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Communication by unvoiced speech: the role of whispering

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ABSTRACT

Most studies on whispering deal with its production and perception, neglecting its communicative role. I have focused on this, especially some social and psychobiological objectives. I have combined a general inquiry into the use of unvoiced speech with stimulus-response experiments on particular signal properties. (1) Analyses of answers to queries revealed that judgments about whispering depend on the social contexts. In the private domain it plays a clearly positive role, but in the public domain it is more problematical. Two causative factors were identified as relevant: (a) an 'ingroup' function of whispering which could induce negative 'outgroup' effects in co-listeners, and (b) a psychobiological component of whispering which could affect the auditory vigilance of co-listeners who were not addressed personally by the signaling, but often wanted to understand a whispered message. (2) Analyses of experimental data confirmed the relevance of these factors. Additionally, they showed that unvoiced speech has a limited transmission range, and is easily masked by background noise. Taken together, the results suggest that whispering is explained best as a close-distance signal adapted for private use among partners.

Key words: verbal communication, whispering, unvoiced speech, ingroup-signal, vigilance.

INTRODUCTION

The performance of whispered speech has been highlighted as a verbal accomplishment that requires much more training and skill than the use of normal speech. The main argument comes from findings on vocal production, which showed that whispering originates from a turbulent noise generated by the friction of the air in and above the larynx, with the vocal folds not vibrating (Eckert and Laver 1994). Thus, it does not incorporate any fundamental frequency (Tsunoda et al. 1997). By sophisticated sensorimotor control, however, subsequent phonation is nevertheless able to generate vowels and consonants successfully (Mansell 1973, Monson and Zemlin 1984, Tsunoda et al. 1994). To emphasize its structural and dynamical properties, whispered speech (or whispering) is also called 'unvoiced speech', to distinguish it from normal speech, also termed 'voiced speech' or 'phonated speech' (Fig. 1).

From the perspective of signal perception, unvoiced speech was often considered to be as understandable as voiced speech. As shown by tests with English, German and Japanese sentences, this effect seems to be independent of language specificity (Higashikawa 1994). Nevertheless, problems may arise for the discrimination of some vowels. This has been traced-back to pitch increases documented for the first and the second formant (Tartter 1991, Higashikawa and Minifie 1999). Aside from verbal information, whispering can also encode prosodic

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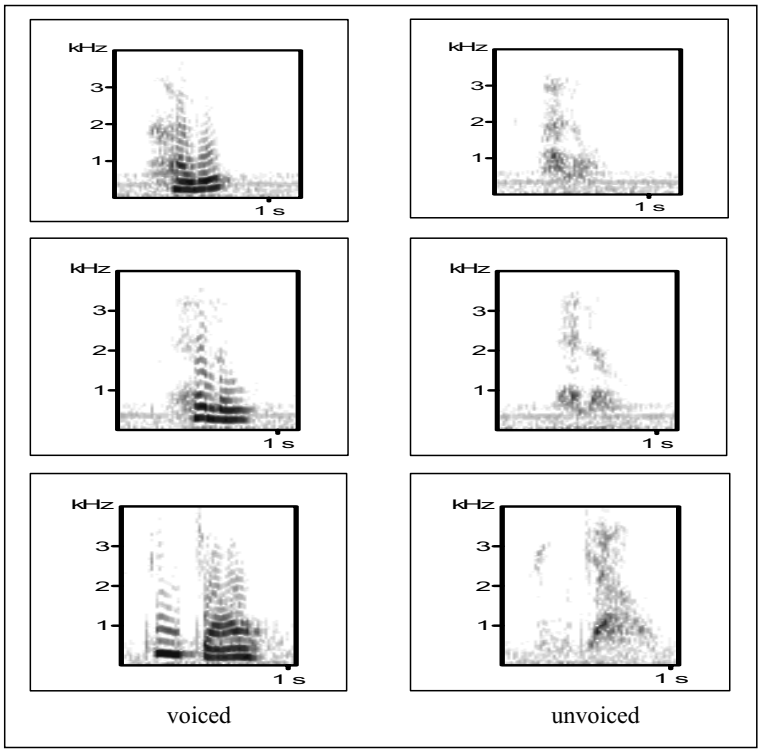

