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Reference speech samples for glotal stop identification

Amostras de referência para identificação da oclusiva glotal

Muestras de referencia para la identificación dela oclusiva glótica

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Abstract

Objective: To establish anchor samples consisting of speech recordings of individuals with history of cleft lip and palate, rated by multiple evaluators as representative of the use of the glottal stop. **Methods:** A total of 480 phrases with plosive and fricative sounds were rated by three experienced speech language pathologist (SLPs) to identify use of glottal stops. The samples were rated individually and those without consensus regarding the use of glottal stops were rated simultaneously by the same evaluators. The samples rated with consensus by the evaluators, regarding the presence or absence of glottal stops during the production of plosive and fricative sounds, were selected to establish anchor samples representative of use of glottal stops. **Results:** A total of 352 samples were rated with consensus by all evaluators. Of these, 120 phrases were representative of the adequate place of production of plosive and fricative sounds and 232

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DCRC - Elaboration and design of the study, data collection, analysis and interpretation of the data and also the elaboration and revision of the article.
VCCM - Involved in the design of the study, the analysis and interpretation of the data and also the preparation and revision of the article.
TAG and MIP-K - Involved in data analysis and interpretation
JCRD - Involved in data collection, analysis and interpretation of data and also in the production and revision of this article.

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were rated as representative of the use of the glottal stops. **Conclusion:** Anchor samples representative of presence and absence of glottal stops for plosive and fricative sounds were established with consensus between multiple evaluators. These anchor samples can be used in future studies involving training of evaluators and preparation of speech language pathologists.

Keywords: Cleft palate; Articulation Disorders; Speech production measurement.

Resumo

Objetivo: Estabelecer um banco de amostras de referência constituído por gravações de fala de indivíduos com história de fissura labiopalatina, julgadas, por múltiplos avaliadores, como representativas do uso da oclusiva glotal. **Método:** Três fonoaudiólogas experientes julgaram 480 frases compostas por sons oclusivos e fricativos, quanto à identificação da oclusiva glotal. As frases foram julgadas individualmente e aquelas que não apresentaram consenso inicial foram novamente julgadas de maneira simultânea pelas mesmas avaliadoras. As amostras julgadas com consenso pelas avaliadoras, com relação à presença ou ausência da oclusiva glotal durante a produção dos sons oclusivos e fricativos, foram selecionadas para estabelecer o banco de amostras de referência. **Resultados:** Os julgamentos realizados evidenciaram consenso das avaliadoras em 352 amostras. Destas, 120 frases eram representativas da produção adequada para os 12 sons de interesse e 232 eram representativas do uso da oclusiva glotal. **Conclusão:** Um banco de amostras de referência representativas da oclusiva glotal foi estabelecido a partir do consenso de avaliadores múltiplos. As amostras de referência poderão ser usadas em estudos futuros envolvendo treinamento de avaliadores e formação de fonoaudiólogos.

Palavras-chave: Fissura palatina; Transtornos da articulação; Medida da produção da fala.

Resumen

Objetivo: Establecer un banco de muestras de referencia constituido por grabaciones de habla de individuos con historia de fisura labiopalatina, juzgadas por múltiples jueces, como representativas del uso de la oclusiva glótica. **Método:** Un total de 480 frases compuestas por sonidos oclusivos y fricativos fueron juzgados a respeto de la identificación de la oclusiva glótica, por tres fonoaudiólogas conexperiencia. Las frases fueron juzgadas individualmente y aquellas que no presentaron un consenso inicial fueron juzgadas nuevamente de manera simultánea por las mismas juezas. Las muestras juzgadas en consenso por las juezas, con relación a la presencia o ausencia del oclusiva glótica durante la producción de sonidos oclusivos y fricativos, fueron seleccionadas para establecer el banco de muestras de referencia. **Resultados:** Los juzgamientos realizados evidenciaron consenso de las juezas en 352 muestras. De estas, 120 frases eran representativas de la producción adecuada para los 12 sonidos de interés y 232 eran representativas del uso de la oclusiva glótica. **Conclusión:** Un banco de muestras de referencia representativas de la oclusiva glótica fue establecido a partir del consenso entre jueces múltiplos. Las muestras de referencia podrán ser usadas en futuros estudios envolviendo entrenamiento de jueces y preparo de fonoaudiólogos.

