DISPE: A DIVERS' SPEECH DATA-BASE

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ABSTRACT: Gas mixture and pressure modify the spectral characterictics of divers' speech. Additionally, constraints imposed on jaw movements by wearing a facial mask affect the speech production process. The auditory feed-back loop is equally concerned. Furthermore, underwater adverse working conditions are characterised by noise from different sources.
As a result, divers' speech is poorly intelligible and communications between divers and surface control need to be enhanced. This is clearly true for both security and task efficiency reasons. To this end, "voice unscramblers" are being used. However, the technological state of commercially available equipment is dated and the quality of speech remains insufficient.
To help with the design, testing and qualification (NORM) of new communication devices, a bilingual (French-English) Data-base is currently being set up. It consists of phonetically balanced lists of 200 words read by 17 divers under sea and in chambers at operational levels from the surface to -300m. These recordings will be edited, labelled and stored for further distribution on a CD-ROM.

INTRODUCTION

Industrial as well as military and scientific submarine operations take place nowadays in more extreme and adverse conditions than was still the case 10 years ago. Success or failure depend on the ability of man to live and work at greater subaquatic depths. Physiologic disorders due to high pressure gas toxicity have been eased through the use of more dependable breathing gas mixtures. Heliox for example, has enabled deeper dives for longer periods of time. Pressure and gas however adversely add their effects to speech production and the resulting acoustic signal becomes distorted. Fo increase (Hollien et al., 1977), Donald Duck effect and formant shift (Tanaka et al., 1974, Ducan & Jack, 1987) have been reported. Additional factors such as respiration, bubble noise, ventilation, electric interferences also contribute to the degradation of speech. Finally, the facial mask itself induces some aerodynamic changes, not to mention the constraints imposed on jaw movements (Hollien et al., 1984).
Communications play a very significant role during dives. This is especially true when a difficult task has to be accomplished under reduced visibility, in a complex and dangerous environment and in the unfortunate case of life equipment defective. For security reasons, but also for better work efficiency and for productivity gains, subaquatic communications need to be enhanced. To help with the design, testing and qualification of new communication equipment, a large scale phonetic study has been recently launched in France. We present in this paper the Divers' Speech Data-base: DISPE which is currently being recorded.

1.Types of communications

Depending on the situation, there exist different types of speech communication. The following table summarizes the most common communication chains, specifying the location of speaker and listener, the ambiant gas and pressure for each of them and which transmission line and additional equipment are used.

Speaker/Listener	Medium 1	Medium 2	Transmission
Diver-diver	Air (P)	Air (P)	acoustic
Diver-surface	Air (P)	Air (P)	acoustic
Diver-surface	Air (P)	Air (P)	wire (1)
Diver-surface	mixture(P)	Air (a)	wire + unscrambler
Bell-surface	mixture(P)	Air (a)	wire + unscrambler
Bell-diver (cross-talk)	mixture(P)	mixture(P)	wire + unscrambler
Chamber-surface	Air (P)	Air (a)	wire
Chamber-surface	mixture (P)	Air (a)	wire + unscrambler
Chamber-chamber	mixture (P)	mixture (P)	wire + unscrambler

(P): Hyperbaric (dry or wet)
(a): atmospheric pressure
(1)or any other non-acoustic device.

Tab.1: Types of subaquatic speech communication

2.Linguistic material

2.1. Short review

A review of litterature was carried out (Casanova et al., 1990). It indicates that linguistic material being referred to the different papers is relatively limited. A number of studies are concerned with vowels and were used to investigate formant shift (Belcher & Hatlestad, 1983; Tanaka at al., 1974). Words have also been investigated. However with the exception of Brown (1976), Morrow et al. (1971), Rothman (1980) and Sergeant (1967), who used the Griffith lists, most of the other studies rely only on a few words which are not really representative of the phonetic structure of any languge. A few sentences were investigated by Brubaker (1968), Crestel (1987), Nakatsui et al. (1972) and Rothman et al. (1980) in a limited number of situations. From the published results , it appears that a model for Helium speech is still not available. The matter is also complicated by the fact that there exists a great interspeaker variability and that different speakers also use different strategies to enhance the intelligibility of their speech.

The need for a systematic collection of linguistically representative speech samples recorded by a sufficient number of speakers at the most common operational underwater depths lead to the present recordings and to the set-up of a comprehensive Data-base.

2.2. DISPE corpus

French: The corpus consists of 4 phonetically balanced lists of 46 words and of 8 sentences where some of these words appear in different syntactic environments (Tab. 2). The words have been selected on the basis of their semantic complexity (no esoteric term) and of their phonological structure. The resulting lists are to be used later for speech intelligibilty tests. The sentences were designed to allow the study of coarticulatory phenomena in connected speech which appear to affect considerably Helium speech intelligibility.

English: The corpus consists of the Griffiths lists.

