DELAYED AUDITORY FEEDBACK EFFECTS ON SIMULTANEOUS INTERPRETERS

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1. Introduction

When people talk they may,consciously or unconsciously, correct their own output, both in content and form. As obvious as this observation may appear, it nevertheless implies a series of considerations which cannot be taken for granted without previous investigation. The fact that speakers may correct their own utterances hints at the existence of a control mechanism for speech, which must somehow rely on a feedback system. Nowadays three different feedback systems related to the control of speech articulation have been described: the tactile system, the proprioceptive system and the auditory system, though it is assumed that most probably other similar systems exist which have yet to be investigated.

Through tactile receptors located in the larynx and in the oral cavity and on the tongue the Central Nervous System receives information concerning the localization of parts of the phonatory organs of the supralaryngeal tract (e.g.tip of the tongue touching teeth, or contact between tongue surface and palate, etc.), concerning the manner and degree of deformation of the oral surfaces, and the onset time of contact (Hardcastle, 1976). Air turbulence during breath inspiration could also provoke a tactile stimulation of the laryngeal receptors. By means of this *tactile feedback* our brain "knows" if the movements within the oral cavity have been carried out correctly in order to reach a given target, e.g. a vowel or a stop consonant, etc.

Another monitoring system of speech production is the *proprioceptive feedback* system, which involves the muscle spindles, joint receptors and Golgi tendon organs. These receptors provide the Central Nervous System with constant information about the position of the phonatory organs, independently from the tactile system. They give very rapid information on the degree of lengthening and tension of the laryngeal, pharyngeal and oral muscles, thus making a global "description" of the shape of the vocal tract obtained through muscle activity (Bava, 1988).

Since time immemorial it had been observed that inborn deafness would generally imply dumbness. This was evidence of the role of hearing in speech production. With an accidental discovery by Bernard Lee, an American engineer, in 1950, the influence of *auditory feedback* on speech was further evidenced. While he was recording his own speech on a tape recorder and at the same time listening to it through headphones, he noticed that this delayed auditory feedback (DAF) could make him dysfluent: he started stuttering, or repeating syllables or prolonging the final parts of words. Lee came to the conclusion that auditory feedback played a major role in the control of speech production, and in particular of correct articulation, voice intensity and pronunciation (Borden & Harris, 1984; pp. 135-142). In clinical audiology the effects of DAF are generally studied in order to assess real deafness in patients who may suffer from hysterical auditory impairments instead of physiological impairments. Moreover, DAF has been thought to be an efficient tool in speech therapy for stutterers (Timmons, 1982), since it turned out to improve fluency in such patients. It is worthwhile mentioning that auditory feedback involves both the transmission of sound waves through the air which reach the ear-drums and the transmission of sound through bone conduction with activation of the inner ear. Auditory feedback is therefore slower than tactile and proprioceptive feedback (the latter being the only one to provide information during the event and not after it; cf. Hardcastle, 1976).

2. Different theories on the effects of DAF on speech production

In normal speakers DAF has been widely used to investigate the role of auditory control on speech in different age groups. The degree of speech disruption under DAF is generally measured by counting the number of syllables uttered per second or words per minute and of dysfluencies and by assessing changes in voice intensity and in the fundamental frequency of the speaker (Siegel et al., 1982). According to several authors, the most disruptive effects generally occur with a 200-msec delay (Waters, 1968; Smith and Thierney, 1971; Siegel et al., 1980), whereas MacKay (1968) tried to demonstrate the existence of a critical delay for every different age by showing that the younger the subjects the longer the most disruptive delay (4 to 6 yr.: 524 msec; 7 to 9 yr.: 375 msec; adults: 200 msec). Though MacKay's "critical interval hypothesis" is still questionable (Siegel et al., 1980), it may be assumed that as children speak more slowly than adults (Haselager et al., 1991), their critical delays may differ according to their age. Another controversial aspect regarding the effects of DAF on speech involves languages. Rouse and Tucker (1966) found that adults were more disrupted by a 200-msec DAF when speaking in their mother tongue (L1) than in a recently acquired language (L2), whereas MacKay (1970) showed exactly the opposite with adult subjects being more disrupted in L2 than in L1.