Palabras claves: Fisura palatina; Trastornos de la articulación; Medida de la producción del habla.

Introduction

Cleft lip and palate (CLP) is one of the most common craniofacial congenital anomalies. It affects velopharyngeal structures and function thus requiring surgical procedure of the palate around the baby's first year. The aim of the surgery is to assist the normal development of speech. Primary cleft palate repair do not always promote appropriate velopharyngeal function, which results in Velopharyngeal Dysfunction (VPD) in approximately 30% of those individuals [2].

Disorders of speech resulted from CLP or DVF are directly related to structural defects that involve hypernasality (nasal air escape) and/or weak intraoral pressure while obstruent consonants are produced. Besides those disorders, it may also be present atypical production from structural alterations at the initial phases of speech-language acquisition. In such productions the oral consonants are performed posteriorly to the vocal tract, pharynx or glottis[3,4]. Most commonly it affects high-pressure sounds (plosive, fricative and affricate) [3,5].

The errors in the production of consonants were named compensatory articulation (CA) by Trost, in 1981[6]. They are also known in European literature as non-oral cleft palate speech characteristics [7,8]. A group of authors proposed a classification of consonant production errors related to CLP or VPD as production errors in pre-uvular and postuvular articulatory places[9]. Among the postuvular errors, the glotal stop (GS) is considered the most atypical production found in the speech of individuals presenting CLP or VPD[10]. The CA of GS type is produced by the abduction of the vocal folds (increase of the air pressure generated by the subglottic area), which is followed by an abrupt release of the airflow. GS is generally used in substitution to plosive sounds[2,3,] although it may be also used in substitution to fricatives and affricates[2,10], mainly when the child has not acquired the fricative phonemes in their linguistic repertoire[2].

The identification of CA in speech-language pathology assessment is crucial to an effective plan of care for individuals with history of CLP and VPD[11]. Studies warn for the importance of characterizing the use of GS in the speech-language pathology assessment in opposition to the omission of consonants, considering that the therapeutic approaches for those variations are different[2]. Consequently, it is necessary a thorough evaluation to identify the disorder of speech in order to guide the plan of care.

The final decision on the speech condition is based on the perceptual evaluation, an essential part when assessing speech of individuals with history of CLP and VPD[5,8]. Although there are methods that confirm the GS identification (spectograph, nasoendoscopy and videofluoroscopy), the confirmation is mainly guided by the perceptual evaluation[2].

The perceptual evaluation of CA might be influenced by several factors[9,13] such as the evaluator's experience in identifying these productions [8,13,14], the choice of materials to be assessed and the quality of the samples used in the evaluation[7,9,16]. It's recognized the difficulty to describe the different types of CA based on perceptual evaluation, even for the most trained ears[13]. Researchers have made some efforts to minimize the subjectivity of the assessment by using resources as speech recording samples both audio and video. This would allow later access to the samples as well as the assessment by multiple evaluators[,14,17]. Kummer[17] highlights the importance of having the samples in order to compare pre and post-treatment. It would also be important to compare the results between different care centers, what was previously reported by other researchers [8,9,16.]

Multiprofessional international centers have been trying to standardize protocols of evaluation and treatment focused on patients with CLP. *Scandcleft, Eurocleft, Americleft, Japancleft*[16,19,20] among other centers, have formed the *Worldcleft*[20] group with the objective of carrying multiprofessional studies on the CLP patient. Brazil has been trying to implement *"Brasilcleft*" mirrored in the international programs. This multiprofessional national project has the participation of CLP specialized centers from different states in the country. This projects aim to standardize the treatment protocols and analysis of the results in post-surgical primary cleft palate repair. Furthermore, the project aims professional training and professional exchange of experience among the areas of Speech-language Pathology and Audiology, Orthodontics and Plastic Surgery. Another objective of the Project would be to achieve better results in the rehabilitation of CLP patients[21].