Fig. 1 – Frequency spectrograms of words spoken either in a normal (= voiced, phonated) manner (left) or in a whispered (= unvoiced) manner (right). Top: German expression of the word 'hallo'. Middle: English expression of the word 'hallo'. Bottom: Expression of 'xin chao', i.e. a Vietnamese equivalent of 'hallo'.

information, and thereby convey clues about a signaler's emotional state (Hultsch et al. 1992). On the other hand, problems in discriminating special emotions, namely 'joy' and 'fear', were reported later (Tartter and Braun 1994). Similar problems can occur if emotions are encoded by normal speech (Scherer and Kappas 1988, Sobin and Alpert 1999), so the issue has been re-investigated with an improved methodological design. The new approach clarified the discrepancy and showed that the decoding of emotional information is based on discrimination processes, but not on clear-cut recognition achievements (Cirillo and Todt 2002).

The study presented here documents some further factors which can affect the perception of unvoiced speech, namely its loudness and particular environmental variables, such as background noise. But I will report first on some fundamental social aspects of whispering. As an empirical treatment of these two issues requires different methodological procedures, they will be dealt with in two separate chapters, and then reviewed together in one general discussion.

I – SOCIAL ASPECTS

The use of whispering has been characterized as being widespread across cultures, but rare in any given society. One major aim of my study is to elucidate factors which could explain this seeming discrepancy. Until now, only a few investigators have treated this issue, and most of them have simply postulated a cultural taboo as the dominant cause of a

restricted application of whispered speech (Miller 1934, Panconcelli-Calzia 1955). Although such taboos certainly play a role, this explanation may prove to be too superficial; a multifactorial causation may be more appropriate.

This rational is supported by the following three arguments: first, one should not overlook the wide distribution of the display (Jensen 1958), though there may well be different reasons why people decide whether or not to use a whispering voice. Second, in the field of communication, the rare occurrence of a specific signal is often correlated with high relevance, and there is evidence that rare usage can help to sustain a signal's salience (Todt 1986). Last but not least, the hypothesized statement has more heuristic value in expanding the point of view and stimulating the search for relevant factors.

Using these arguments as a reference, my study was designed to investigate the use of whispered speech from a social perspective. Little is known about the occurrence rate of whispering, or 'when' and 'why' it is used. There is also a lack of information on how it is judged by people who just witness its application in a public audience, e.g. as a kind of 'co-listener'.

MATERIALS AND METHODS

In order to learn more about when and why people like or dislike communicating by whispering, data were collected by students who had been trained to use questionnaires and, when necessary, to combine them with interviews. These took place in streets or at other public locations, e.g. airports, where people often were waiting and ready to respond when asked to answer questions or to fill-in questionnaires.

To avoid errors that can arise from this kind of data sampling, we applied five types of questionnaires each corresponding on particular core-questions, but differing in their order and also in a number of side-questions. When filling-in our questionnaires, subjects (70 persons for each of the five types of questionnaires = 350, in total) could give their votes either by choosing among alternative items, or by indicating their first, second, or third priority. Additionally, subjects were asked to give us some private information, namely their gender, age and cultural origin. A one-way analysis of variance (ANOVA) was applied to test for statistical significance.

RESULTS

The results were subdivided into the following three subsets of data: general information, aspects of whispering in the private domain, and in public.

General Information

Our data showed that the majority of subjects had a positive attitude towards whispering. Nevertheless, many people were more specific and stressed that their opinion would depend on particular circumstances. When asked how often they would whisper, most subjects said 'seldom' (59%) or 'from time to time' (24%).

A specific set of data referred to an aspect of social facilitation and confirmed that whispering can have a strong 'contagious' effect. More than 50% of the subjects recalled experiencing such contagious effects themselves, for example, when addressing somebody with a friendly question like 'hey, did you hear something, too?', or 'hey, what's the matter with you?', or during playful situations, especially, when they were young.

Private Domain

About 38% of subjects admitted to using whispered speech in private, often quite frequently. Private whispering was used with special forms of tenderness, affiliation or invitations for playful interaction to the life mate or a partner, preferentially without other people around. Such whispering could take place in close contact to an addressee, but also on the phone. In addition, several subjects also admitted to contacting their partner by whispered words in public, with similar aims (e.g. 'signaling their bonding').