Generally speaking, however, most experimental studies on DAF tend to consider a delay of 200 msec the most disruptive one for normal adult speakers, regardless of their native language. Finally, as regards the idea of possible lasting residual effects of DAF on normal speakers undergoing experiments with DAF-conditions, the authors of the present study refer to the works by Zalosh and Salzman (1965) and by Ham et al. (1984) to support their firm belief in as well as their personal experience of the harmlessness of this practice.

3. Aim of the present study

During simultaneous interpretation auditory feedback may play the same important role as in any other normal speech act, though it may be somehow influenced by the fact that the interpreter has to do with two languages at the same time, that his auditory sensory modality is already aroused by external stimuli and that he generally has to speak faster than normal speakers (Daró, 1990).

In relating the effects of auditory feedback on speech to simultaneous interpretation three main questions arise:

1. To what extent does auditory feedback intervene in the course of simultaneous interpretation?
2. Do adult subjects trained as simultaneous interpreters show the same critical delay of 200 msec as normal adult speakers?
3. Does auditory feedback somehow change according to the languages involved as input or output vehicles?

The present paper shows the preliminary results of an experimental study on the effects of DAF during simultaneous interpretation. Critical DAF values in students of simultaneous interpretation were first of all assessed during verbal tasks other than simultaneous interpretation, as not a single study including simultaneous interpreters has been reported in the literature so far and we could not assume by default that simultaneous interpreters would show the same disruption effects as normal speakers.

4. Materials and methods

Subjects.

Twelve student interpreters attending either the 3rd or the 4th year at the School for Translators and Interpreters of Trieste (SSLM), 9 females and 3 males aged 21 to 27 (average

age: 24 yrs), 10 with right-hand preference and 2 non-right-handed, underwent this experiment. The subjects' mother tongue (L1) was either Italian (subjects 3, 5, 7, 9, 10 and 11) or German (subjects 1, 2, 4, 6, 8 and 12), their second language (L2) thus being either German or Italian, with the exception of one subject who was a compound German/English bilingual, born within a mixed marriage and having attended Italian schools since the age of 16. All the subjects also knew at least another language (L3). None of them suffered from any neurological disease or auditory impairment.

Procedure

The subjects' task was to recite aloud the days of the week and the months of the year the wrong way round, thus starting from the last day of the week (Sunday) or last month of the year (December) and finishing with the first day or month, respectively (Monday or January). Weeks and years were to follow one another without interruption until the examiner gave a stop signal. Each subject had to carry out two trials of one minute each, in each one of the following conditions: 1. under no delay, thus with normal auditory feedback (NAF) in L1; 2. with NAF in L2; 3. under delayed auditory feedback (DAF) with a 250-msec delay in L1; 4. under DAF with a 200-msec delay in L1; 5. under DAF with a 150-msec delay in L1; 6. under DAF with a 250-msec delay in L2; 7. under DAF with a 200-msec delay in L2 and 8. under DAF with a 150-msec delay in L2. The order of these eight conditions was counterbalanced across the subjects. The subjects were told to speak at high speed, though they were also instructed on the importance of the correct articulation of every syllable with no pronunciation mistakes. Correct articulation thus had priority over speaking speed. Before starting the experimental trials the subjects had to carry out two exercise trials of 30 seconds each to become acquainted with their task. After completing the test in each condition the subjects were allowed a few minutes' rest.

The delayed auditory feedback effect was obtained by means of a special electronic device which sends back the speaker's own voice with a certain delay (expressed in msec.). The speaker speaks into a microphone and listens through earphones to his own delayed voice. The delay interval can be previously fixed by operating a digital keyboard similar to that of a telephone keyboard. In the present experiment three different delay intervals were used: 150, 200 and 250 msec.; voice intensity was about 55 dB (the norm being 50-60 dB).

All trials were recorded on a TMC-5 Sony tape recorder with an ECM-144 Sony condenser microphone and revised by two bilingual correctors (German-Italian and Italian-German, respectively).The total number of words (NW), of general mistakes (GM) and of prosodic mistakes (PM) produced by each subject in each condition was calculated. GM would be dysfluencies, stuttering, wrong articulation of phonemes or syllables and disruption of or deviation from the correct sequence of either days or months (e.g. inversions, omissions, repetitions, substitutions etc.); PM would be any deviation from the subject's standard pronunciation, prolonged voicing and wrong intonation.

