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Original article

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Abstract

Objectives: To develop an experimental protocol to study the vocal effort generated by introducing barriers to communication, and its relationship with certain personality traits. **Material and methods:** The experimental protocol consisted of an interactive game in which the subject gave an investigator instructions to adopt various body positions (semi-directed communication situation). The Control situation included no constraints on communication. Then a Distance Constraint (increased distance between subject and investigator) and a Time Constraint (generation of performance stress by putting the subject in competition with others) were introduced. The vocal parameters studied comprised vocal intensity and fundamental frequency in the middle of the vowel of 3 target phonemes. Subjects also took the NEO FFI-R personality test. **Results:** The study included 41 women aged between 18 and 52 years. Vocal intensity and fundamental frequency increased significantly with the introduction of the constraints ($p < 0.05$), intensity passing from 75.5 dB to 81.8 dB and frequency from 249.4 Hz to 335.8 Hz. No correlations were found between these changes and results for the various personality traits. **Conclusions:** This ecological protocol enables the impact of both physical and emotional obstacles to communication to be studied. No correlations between vocal effort and personality traits emerged. A larger-scale study would be necessary to analyze the continuum between vocal effort and vocal forcing, to improve speech therapy for dysfunctional dysphonia.

Key-words: Dysphonia, Voice disorders, Acoustic analysis, Vocal effort, Personality

Introduction

In healthy subjects, vocal effort is a natural response to situations of difficult communication. When chronic or involuntary or inappropriate, it may lead to vocal forcing and hence to certain forms of dysphonia [1]. Various factors are involved in onset and maintenance of vocal forcing: external factors concerning the environment and obstacles to communication [2], and internal factors concerning the individual and his or her perception of such obstacles and their importance. These perceptual factors and the resulting reactions are related to personality [3-5].

Vocal forcing thus results from interactions between several factors that are inter-related in a way that makes them difficult to distinguish. Understanding these interactions and the resulting vocal behavior is essential for effective speech therapy in dysphonia involving vocal forcing. There is, however, no routine test assessing the respective impacts of the various factors underlying vocal effort.

The objective of the present study was firstly to draw up an experimental protocol to study disturbance of phonation by obstacles to communication, in an optimally ecological situation of vocal effort.

The second objective was to analyze the relation between such vocal effort and certain personality traits.

Material and methods

Forty-one healthy female volunteers, aged 18 to 70 years, were included. Exclusion criteria comprised known history of phonopathology, dysarthria, neurologic disorder or hearing loss. Subjects provided informed consent after clear, honest and adapted information on study objectives and methodology. Subjects were coded by number so that results would be anonymous.

To study phonation disturbance by obstacles to communication, an experimental protocol of vocal effort induction by modification of external factors was designed. The protocol involved 3 participants: the experimental subject, and a first and a second investigator. An interactive game was set up between subject and first investigator, in a semi-directed communication situation. The subject instructed the investigator to adopt various body positions, based on a set of 16 cards (cf. Figure 1) showing a person from behind in various positions with 3 accessories (ball, hat, glove), guiding the investigator (whose back was turned) in assuming the correct position; the first investigator followed the instructions until the second investigator approved the body position, at which point the subject went on to the next position. The experiment was conducted in a room with an opening onto the outside. The subject underwent 4 conditions, in the following order:

- Control situation (C), without communication constraint, with a 2-meter distance between subject and investigator;

- Distance Constraint situation (DC), with distance between subject and investigator increased to 15 meters;

- Temporal Constraint situation (TC), with stress induced by social desirability by putting the subject in competition with others to achieve as many investigator positions as possible in 90 seconds;

- Distance + Temporal Constraint situation (DC-TC), associating the two.

The session began with non-analyzed trial run to check the subject's understanding of the protocol and the functioning of the recording equipment. Only the C and DC-TC conditions were then used for statistical analysis and comparison with personality traits.

Acoustic vocal parameters were extracted from target phonemes (French /a/ as in "ballon" (ball) and /o/ and /e/ as in "bonnet" (hat)): mid-vowel vocal intensity in dB and mid-vowel fundamental frequency in Hz. For recording, the subject was equipped with a micro-helmet, connected to an EVA2™ assisted vocal assessment device, with analysis by Phonedit® software (SQLab, LPL, Aix-en-Provence, France).