The data did not vary with the cultural origin of subjects [$F_{(1,5)} = 0.003$, p=0.959; n.s.]. In terms

of gender-related specificity, however, I found that males used whispering significantly more often to express tenderness than did females [$F_{(1,5)} = 193.72$, $p =< 0.0001$]. A more detailed evaluation of the data revealed that private whispering was particularly frequent during an early stage of 'courtship'. Its repeated use obviously reflected a positive ingroup experience, which seemed not only to reinforce the performance of whispering, but also to strengthen the bonding of mates.

Public Domain

Most subjects (> 92%) admitted to using whispered speech in public. In addition, they provided a lot of interesting information about the contexts and motives of their own whispering. For example, 65% of the subjects addressed their own whispered words mainly to one particular person either a close friend, or a particular partner (e.g. the own mate), or a close relative, especially a child. If whispering was directed to two or more persons (24%), similar addressees were preferred.

Questions about motivation yielded a selection of specific responses. In reply to the question 'why did you whisper in public?' responses were as follows: 'In the first place, I whispered in order to: (a) avoid disturbing someone (24%); (b) communicate a secret message to a specific person (22%); (c) confirm affiliation to such an addressee (17%); (d) initiate a playful encounter, or just for fun (14%); and finally, (e) attract the attention or induce curiosity in members of an audience (11%).

Interestingly, the latter aspect (e) was also cited in a reverse sense, i.e., as a reason not to whisper in public. For example, subjects argued that they avoided using unvoiced speech in order to avoid attracting the notice of others and thereby disturbing them. Aside from this aspect, two well-known and widespread taboos were evident in this context: i.e., 'whispering is impolite', and 'whispering means lying'.

Opinions about whispering were also evaluated in relation to the role of a subject, or a 'co-listener'. According to their statements, 80% of subjects admitted to remember perceptional experiences with whispered vocalizations of other people more clearly than instances when they were whispering themselves. When commenting on whispered vocalizations of other people who did not address them, they provided the following information in order of priority: (a) I had a desire to listen to and understand the speech (35%); (b) I suspected that the speakers were talking about me, and felt excluded (20%); (c) I felt neither concerned about it nor disturbed by the sound (15%); (d) I felt simply disturbed by the whispering voices (15%). Further details are given in Table I.

Again, these data showed no differences related to the cultural origin of subjects [$F_{(1,5)} = 0.153$, $p=0.941$; n.s.]. With respect to gender, a similar result was obtained [$F_{(1,5)} = 0.014$, $p=0.91$; n.s.]. With respect to age, however, two differences were highly significant: in young people (age < 20 years): a particularly large portion admitted 'a desire to listen' [$F_{(2,14)} = 20.72$, $p< 0.001$], whereas a particularly small portion admitted 'not to mind' [$F_{(2,14)} = 20.68$, $p< 0.001$] an exposure to public whispering (Table I).

CONCLUSIONS

The general inquiry documented that whispering, although being relatively rare, can be regarded as a socially significant form of communication. In the private domain, it seemed to play a clearly positive role. There was evidence that it can serve to mediate tenderness, or even support the bond between mates. In public, on the other hand, applications of whispering were characterized as being problematic and thus restricted to specific situations. This suggests that its rarity could be a consequence of the rarity of adequate situations.

Most of my general findings were not unexpected, but some were more remarkable, such as the effect of social facilitation and also the role of a 'co-listener'. As shown, experience with the latter was remembered better than most instances of personal involvement, i.e. cases of self-whispering or of be-

TABLE I

Distribution of votes collected during a general inquiry (sample size: 350 people). Data are given in percentages (M=mean; SD=standard deviation). The sample includes 76% natives, i.e. Germans. Gender distribution was symmetrical. Choices refer to alternative or first priority answers addressed to the question: 'What do you think or feel, if you are co-listening to the public whispering of other people?' Significant values ($p < 0.001$) are marked* (see text).

whispers in public	vote distribution (%)													
choices	cultural origin				gender				years of age					
	natives		non-natives		females		males		< 20		20-50		> 50	
	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD	M	SD
I want to listen	36.4	6.2	38.4	6.7	37.7	5.2	33.3	5.7	51.9 *)	7.2	28.6	4.9	31.3	3.9
I don't mind	24.7	4.6	22.6	5.4	24.5	4.2	25.0	5.1	7.4 *)	2.8	28.6	3.7	34.4	5.6
I feel excluded	20.8	5.0	21.3	3.8	22.4	3.7	16.7	3.6	22.2	4.5	23.8	4.1	12.5	2.4
I feel disturbed	14.3	3.7	15.5	4.6	13.2	4.9	16.7	2.9	14.0	2.7	16.7	3.2	12.5	3.0
rest	3.9	1.6	2.2	0.7	1.9	1.1	8.3	2.3	3.7	1.8	2.4	1.6	9.4	2.2

ing directly addressed by a whisperer. To further investigate these and other issues, I formulated the following two hypotheses:

Ingroup hypothesis. – Whispering is a typical 'ingroup'-signal, what means that it can induce judgements of co-listeners, depending on whether these feel either socially integrated or segregated.