5. Results

The average number of words per minute (w/m) produced by the subjects in both NAF conditions (NW NAF=85.06; NW NAFL1=90.37G; NW NAF L2=79.75) and in the six DAF conditions (NW DAF=85.61; NW DAF L1=89.26; NW DAF L2=81.96) taken together was calculated and processed by means of an analysis of variance. There was no significant difference in the average number of w/m produced under NAF as opposed to DAF, whereas the difference between the average number of w/m produced in L1 as opposed to L2 in all conditions taken together was significant (NW L1=89.82; L2=80.85; $F(1,11)=10.679$; $p<0.01$; cf. Figure 1).

In DAF conditions the subjects made on average more general mistakes (GM) than in NAF conditions, though this difference was not significant (GM NAF=5.96, GM DAF=7.97; GM NAF L1=5.75, GM DAF L1=7.74; GM NAF L2=6.17, GM DAF L2=8.19).

Prosodic mistakes (PM) were found only under DAF and not under NAF (PM NAF=0.00; DAF=0.63; $F(1,11)=3.881$; $p=0.07$). In DAF conditions the subjects made more prosodic mistakes in L2 than in L1 (PM DAF L1=0.27; PM DAF L2=0.98; $F(1,11)=3.138$; $p=0.1$).

The number of words produced in L1 and in L2 under DAF with delays at 250, 200 and 150 msec respectively was also calculated. The analysis of variance showed that the average number of words uttered per minute significantly changed according to the different delay intervals ($F(2,22)=4.228$; $p<0.02$), with the following results: L1 DAF 250 msec=93.46; L1 DAF 200 msec=89.5; L1 DAF 150 msec=84.87; L2 DAF 250 msec=84.54; L2 DAF 200 msec=82.29; L2 DAF 150 msec=79.08 (cf. Figure 2).

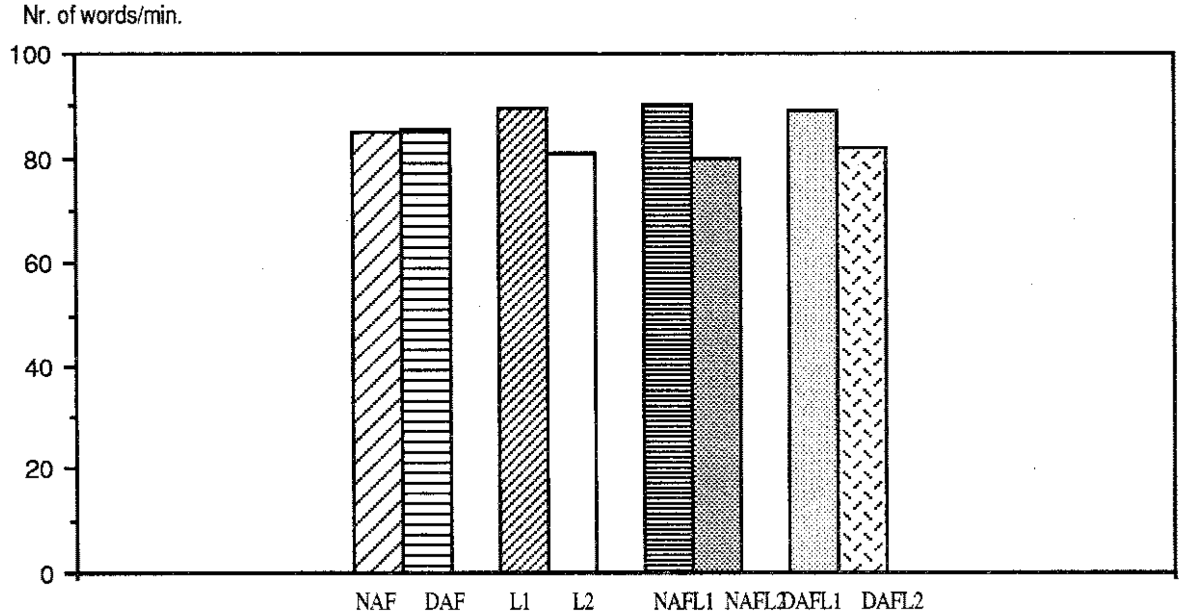

Fig. 1. Average number of words per minute produced in NAF and DAF conditions in L1 and L2.
* $p<0.01$ (significant)