Corpus:

LIST A: Loi, Capot, Gnon, Bachot, Chien, Hache, Rance, Lait, Pack, Pâques, Mille, Toge, Ralant, Ane, Sure, Pile, Bain, Sou, Un, Deux, Cagnes, Carne, Basse, Qui, Deuil, Ouest, Ouirent, Jade, Yard, Achille, Ouais, Bouille, Ragot, Pis, Bâche, Epile, Râpe, Fiche, Vingt, Batte, Bêche, Biais, Juter, Meute, Manie, Dans

Tapes	Date	Spk.	Situation	Depth	Pp.O2	% O2	% He	Gas (C)	Mask or Helmet
n° 1	21/12/89	2	Chamber	- 60 m	1, 47 b	21	-	40°	_
n°3	14/15/02 1990	5	Wet Chamber	-180 m	570 mb	3	92,7	_	Kmb 17 X-LITE
n° 3	15/02/90	5	Bell	-180 m	400 mb	2, 2	92,5	31°	Beyer DT 109
n°4	15/02/90	5	Chamber	-180 m	409 mb	2,1	92,3	31°	_
n°5	17/02/90	5	Chamber	-150 m	502 mb	3,05	92,1	30,5°	_
n°6	18/02/90	5	Chamber	-103 m	506 mb	4,4	90,8	29,5°	_
n° 7	19/02/90	5	Chamber	- 55 m	511 mb	7,7	87,6	29°	_
n° 9	13/14/03	5	Wet Chamber	-180 m	570 mb	3	92,5	_	X-LITE
n°10	18/03/90	5	Chamber	- 84 m	500 mb	5,3	91,2	29,5°	_
n°12	09/10/05 1990	5	Wet Chamber	-200 m	407 mb	1,9	94,08	_	X-LITE
n°13	10/05/90	5	Chamber	-200 m	411 mb	1,9	94,3	31°	_
n°14	11/12/05 1990	5	Wet Chamber	-300 m	737 mb	2,38	93,5		X-LITE Kmb 17
n° 15	12/05/90	5	Chamber	-300 m	400 mb	1,31	96,4	31,5°	_
n° 16	13/05/90	5	Chamber	-255 m	500 mb	1,89	95,9	31,5°	_
n° 17	15/05/90	5	Chamber	-178 m	501 mb	2,6	95,8	31,5°	_
n°18	18/05/90	5	Chamber	- 60 m	499 mb	7,2	90,43	30°	_

TAB.3:List of French recordings in the DISPE Data-Base

LIST B: Doigts, Calot, Bon, Badaud, Bien,Hâle, Danse, Dais, Page, Pâle, Mig, Tome, Talent, Aine, Sar, Bile, Pin, Doux, Ain, Don, Cache, Carde, Bave, Gui, Oeil, Veste, Virent, Rade, Jarre, Agile, Niais, Bouffe, Râteau, Pou, Bague, Emile, Rave, Quiche, Rein, Bave, Bête, Pied, Chuter, Mante, Mamie, Zan

LIST C: Poids, Cadeau, Don, Ballot, Mien, Are, Panse, Mai, Panne, Passe, Miche, Tonne, Palan, Une, Serre, Huile, Faim, Chou, An, Doux, Caille, Carme, Baffe, Riz, Seuil, Geste, Rire, Lad, Barre, Asile, Geai, Bouse, Rabot, Pain, Bac, Ethyle, Rate, Chiche, Faim, Base, Baisse, Lier, Futé, Motte, Mali, Rang

LIST D: Bois, Canot, Long, Barreau, Rien, Ane, Chance, Gai, Pagne, Pâte, Mime, Toque, Salant, Aune, Sort, Mille, Vin, Bout, On, Dos, Canne, Carpe, Base, Pis, Feuille, Zeste, Lyre, Fade, Var, Habile, Chaix, Bouge, Rameau, Peu, Basse, Edile, Rase, Niche, Sain, Bagne, Benne, Nier, Muter, Math, Marie, Gens

SENTENCES: C'est un peu fade comme pâte, il faudrait un zeste de citron.
Emile a de la chance, car il fait rire les gens.
A Pâques, nous irons à Cagnes ou dans le Var.
Marie a une bague qui va bien à son doigt.
Le chien de la meute est dans sa niche.
Il est bête comme ses pieds, mais il a du talent.
L'âne porte sur son dos un ballot de foin.
Tous les ans, on envoie mille tonnes de riz au Mali.

Tab.2: Linguistic material recorded in the DISPE Data Base

3. Recordings

3.1. Speakers

Up to now, 17 male speakers have been recorded. They are experienced professional divers. 15 of them belong to the French Navy (GISMER). They have been selected according to the following criteria:

-Age: 20 to 35
-Audiologic control: normal
-Speech production: no defect
-language: standard variety.