An important aspect of the standardization of protocol and analysis of the results in speech-language pathology and audiology is the training of professionals for the perceptual evaluation [7,9,22].

The standardization targets to achieve high level of inter-rater reliability [7,9]. Researchers have supported the use of reference samples as a method to improve inter-rater reliability when assessing different speech aspects including hypernasality [14,23] and articulation [14]. Researches demonstrate that reference samples may be efficient to control internal patterns considering that listeners become familiarized with the references. They memorize the models and therefore it helps the reliability of the evaluation [24,25].

For clinical and research matters, there is a need of a high level of reliability of the speech assessment methodology in order to assist the analysis of treatment outcomes. This way, more efficient methods to reach those levels of reliability are searched. Among those methods we can mention the establishment of a database that encompasses representative samples of speech aspects to be analyzed. In literature, there is no mention of an existing database that targets to assist the identification of CA GS type by evaluators who work with CLP or VPD population. The present study aims to create a database of speech reference sample in which recordings assessed by multiple evaluators are representative to the use of GS.

Method

The present study was approved by the Ethics in Research Committee of the same institution in which it was conducted. Its registration number is 32351314.5.0000.5441

The study used samples of speech stored from database recordings in an institution specialized in craniofacial anomalies. There were selected the recordings that used speech stimuli made by the recording protocol from *Brasilcleft*[21] Task-Force.

Brasilcleft is a recording protocol made by segments of spontaneous speech (a description of patient's daily routine), numeric count (1 a 20) and 21 phrases that contemplate Brazilian Portuguese sounds. The 21 phrases are divided in 6 plosives, 6 fricatives, 3 nasals, 3 liquids, and 3 other phrases combining nasal and oral consonants. In order to facilitate the identification and characterization of the target sound during the perceptual assessment by the speech-pathology therapist, all 21 phrases were composed by recurrent target sound combined with vowels and semi-vowels[26]. The selected stimuli in this study included 12 phrases related to the high pressure sounds (6 plosives and 6 fricatives) from *Brasilcleft (papai olha a pipa, a Bibi babou, o tatu é teu, o dedo da Duda doeu, o cuco caiu aqui, o Gugu é legal, a Fifi é fofa, o vovô viu a vela, o saci saiu, a rosa é azul, Xuxa achou o chá, a Juju é jóia)*. The latter phrases were picked to help identifying the presence or absence of the use of GS by the evaluators.

The speech recordings selected for this study were taken from two databases in the same institution. The recordings were captured during speech assessment procedures. Headsets Shure PG30 and Karsect HT-2/HT-9 are used to capture the samples in acoustically prepared rooms. After the recordings, software *Sony® Sound Forge* 8.0 is used to store the audio signal in a computer and a main server. Before capturing the speech signals, patients are informed on the stimuli to be repeated and procedures involving the recordings. The repetitions are asked with a two-second break between them. It is used a neutral intonation so to avoid variations in the intonation curve. If necessary they are repeated more than one time in order to correct pronunciation mistakes. After this, they are saved in the database in *wave* extension files.

In the present study, 149 recordings (each recording contemplating the 12 phrases that corresponded to the plosive and fricative sounds) were initially selected, which resulted in 1788 (149X12) phrases. From this total, only were included in this study the ones who matched the following inclusion criteria: (a) good audio quality, (b) no signals of vocal alteration and (c) representative of speech samples showing presence and absence of GS in each of the targeted sounds. The initial selection of the phrases to be included in this study was made based on the evaluations performed by the first author of the study. This author has a four-year daily clinic experience on speech assessment in CLP or VPD patients.

After meeting the inclusion criteria, ten phrases representing the target production for each of the 12 targeted sounds (six plosive and six fricative) were included in the study, totaling 120 phrases containing adequate speech. On a first moment, it was considered the inclusion of 30 GS representative phrases for each of those sounds (totaling 360 GS phrases), which would result in 480 speech samples. However, after analyzing the audio recordings from both databases that were consulted, it was not possible to find the number of samples

initially considered, especially for the six fricative sounds. The reason is that in this kind of articulation GS occurs in a lower frequency in relation to the plosives [12].

