

Design Characteristics of the Included Studies

No.	Author(s)	Year	Design				
			RCT	CBA	BA	FU	GP
5	Montes et al.	2019			X	X	
8	Herbein, Golle, Tibus, Zettler et al.	2018	X				
18	Laukka et al.	2008	X				
22	Goberman et al.	2011			X		
27	Herbein, Golle, Tibus, Schiefer et al.	2018	X				
34	Bördlein & Sander	2020			X	X	
35	Pawlik & Perrin	2020			X		X
44	Asan & Çeliktürk-Sezgin	2020		X			
45	Rickards-Schlichting et al.	2004			X	X	
46	Anderson et al.	2017	X				
47	Bozkurt et al.	2018			X		
48	El Mortaji	2018			X		
49	Knight et al.	2016			X		
50	Liao	2014			X		
51	Mancuso & Miltenberger	2016			X	X	
52	Montes et al.	2021			X	X	X
53	Ortiz et al.	2022			X	X	X
54	Perrin et al.	2021			X		X
55	Spieler & Miltenberger	2017			X		X
56	Anderson et al.	2013	X				
57	Cavanagh et al.	2014			X		
58	Plaisted et al.	2022	X			X	
59	McCann et al.	2021			X		

Note. No. = number listed in the references; RCT = Randomized controlled trial; CBA = Controlled before-and-after study; BA = Before and after study; FU = Follow-up; GP = Generalization phase

Table 2

List of Appellations Used in This Scoping Review and Their Corresponding Terms in The Review Studies

	Appellation in the scoping review	Terms used in other studies
Voice	Intonation	18: f_0 max, f_0 SD 22: Pitch variation, f_0 SD 47: Stress and Intonation 49: Intonation 57: Melodic variety and intonation
	Sound pressure level (SPL)	5, 52, 53, 55: Voice projection 18, 48, 49, 50: Intensity 22: Loudness 51, 57: Volume
	Breath support	5, 22, 52, 53, 55: Breathing 8, 27: Speech respiration 47: Breathing patterns
	Fundamental frequency (f_0)	18: f_0 mean 22: Pitch, mean f_0 45, 48, 50, 58: Tone
	Others	18: Vocal quality 44: Control of voice 45: Stress of mouth and throat 47: Resonance
Speech	Disfluencies	5, 8, 27, 45, 51, 52, 53, 54, 55: Fluency 5, 22, 34, 35, 51, 52, 53, 54, 55: Rate of disfluencies/min 44, 48, 49, 57, 58: Disfluencies
	Speech rate	5, 18, 22, 48, 49, 50, 51, 52, 55: Speaking rate 5, 53: Number of spoken words/min 22: Articulation rate 47: Speech speed 57, 58: Pace
	Length of speech	8, 27, 46, 56: Length of speech in min 58: Time spent speaking in min 59: Number of words
	Quality of articulation	44, 47, 50: Pronunciation 48, 50: Articulation 57: Enunciation

Note. The numbers in this table refer to the number in the references.