Vigilance hypothesis. – Whispering can affect the psychobiological state of recipients, and in particular raise their auditory vigilance; thus, even 'outgroup'-people may feel a desire to be a co-listener; i.e. to understand the whispered words.

I report here on experiments conducted to test predictions of the second hypothesis. Results of experiments investigating the first hypothesis will be published elsewhere (Cirillo and Todt in prep.).

II – TESTING THE VIGILANCE HYPOTHESIS

Earlier research on the emotional properties of speech indicated that exposure to whispered phrases can affect a hearer's psychobiological state (Cirillo and Todt 2002). Now, this conclusion has been further substantiated. Our results suggest, in particular, that hearing a whispering voice can induce a desire to listen and especially to understand the sound patterns. To further investigate this idea, I have conducted an experiment designed to examine whether people would pay more attention to whispered words than to phonated words, thus achieving a better understanding of them. My expectation was that unvoiced stimuli could induce a higher level of 'sustained attention', or 'vigilance', than voiced stimuli. I also expected that environmental factors, such as bright light or darkness, could also make a contribution. This expectation was encouraged by a study of Todt and Brumm (2001) suggesting that darkness can raise the auditory vigilance of people.

But first I conducted an experiment designed to explore some properties of the performance of whispering, preparing the way for experiments on the perception of whispering. Since whispering is a typical 'low-volume' signal, the first approach concentrated on the role of vocal amplitude.

MATERIALS AND METHODS

Signal performance. Participants of the experiments on signal performance were students of biology, who – after instruction – voluntarily agreed to take part in my study. Subjects (n=8) had to speak a given text as loudly or as softly as possible, or at an intermediate level. To standardize the design, subjects were asked to simply speak sequences of numbers. Individuals were seated in a sound-protected test chamber with walls shielded against echo-effects. The order of experiments and tasks within experiments was changed across subjects. Amplitude measures were taken at a speaker-microphone distance of 1 m using a Rode and Schwarz EZ GA2 precision sound level meter. The sequences of numbers spoken by the subjects were recorded on tape.

Signal perception. Here the participants, students of biology (n=104), were placed in a sound protected room and asked to decode auditory stimuli presented to them via headphones. This setting allowed us to test up to 12 subjects simultaneously, although we made sure that each subject treated their experimental task individually, decoding the result immediately after each stimulus. Subjects with hearing deficits were excluded. Sets of ten different numbers (numbers of four syllables and in random order) were recorded on tape in either a phonated or a whispered expression. Playbacks of tapes differed in the amplitude of stimuli.

Three sets of experiments were carried out. In the first set, subjects were exposed to sounds with an amplitude of about 45, 35, 25, or 20 dB_{SPL}. Sound Pressure Levels were measured with the same sound level meter and standardized at 1 m from the source. The succession of trials was varied randomly across test sessions.

In the second set, I presented the same sets of stimuli, but with environmental noise added. The spoken numbers were received via headphones, the noise through a loudspeaker with an overall amplitude of 45 dB. To simulate a normal situation, I did not use white noise, but background noise recorded in the waiting hall of an airport. In the third set of experiments, I examined an influence of another contextual variable: i.e. the level of effect of room lighting. The same type of design as in the first experiments was used with the following differences: (1) subjects were other students (n=84) who had not participated in former experiments; (2) auditory test stimuli were presented with an amplitude of about 25 dB, to challenge the recognition ability of subjects; (3) tests were conducted either under normal room light or in full dark. The succession of these conditions varied randomly across test sessions. Each test started after a period of adaptation to either light or darkness (5 min), then lasted for about 1 minute, and finally was separated from another test by 3 minutes. Immediately after each stimulus, subjects had to write down what they heard. It was expected that the influence of darkness would improve, by raising the vigilance level of subjects, the decoding of stimuli (Fig. 2).