By using the convenience samples it was kept the initial idea of having 480 phrases. However, the inclusion of the total of GS representative phrases found in the consulted databases for each of the 12 targeted sounds resulted in a higher number of GS for plosive than fricative sounds. Table 1 shows a summary of speech samples included in this study (N=480), 360 phrases considered as representatives of GS and 120 of adequate oral production from the 12 targeted sounds.

Table 1. Distribution of samples according to target and stimulus, number of phrases without and with Glotal Stop (GS), number of GS production possibilities in each phrase and total possibility of GS production for each target..

Target	Stimulus	Phrases without GS	Phrases with GS	Possibility of GS for each phrase	Total Possibility of GS for each target
[p]	**P**a**p**ai olha a **p**i**p**a	10	60	4	280
[t]	A **b**i**b**i **b**a**b**ou	10	30	4	160
[k]	O **t**a**t**u é **t**eu	10	60	3	210
[b]	O **d**e**d**o **d**a **D**u**d**a **d**oeu	10	30	6	240
[d]	O **c**u**c**o **c**aiu a**q**ui	10	60	4	280
[g]	O **G**u**g**u é le**g**al	10	30	3	120
[f]	A **F**i**f**i é **f**o**f**a	10	24	4	136
[s]	O **s**a**c**i **s**aiu	10	24	3	102
[ʃ]	**X**u**x**a a**ch**ou o **ch**á	10	19	4	116
[v]	O **v**o**v**ô **v**iu a **v**ela	10	05	4	60
[z]	A ro**s**a é a**z**ul	10	07	2	34
[ʒ]	A **J**u**j**u é **j**oia	10	11	3	63
	Total	120	360	N/A	1801

N/A= not applicable.

The 480 phrases included in this study were edited with software *Sony® Sound Forge* 8.0. This edition resulted on a material with 12 files, each of them representing one target sound to be evaluated. The evaluation of the samples was performed by three speech-language pathologists with a minimum of 11-year experience in evaluation of speech in CLP and CA patients. As evaluators in this study, they assessed the samples in two ways: at first, individually and, when necessary, simultaneously.

Individual perceptual evaluation

The perceptual evaluation of the 480 phrases was performed individually at first. Each evaluator was responsible to identify the presence or absence of GS in each, some or all targets in each sentence, according to the stimulus presented. The examiners were instructed to listen to each phrase as many times as necessary until they were capable of identifying the presence or absence of GS. This identification considered every syllable in which the target sound occurred. Additionally, evaluators reported the presence of other disorders in the space of the answer sheet reserved for comments.

All data were gathered in an Excel spreadsheet, where in every syllable was identified the occurrence of 100% agreement (consensual evaluation) inter-raters in relation to the presence or absence of GS. Those phrases in which were not identified 100% agreement in every syllable were again organized and presented to the evaluators for a second assessment.

Simultaneous perceptual evaluation

The same three evaluators involved in the first assessment also performed the second evaluation and used the same criteria. For the simultaneous assessment, three individual earphones were connected to the same computer and to a signal splitter. The evaluation lasted one hour. The evaluators listened to every sentence, indicated their assessment and discussed the production where there was no consensus in order to reach an agreement on the presence or absence of GS for each syllable.

After listening to a specific sample and discussing the productions, if it was not possible to establish an inter-rater agreement the sample was excluded from the study.

After individual and simultaneous evaluation, all phrases with 100% inter-rater agreement were included in the reference sample database.

Analysis of the results

It was calculated the percentage of consensual evaluation individually obtained for 480 speech samples (120= adequate production of target sound and 360= representative of GS use) on the 12 targeted phrases. After that, it was calculated the percentage of consensual evaluation simultaneously obtained by three evaluators (in those cases in which there was not 100% agreement in previous individual assessment). Speech samples with complete evaluation agreement were used to define the database.