Individual differences in mean vocal intensity and fundamental frequency between the C and DC-TC situations were calculated.

The relation between the induced vocal effort and certain personality traits (internal factors) was assessed using the NEO FFI-R personality test (NEO Five Factor Inventory, short form of the NEO PI-R or Revised NEO Personality Inventory [6,7]), comprising 60 items in the form of statements on which the respondent gives her opinion as Strongly disagree (SD), Disagree (D), Neutral (N), Agree (A) or Strongly agree (SA). The 5 traits thus assessed are: neuroticism, extraversion, openness to experience, agreeableness and conscientiousness [8], each ranked as low, average or high.

Analysis of variance was used to assess whether Intensity and Frequency were influenced by DC and TC. The Mann-Whitney test was used to compare mean values. The significance threshold was set at $p<0.05$.

Results

Subjects comprised 41 healthy female volunteers aged 18-52 years.

1) Vocal intensity and fundamental frequency according to communication situation (Table 1)

Vowel intensity and fundamental frequency increased significantly when distance and time constraints were introduced ($p<0.05$): intensity from 75.5 dB to 81.8 dB, and frequency from 249.4 Hz to 335.8 Hz.

2) Acoustic parameters and personality traits

Intensity was greater in DC-TC than C for all subjects except 1. Mean increases were grouped by personality trait levels for analysis (Table 2). One-factor analysis of variance found no significant difference in vowel intensity according to level of any personality trait, although there was a trend toward an association between extraversion and increased intensity under constraint ($p=0.07$).

Fundamental frequency was higher in DC-TC than C for all subjects. Mean increases were grouped by personality trait levels for analysis (Table 3). One-factor analysis of variance found no significant difference in vowel intensity according to level of any personality trait.

Discussion

The present study sought to shed light on the vocal forcing that is implicated in many dysfunctional dysphonias. It provides data on the vocal effect of introducing communication constraints. Subjects make a vocal effort in order to be heard or understood more effectively, both speaking louder and modulating other parameters such as timbre and respiratory and postural behavior. Intensity increases and, with it, frequency [9]. Increases range between 2 and 8 dB and between 3 and 12 Hz per distance doubling [2,10,11]. Findings vary, as other environmental factors interfere, notably the acoustic conditions of the room (anechoic chamber, long narrow corridor, meeting room, room with resonance, etc.), affecting auditory feedback of the speaker's voice, with significant alteration of sound level [10,12,13].

Although these were not analyzed, we also noticed changes in prosody and syntax. Under constraint, some subjects stopped trying to speak in sentences, over-articulated (i.e., shortening consonants in favor of vowels), hesitated or on the contrary became authoritarian or aggressive. Posture also changed: some subjects froze, while others mimed the movements they were asking the investigator to make. It would also have been interesting to analyze posture in the anteroposterior plane, known to change under vocal effort [14,15].

The present study provides a protocol to induce ecological vocal effort by inducing stress while maintaining the spontaneity of communication without sacrificing rigor and reproducibility. The semi-directed situation led the subject to speak in her own words, without restriction. The instructions were simple and relatively non-directive, leaving room for natural communication. The presence of the first investigator provided visual feedback of success or failure of transmission of the message, allowing the subject to adjust phonation to maintain efficacy despite the constraints introduced. However, being fitted with recording equipment connected up to a computer may have introduced bias in the spontaneity of communication, which needs to be taken into account in interpreting the results. That the order of the conditions was not randomized may also have introduced bias, with the subject progressively getting used to the exercise Although 2 of the 3 study vocoids came after a voiced bilabial occlusive consonant, they were followed by different consonants depending on the word, and thus had differing phonetic contexts. It would be useful to supplement the present analyses by comparing the respective increases in intensity and frequency according to the vowel being produced. Lastly, physical or mental fatigue was not taken into account, although it could affect behavior. A test-retest design (e.g., evening versus morning) could check the consistency of the subjects' behavior.

The present pilot study was performed with female subjects, as dysfunctional dysphonia mainly affects women [16]. The words "bonnet" and "ballon" were chosen on phonologic criteria: continuous voicing, little occlusion, and no silent final [e].