Same criteria will apply for the selection of English speakers.

3.2. Conditions

Speech was recorded during simulated dives from sea level to -300m in a caisson, a bell and in a wet chamber. Table 3 summarizes the various prevailing conditions in terms of number of speakers, gas composition, temperature, and facial equipment used by the different speakers.

3.3. Procedure

The speakers were first trained with the linguistic material by one of our instructors 3 days before the sheduled dive. When they felt comfortable with the word lists and sentences, they were recorded in a quiet room adjacent to the hyperbaric centre. The whole corpus was repeated twice by all speakers. A test was then conducted with one diver to check at ambiant atmosphere the quality of the transmission line from the chamber to the control desk. During dives, the recordings took place at the bottom (dry and wet) and during the decompression phase at specified depths. Watersealed lists were read by the divers. In case of error or misspelling, the diver was asked by the experimenter from the surface to read again these items at the end of the session. These words or sentences were displayed in front of a viewport.

Concluding remarks

The recordings we have collected up to now will be segmented and labelled by a group of phoneticians. A systematic recording of the English Griffith list is about to start. French and English recordings will be organized in a comprehensive Data-base of hyperbaric speech. A CD Rom complying to the S.A.M. standard should be released in the last quarter of 1991. The Data-base will be available for scientific investigations as well as for industrial Research and Development purposes. In addition, it is expected that it will also be used for qualification (NORM) of communication equipment.

Aknowledgement

This research was partially funded by a grant from La mission interministérielle de la Mer (MISMER), by the financial support of Ministry of Industry (Centre d'études pétrolières et maritimes) and of the Provence-Alpes-Côte d'Azur "Route des Hautes Technologies Program".
We aknowledge the most valuable cooperation of the French Navy, which made the recordings possible at the Toulon hyperbaric centre (GISMER & CEPISMER). We would in particular like to thank Capitaine de Frégate Plançon.

BIBLIOGRAPHY

Belcher E. O. , S. Hatlestad (1983);*Formant frequencies, bandwiths and Qs in helium speech,* JASA, vol. 74 , 2 , pp . 428-432.

Brown D. D., Feinstein S. H. (1976); *An evaluation of three helium speech unscramblers to a depth of 1000 feet,,* Journal of Sound and Vibration, 48, 1, 123-135.

Brubaker R. S. , Wurst J. W. (1968); *Spectrographic analysis of divers' speech during decompression,;* JASA, vol. 43 , pp. 798-802.

Casanova, M.H. et al. (1990)*Etude sur l'intelligibilité de la parole en milieu subaquatique-hyperbare,* Rapport final, Institut de phonétique d'Aix en Provence & INPP Marseille.

Crestel J. (1987); *Contribution à l'amélioration de l'intelligibilité de la communication orale en plongée hyperbare: modélisation de la source glottique,* Thèse de doctorat de l'université de Rennes I.

Duncan G. & Jack M. (1987);*The helium speech effect,Aspect of speech technologie ;* (M. Jack & J. Laver ed.), Edinburgh University Press. pp. 216-283.

Griffiths J. D. (1967); *Rhyming minimal contrasts : a simplified diagnostic articulation test,;* JASA, n°42 pp. 236-241.

Hollien H, Hicks J. W. jr., Hollien P. (1984); *Motor speech characteristics in diving,* Proc. Tenth. Inter. Cong. Phonetic Sciences, (M. Broecke & A. Cohen eds. , Dordrecht, Holland, Foris pubs. 2B), pp.423-428.

Hollien H., Shearer N., Hicks J.W. jr. (1977);*Voice fundamental frequency levels of divers in helium-oxygen speaking environments,* Undersea biomedical research, Vol. 4, n°2, pp.199-207.

Morrow C. T. & Austin J. Brouns (1971); *Speech communication in diving masks. I & II;* JASA , vol. 50, 1, pp. 1 -22.

Nakatsui M., Suzuki J., Takasugi T., Tanaka R. (1972); *Nature of helium speech : systematic observation and analysis during simulated dives,* Journal of radio research laboratories, pp. 1615-1627.

Rothman H. B., Gelfand R., Hollien H., Lambertsen C.J. (1980); *Speech intelligibility at high helium-oxygen pressures*, Undersea biomedical research, Vol. 7, n°4.
Sergeant R. L. (1967); *Phonemic analysis of consonants in helium speech*, JASA , vol.41, 1, pp. 66 to 69.

Tanaka R., Nakatsui M., Takasugi T., Suzuki J. (1974); *Source characteristics of speech produced under high ambient pressures,Journal of the radio research laboratories*, Vol. 21, n°105, pp.269-273.

Tanaka R., Nakatsui M., Suzuki J. (1974); *Formant frequency shifts under high ambient pressures,Journal of the radio research laboratories*, Vol. 21, n°105, pp.261-267.