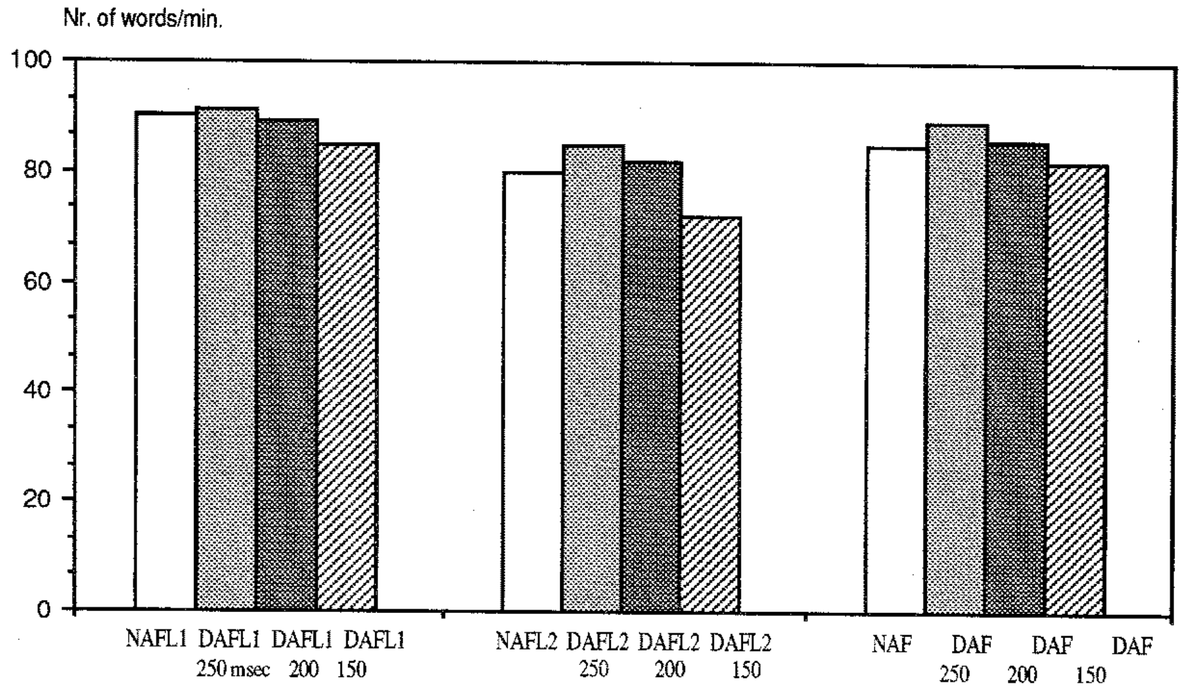

Fig. 2. Average number of words per minute produced under NAF and under DAF with different delay intervals (150, 200 and 250 msec) in L1 and L2 respectively.
* $p<0.01$ (significant)

6. Discussion

One of the criteria used in the present study, aiming at assessing the role of auditory feedback in subjects trained as simultaneous interpreters, was speech fluency in L1 and L2 respectively. Our measure parameter for speech fluency was the number of words per minute (w/m). The first major result showed a more fluent speech in L1 than in L2 (L1=89.82 w/m; L2=80.855 w/m). Thus, in spite of the fact that our student interpreters actually mastered their second language very well and were extremely fluent in it, they nevertheless were generally more fluent when talking in L1. As obvious as this result may appear, it might at least be considered as an objective parameter when discussing the advantages of interpreting into one's mother tongue rather than in a second language.

A second, rather striking result of this experimental investigation was the lack of any significant difference in speech fluency between DAF and NAF conditions. Considering both L1 and L2 together, speech fluency was 85.06 w/m in NAF conditions and 85.62 w/m in DAF conditions, suggesting that speech fluency was generally not impaired by a delayed auditory feedback. It should be stressed that in DAF conditions the subjects generally made more global mistakes as well as mistakes in prosody, though neither of these data were significant. In our opinion, while learning interpretation strategies student interpreters most probably also learn how to pay less attention to the auditory feedback information. As the incoming message is of the utmost importance in the process of interpretation, the interpreter probably gradually learns how to ignore a large proportion of his natural auditory feedback. Another possible explanation would consider the interpreters' (acquired) tendency to divide their attention over the many different stages of a simultaneous interpretation process. It might be assumed that while simultaneously translating a given text, the interpreter alternately pays more focalized attention on the input for a given time lag (t_x) and on his own output for another time lag (t_y). The results of the present investigation show that t_y is undoubtedly shorter than t_x, because if our subjects had had the habit of paying more attention to their own output, DAF conditions would have been significantly more disturbing than NAF conditions, in that they would have caused a greater number of general and prosody mistakes and a significant decrease in speech fluency.