Results

Individual evaluation showed that from 480 speech samples there was inter-rater agreement in 316 (65,8%) phrases. From the 316, 120 (38,0%) phrases were representative of production of the target sound and 196 phrases (62,0%) were representative of GS uniquely. More specifically, all evaluators agreed on the assessment in 120 phrases representative of production of the target sound. There was an intra-rater agreement in 196 (54,4%) out of 360 phrases representative of GS (Table 2). A thorough analysis of the data showed that in 195 phrases evaluators agreed on the presence of GS in every syllable from every phrase representative of SG. In a single phrase (/g/) the evaluators identified GS in 2 out of 3 syllables that might show this kind of alteration.

Table 2. Individual consensual evaluation in the samples without and with Glotal Stop (GS) for each target sound

Target	Phrases without GS	Consensus in Phrases without GS	Phrases with GS	Consensus in Phrases with GS
[p]	10	10 of 10 (100%)	60	30 of 60 (50,0%)
[t]	10	10 of 10 (100%)	60	30 of 60 (50,0%)
[k]	10	10 of 10 (100%)	60	30 of 60 (50,0%)
[b]	10	10 of 10 (100%)	30	19 of 30 (63,3%)
[d]	10	10 of 10 (100%)	30	12 of 30 (40,0%)
[g]	10	10 of 10 (100%)	30	18 of 30 (60,0%)
[f]	10	10 of 10 (100%)	24	17 of 24 (70,8%)
[s]	10	10 of 10 (100%)	24	16 of 24 (66,7%)
[ʃ]	10	10 of 10 (100%)	19	16 of 19 (84,2%)
[v]	10	10 of 10 (100%)	05	00 of 05 (00,0%)
[z]	10	10 of 10 (100%)	07	03 of 07 (42,8%)
[ʒ]	10	10 of 10 (100%)	11	05 of 11 (45,4%)
Total	120	120 de 120 (100%)	360	196 de 360 (54,4%)

Later data analysis of the 360 phrases representative of GS showed that, out of 164 (45,6%) which did not present inter-rater agreement, 41 showed other disorders such as dysphonia (N=6), nasal air escape (N=3), weak pressure (N=7) and others AC (N=25). Those 41 samples were automatically excluded from the study, leaving a total of only 123 samples that did not present inter-rater agreement to be used in the second assessment, which was the simultaneous evaluation.

Although 123 phrases were available for the simultaneous assessment, this evaluation was performed exclusively for the sounds that were not previously established the defined total of 30 samples representatives of GS. Therefore, 52 phrases were simultaneously evaluated, from which 18 samples of voiced plosive sounds and 34 of fricative sounds (voiced and voiceless) (18+34=52). There was agreement on 10 (55%) out of 18 samples with voiced plosive sounds (one sample for [b], six for

[d], three for [g]). There was also agreement on 26 (76%) out of 34 samples with fricative sounds (seven for [f], five for [s], one for [ʃ], five for [v], four for [z] and four for [ʒ]). From the 52 samples presented, 36 were evaluated as representative of GS use by simultaneous agreement (Table 3).

From both evaluations performed, it was classified a total of 352 samples (316 –individual assessment + 36 – simultaneous assessment) to this study. Out of those 352 samples, 120 were classified as representative of adequate production of the 12 targeted sounds. Other 232 were classified as representative of GS presence (196 –individual assessment + 36 – simultaneous assessment). (Table 3)

Table 3. Evaluation (individual and simultaneous) obtained for each target sound

Target Sounds	[p]	[t]	[k]	[b]	[d]	[g]	[f]	[s]	[ʃ]	[v]	[z]	[ʒ]	Total
Absence of GS in IE¹	10	10	10	10	10	10	10	10	10	10	10	10	120
Presence of GS in IE¹	30	30	30	19	12	18	17	16	16	0	3	5	196
Presence of GS in SE²	N/A	N/A	N/A	1	6	3	7	5	1	5	4	4	36
Total	40	40	40	30	28	31	34	31	27	15	17	19	352

¹Individual evaluation; ²Simultaneous evaluation; N/A= not applicable.