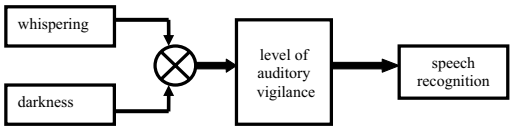

Fig. 2 – Schema illustrating the concept of a vigilance experiment. It describes the prediction that the variables listed on the left side (here: whispering and darkness) raise the level of auditory vigilance, and that this effect would influence the variable on the right side (here: speech recognition).

Data analyses. Errors and successes in number recognition were evaluated according to the different test variables, i.e. voice quality, stimulus amplitude, noise level and room lighting. To test for statistical significance of results, I applied ANOVA or χ^2-methods (df1). Significance was accepted at a level of $p < .05$.

RESULTS

Signal performance. As shown in figure 3, amplitude measures received for a given verbal category formed a coherent distribution. Values for phonated

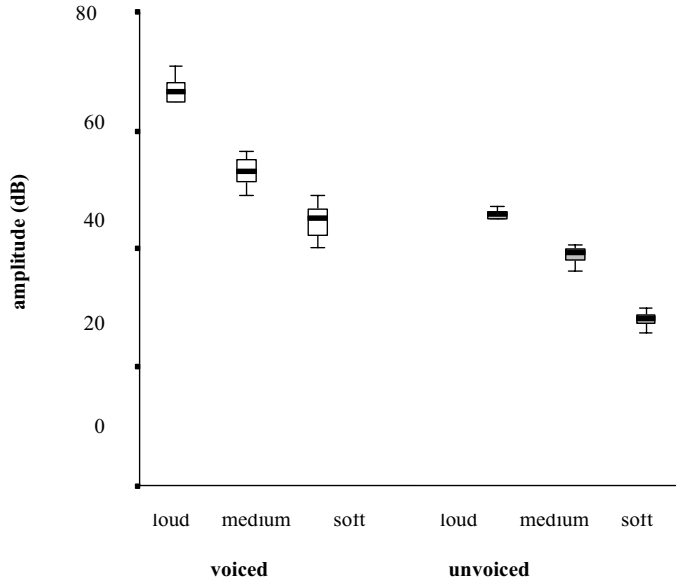

Fig. 3 – Boxplots of amplitude measures ascertained for words (here numbers) spoken either in normally (left) or in a whispered manner (right). Pooled data. Data referred to a total of 400 words recorded from eight subjects (see text).

speech varied from 74 dB (extremely loud), over 59 to 52 dB (normal) to 42 dB (extremely low); measures of whispered speech ranged from 52 dB (extremely loud), over 40 to 35 dB (normal) to 31 dB (extremely low). All subjects showed significant differences in the median amplitude values between the three speaking levels for both phonated and whispered speaking (Friedman ANOVA: $\chi^2 = 16$, N = 8, $p < .001$).

Signal perception. Some effects were revealed that were clearly amplitude-related effects, in particular: (1) stimuli presented with an amplitude of about 45 dB were as well understood as given in a normal voice; (2) with a stimulus amplitude of about 35 dB, phonated numbers were decoded correctly, whereas a few decoding errors appeared with whispered numbers, but this difference was not significant; (3) the proportion of correctly decoded numbers was clearly reduced if amplitude levels were lowered to about 25 dB, and the reduction was especially drastic for the whispered stimuli (Fig. 4);

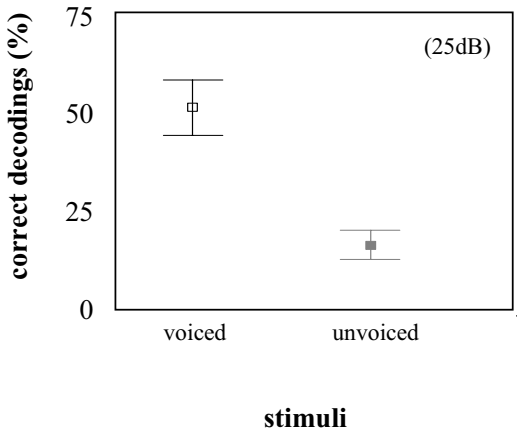

Fig. 4 – Percentage of correctly decoded stimuli plotted against stimulus quality (median and interquartiles); i.e. voiced (= phonated) numbers (left), or unvoiced (= whispered) numbers (right). The two squares refer to stimuli presented through headphones with an amplitude of about 25 dB.