No significant correlation with personality emerged, probably due to lack of power, with many factors and few subjects. There was nevertheless a trend toward an association between extraversion and increased vocal intensity under constraint: extraverted subjects tended to increase intensity more than did introverts in situations where communication became difficult. This was shown in other studies comparing healthy versus dysphonic subjects with or without lesions [4,17-19]. If vocal production is expected to get a "result", then considerations of social desirability will inspire extraverted subjects to do whatever it takes to "meet objectives". Personality also affects how the individual reacts in an anxiogenic situation, either absorbing the stress or exacerbating it. Acoustic parameters are modulated by emotional state [20]. Personality is likely to affect vocal effort especially in the TC condition, in which the obstacle is largely "mental": emotion probably plays a major role in what the subject makes of this communication stress. A comparative study between the C and TC

situations would be interesting, to determine the role of emotion and its relation to personality.

The NEO FFI-R is a short form of the NEO PI-R test [6,7]. Although standardized and validated, it is less precise than the full form, and provides only a general profile, neglecting the facets of the traits and taking little account of interindividual differences in personality. Moreover, it is a self-administered questionnaire, so that social desirability factors come into play. The timing of administration is also debatable: right after the experimental session, possibly in a situation of stress, with risk of context bias.

Conclusion

The vocal effort induced by two types of constraint (talker-to-listener distance and stress) is close to the natural communication situation. The ecologic nature of the protocol was of good quality, as the subject was free to express herself (semi-directed situation), with both a physical (distance) and an emotional (time) obstacle. Many other factors involved in vocal effort require more precise analysis, such as target vowel timbre, and postural and respiratory behavior. No correlation between vocal effort and personality traits could be shown, although this would be worth studying in larger-scale investigations. Studying the continuum between vocal effort and vocal forcing would shed light on speech therapy modalities in dysfunctional dysphonia.

Disclosure of Interest: The authors declare that they have no conflicts of interest concerning this article

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Figure 1: Example of card

Table 1: Mean intensity and fundamental frequency according to communication situation

		Mean	Minimum	Maximum	Standard deviation
Intensity (dB)	C	**75.5***	65.8	88.7	5.5
	DC-TC	**81.8***	73.3	91.1	5.2
Fundamental frequency (Hz)	C	**249.4***	211.8	304.1	20.3
	DC-TC	**335.8***	253.4	424.2	37.6

C = control situation; DC-TC= distance constraint and time constraint
**p<0.05 between C and DC-TC*

Table 2: Correlation between variation vowel intensity and personality traits

		Low	Average	High	p
Neuroticism	n	13	22	6	
	Mean (dB)	5.6	6.7	6.2	0.569
	Standard deviation (dB)	3.5	2.8	2.9	
Extraversion	n	6	24	11	
	Mean (dB)	4.3	6.1	7.7	0.0743
	Standard deviation (dB)	1.8	3.4	2.0	
Openness	n	10	15	16	
	Mean (dB)	6.4	6.8	5.7	0.589
	Standard deviation (dB)	4.5	3.1	1.6	
Agreeability	n	10	14	17	
	Mean (dB)	8.0	5.6	5.8	0.111
	Standard deviation (dB)	2.5	2.9	3.2	
Conscientiousness	n	9	7	25	
	Mean (dB)	6.2	6.5	6.2	0.973
	Standard deviation (dB)	2.9	2.4	3.4	

Table 3: Correlation between variation vowel frequency and personality traits

		Low	Average	High	p
Neuroticism	n	13	22	6	
	Mean (Hz)	80.6	90.1	85.4	0.702
	Standard deviation (Hz)	46.7	23.5	20.9	
Extraversion	n	6	24	11	
	Mean (Hz)	83.4	83.3	94.7	0.606
	Standard deviation (Hz)	16.4	35.9	29.5	
Openness	n	10	15	16	
	Mean (Hz)	100.4	88.5	75.6	0.149
	Standard deviation (Hz)	31.9	34.5	27.0	
Agreeability	n	10	14	17	
	Mean (Hz)	101.0	79.1	83.8	0.229
	Standard deviation (Hz)	34.8	28.4	31.9	
Conscientiousness	n	9	7	25	
	Mean (Hz)	97.6	92.0	80.3	0.335
	Standard deviation (Hz)	26.7	35.0	32.5