The 352 samples with 100% inter-rater agreement formed a database of representative samples of absence and presence of GS. The phases of database formation are shown in Figure 1. Out of the 352 samples that formed the database, 173 (49,1%) were representative of female voices, children (N=48), adolescents (N=67) and adults (N=58). The remaining 179 (50,9%) were representative of male voices, children (N=57), adolescents (N=58) and adults (N=64). All samples belonged to CLP patients who already went through surgery, except for one sample that belonged to a CA patient without apparent cleft.

Discussion

Compensatory articulations, especially the glottal stop, directly affect speech intelligibility of CLP and/or VPD patients. Treatment of these conditions involves speech therapy, which depends on an appropriate identification of those speech disorders [2,13]. The identification of AC requires the speech-language therapist hearing as an assessment tool during the perceptual evaluation of the speech. It is a subjective process, which is associated to the variation of intra-rater reliability [27]. Researchers [24] mentioned that the variability in intra-rater agreement could be attributed to the norms or internal patterns acquired by the listeners from the experience with different voices stored in their memories. Other researchers [25] agreed with this affirmation and suggested the use of external patterns as a reference to balance listener's internal norms. In this sense, the creation of a database with sample references might help to adjust and train the internal patterns of the evaluators.

The present study aimed to create a database of samples representative of presence and absence of GS. The intention is to contribute with *Brasilcleft* Task Force in the effort to standardize protocols for identification of the speech results so as to reach professional training and adjustment [21]. As researches do not describe databases of reference samples representative of CA associated with CLP, the creation of such a GS sample database is pioneer and may bring important contributions to the training of evaluators in research as well as for clinical matters. Moreover, it may contribute to the formation of speech-language therapists and to the development of materials for distance learning, which would allow the identification, prevention, diagnosis and treatment of GS.

Considering that researches highlight the importance of evaluators experience on the identification, characterization and classification of speech disorders associated to CLP [8,13,14], this study chose experienced professionals, first individually and after simultaneously, similarly to procedures used in a previous study[14]. The phrases include in the database reference samples were those that showed 100% inter-rater agreement after the evaluations