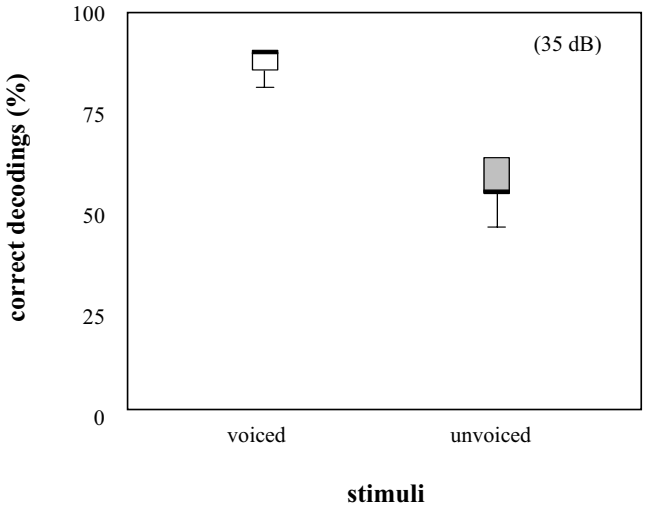

Fig. 5 – Boxplots showing the proportion of correctly decoded stimuli plotted against stimulus quality, here: phonated numbers (left) or whispered numbers (right). Stimuli were presented through headphones with an amplitude of about 35 dB in addition to environmental noise that was played-back with an amplitude of about 45 dB and served to test masking effects.

this effect was highly significant [$F_{(1,103)} = 139.37$, $p < .0001$]; (4) with a stimulus amplitude of about 20 dB, the proportion of correctly decoded numbers showed a further decline for either kind of speech version, and the difference between test results remained significant [$F_{(1,103)} = 33.56$, $p < .0001$].

Results of the study of the effects of environmental noise uncovered effects that were clearly related to stimulus quality. With a level of background noise of about 45 dB, phonated numbers were identified with significantly [$F_{(1,95)} = 375.75$, $p < .001$] less errors than in a whispered version (Fig. 5).

The study of whether and how light levels can influence decoding of verbal information yielded two results (Fig. 6). First, the decoding success with whispered numbers was clearly below that one with phonated numbers; this effect was not significantly different between normal light and darkness. Second, the decoding success achieved in the dark was slightly better than under normal light conditions, and this was true for both voice qualities, whispered numbers and phonated numbers; statistically, however, this difference was not significant [$F_{(1,83)} = 1.99$, $p = .16$].

CONCLUSIONS

Whispered words were generally vocalized with an amplitude around 45 dB. Given that stimulus loudness decreases by approximately 6 dB when the distance is duplicated, I conclude that hearing a whispered stimulus of about 35 dB corresponds with a sender-distance of about 4 meters. As my results indicate, this distance can be regarded as that spatial range above which a whispering voice may not be appropriate. Other authors have estimated 4 m as a boundary span for a communication by whispering (Hultsch et al. 1992).

Although my tests with stimulus amplitudes of 25 dB or less served only to explore the limits of perception, and not to study recognition of whispered signals transmitted over a distance of about 10 m or more, my results confirm that whispering is used best if it is signaled to a nearby addressee.

However, even at a short distance, whispering

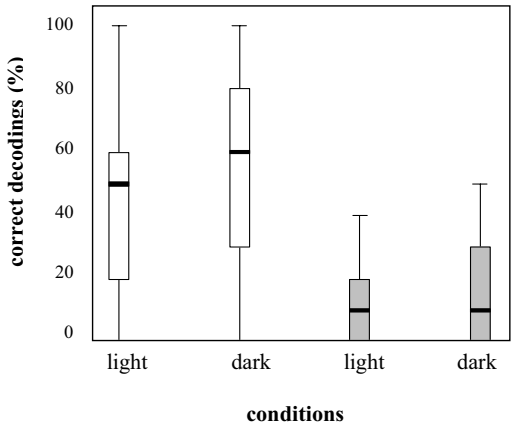

Fig. 6 – Percentage of correctly decoded stimuli (here: numbers) shown for the two experimental conditions: tests in normal light or in the dark. Left boxplots: phonated numbers. Right boxplots: whispered numbers. Stimuli were presented through headphones with an amplitude of about 25 dB.

may be less reliable than phonated speech, as shown by the impact of environmental noise. In a pilot experiment conducted in the waiting hall of an airport, I found that the masking effect of noise above 90 dB can render the producer of a whispered voice unable to recognize its own words (Cirillo unpubl. data). This effect can be explained as a consequence of sound transmission to the ear via bones and tissues which can work well for normal speech, but is constrained for whispered vocalization with its missing fundamental frequency.

Finally, the experiment testing possible effects of light level provided results which were in line with findings of other investigators who studied the startle response of subjects presented with short stimuli of normal speech (Grillon et al. 1997). On the other hand, however, the results did not confirm my expectation (Fig. 2) that the decoding success of whispered stimuli would be better in the dark, though I cannot exclude the possibility that my findings were a consequence of the methodological procedure. Subjects had only five minutes to adapt to a given light condition, perhaps too short a time span for the development of distinct darkness-related effects. A longer exposure to darkness could have raised the auditory vigilance of subjects and improved their decoding success for either class of auditory stimuli.

III – DISCUSSION

The results of these studies allow us to better characterize the communicative role of whispered speech. Answers were gathered to such questions as 'when?' or 'why?' people normally whisper. The results also indicated how well people judge an exposure to a whispering voice. In addition, they showed that whispering can have a contagious effect. Age- or gender-related differences may occur, whereas culture-related effects were not found. These results suggested two hypotheses. One of them predicted that whispering is an 'ingroup'-signal that, in people who are not addressed, can induce negative judgements or feelings of being socially excluded (ingroup hypothesis). The other one anticipated that whispering can raise the auditory vigilance of listeners who are not addressed and even 'outgroup' people may feel a desire to understand the perceived vocalizations (vigilance hypothesis). This latter hypothesis was then experimentally examined with other approaches that served to clarify significant signal properties of unvoiced speech.

The social properties of whispering can be compared to the properties of human laughter. This vocalization is another universal display of humans that is also a typical 'ingroup' signal (Kipper and Todt 2003a). If performed within a given group of persons, laughter – like whispering – has clearly positive effects, whereas negative effects can be observed across different groups (Alexander 1986, Kipper and Todt 2003b). These properties are closely related to the so-called 'contagious effect' (Provine 1992). As documented by this study, this holds for whispering too, although with laughter the contagious effect can be so strong that people who do not join-in can be regarded as 'outsiders' (Todt 1997). Interestingly, there are two further similarities between whispering and laughter. One concerns

structural properties which become clear if people are exposed to unvoiced laughter, which can induce negative feelings in addressees (Bachorowski and Owren 2001). The other similarity concerns a transmodal aspect: laughter, like whispering, is accompanied by a visual display. However, whereas the signaling linked to laughter is given by distinct facial expressions, gestures encoded in hand or head movements are the preferred visual correlates of a whispered message.

It has been hypothesized that whispering can be considered as a cultural ritual which has evolved from normal speech, presumably as an adaptation to specific 'ingroup' functions (Cirillo and Todt 2003). This hypothesis accords with many results of my study on whispered speech. The consequences I have described, when whispering was used in public, could be explained as a result of the functionally incorrect use of the ritual.

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RESUMO

A maioria dos estudos sobre cochicho trata de sua produção e percepção, negligenciando seu papel de comunicação. Eu me concentrei neste aspecto, especialmente nos objetivos sociais e psicobiológicos. Combinei uma enquete geral sobre o uso de fala não articulada com experimentos sobre certas propriedades dos sinais. (1) A análise das respostas aos testes revelou que as opiniões sobre cochicho dependem do contexto social. No domínio privado, o cochicho tem um papel claramente positivo, mas em público ele fica mais problemático. Dois fatores causais foram identificados como relevantes: (a) uma função intra-grupal do cochicho que poderia induzir um efeito extra-grupal negativo nos outros ouvintes, e (b) um componente psicobiológico do cochicho que poderia afetar a vigilância auditiva dos ouvintes que não eram destinatários do sinal, mas que freqüentemente queriam entender a mensagem cochichada. (2) As análises dos dados experimentais confirmam a relevância desses fatores. Adicionalmente, elas mostram que a fala não articulada tem um alcance limitado e é facilmente mascarada pelo barulho ambiente. Tomados juntos, os resultados sugerem que o cochicho é melhor explicado como sendo um sinal de comunicação de proximidade adaptado para uso privativo entre parceiros.

Palavras-chave: comunicação verbal, cochicho, fala não articulada, sinal de grupo, vigilância.

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