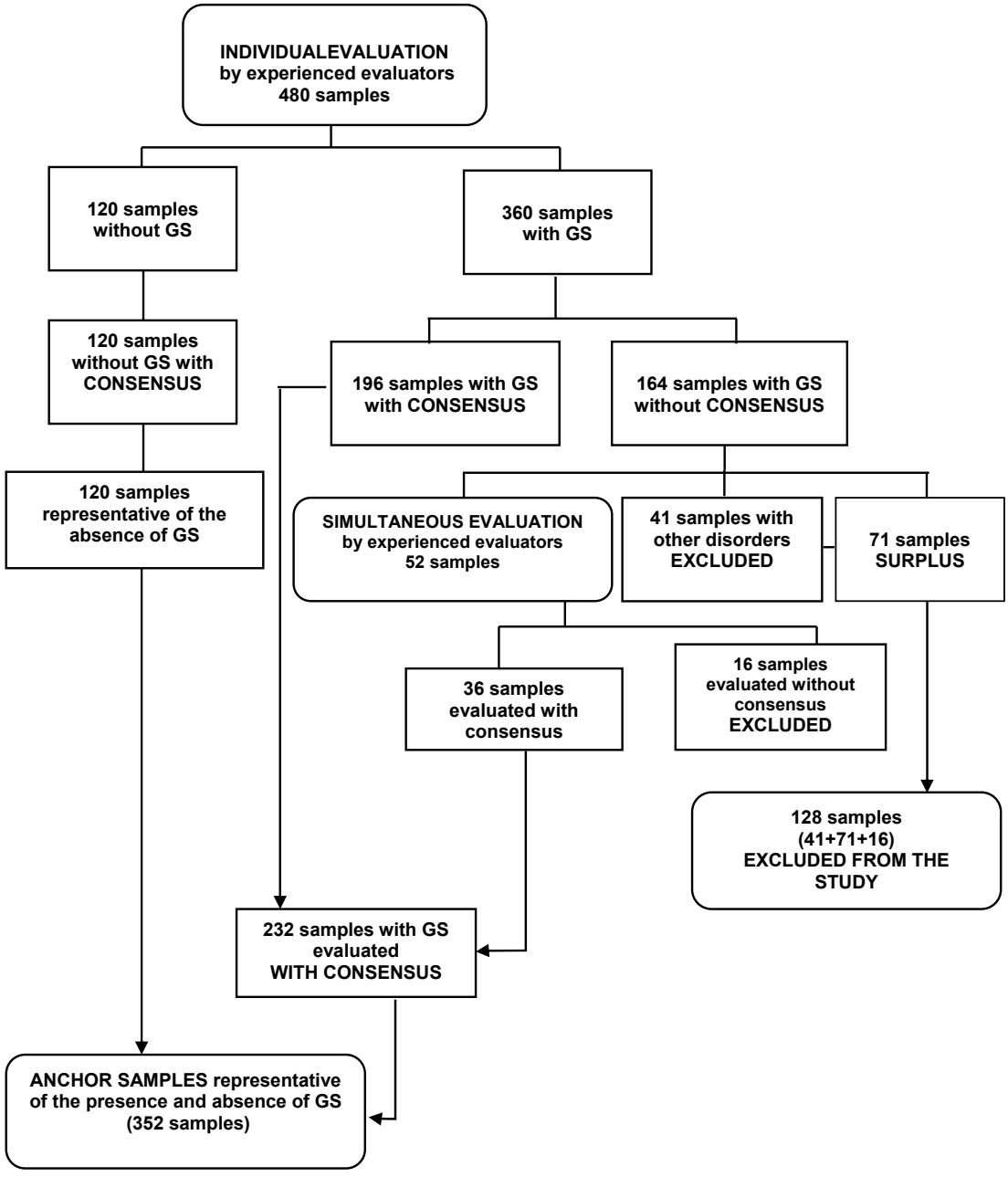

Figure 1. Organogram of the evaluation leaded by the evaluators for establishment of the bank of samples of reference.

were performed. More specifically, the standardized samples with highest level of inter-rater agreement (100%) were obtained to form the reference samples. This agrees to reports of researchers[28] that suggest the importance of choosing as reference samples the ones associated with high levels of inter-rater agreement. As emphasized in publications, experienced evaluators may serve as a source of coherent decisions when the goal is to set a high level of agreement [28].

Several researchers mention the need to set strategies to increase inter-rater reliability [24,25,29].

Efforts have been made to reach this objective as recent studies on the training of evaluators have shown [22,23,30]. The use of sample included in a reference database, as established in this study, may minimize the subjectivity of perceptual evaluation and improve inter-rater agreement.

The samples evaluated were controlled on the stimuli that were emitted by using *Brasilcleft* protocol. This includes the obstruent target sound, on recurrence and the level of the phrase, avoiding the inclusion of other high pressure or nasal sound in the same phrase, as recommended in literature [7,9]. Since the goal of this study was a reference sample database representative of GS only, other sound disorders were not selected. Future studies could use GS samples combined with other speech and voice disorders since it is common to have the presence of more than one symptom in the speech of CLP patients. It is also important that the clinician be able to identify the GS even in the presence of other disorders associated to CLP and/or VPD. Future studies could also verify if the use of the reference samples as established in this study database can collaborate in the training of evaluators with no experience in disorders of speech presented by subjects with CLP and/or VPD. This investigation would contribute to understand if the database proposed in this study would help not only in the formation of speech-language therapists but also to the development of materials for distance learning.

Conclusion

A database with reference samples representative of the presence or absence of GS was created based on consensual evaluations from multiple examiners. This database may be used in future researches as a tool for training the evaluators as well as in the formation of speech-language therapists. It could also be used in the preparation of distance learning materials, which could identify GS therefore allowing prevention, diagnoses and treatment.

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