Finally, as our hypothesis was that in individuals trained as simultaneous interpreters speaking speed generally tends to be higher than in normal speakers (cf. Daró, 1990), we tried to find another reliable parameter to support this idea. Previous investigations generally showed that the more slowly people speak, the longer the most disruptive delay interval is (cf. MacKay, 1970; Siegel et al., 1980). Several authors seem to agree upon a 200-msec delay as the most disruptive one in normal adult speakers (MacKay, 1970; Smith and Tierney, 1971; Elman, 1983; Ham et al., 1984), therefore we expected our fast-speaking subjects to be more disrupted by a delay interval under 200 msec. For this reason they underwent DAF sessions with delay intervals at 150, 200 and 250 msec. The subjects were told to speak fast and at the same time *to assure clear and correct articulation*, thus reaching an average expression pace of 3.55 syllables per second in all sessions taken together. At this rate we found that the most disruptive delay interval was at 150 msec. Assuming that this is more or less the general speaking speed of an interpreter during simultaneous interpretation (or even faster), it may be inferred that the most critical auditory delay in SI is about 150 msec (or even shorter). It may therefore be assumed that in simultaneous interpreters, whose speaking speed generally increases along with the acquisition of interpretation strategies, the neurophysiological mechanisms accounting for normal auditory feedback functions undergo a re-organization according to the speech rate every interpreter tends to use.

As in Rouse and Tucker (1966) in DAF conditions our subjects were surprisingly more disrupted when speaking in L1 than in L2, as if they had the tendency of relying more on auditory feedback while expressing themselves in their mother tongue than in their second language. The idea is that auditory feedback becomes more significant with language mastery (cf. also Siegel et al., 1980), but further investigation in this direction is needed before attempting any other reasonable explanation.

References

BAVA, A. (1988). The neurophysiological bases of language use and speech. In: *The Theoretical and Practical Aspects of Teaching Conference Interpretation* (Gran L. and Dodds J. Eds.), pp. 39-70. Campanotto, Udine.

BORDEN G.J. and HARRIS K.S. (1984). *Speech Science Primer. William & Wilkins*, Baltimore/London.

DARO' V. (1990). Speaking speed during simultaneous interpretation. A discussion of its neuropsychological aspects and possible contributions to teaching. In: *Aspects of Applied and Experimental Research on Conference Interpretation* (Gran L. and Taylor C. Eds.), pp. 83-92. Campanotto, Udine.

ELMAN J.E. (1983). Oral vs. manual tapping with delayed auditory feedback as measures of cerebral dominance. *J. Speech Hear. Res.*, 26:97-106.

HAM R., FUCCI D., CANTRELL J. and HARRIS D. (1984). Residual effects of delayed auditory feedback on normal speaking rate and fluency. *Percep. Mot. Skills*, 59:61-62.

HARDCASTLE W.J. (1976). *Physiology of Speech Production.* Academic Press, London.

HASELAGER G.J.T., SLIS I.H. and RIETVELD A.C.M. (1991). An alternative method of studying the development of speech rate. *Clinical Linguistics and Phonetics*, 5:53-63.

MACKAY D.G. (1968). Metamorphosis of critical interval: Age-linked changes in the delay in auditory feedback that produces maximal disruption of speech. *J. Acoust. Soc. Am.* 43:811-821.

MACKAY D.G. (1970). How does language familiarity influence stuttering under delayed auditory feedback? *Percep. Mot. Skills*, 30:655-699.

ROUSE R.O. and TUCKER G.R. (1966). An effect of delayed auditory feedback on speech in American and foreign students. *J. Speech Hearing Res.*, 9:456-460.

SIEGEL G.M., FEHST C.A., GARBER S.R. and PICK H.L. (1980). Delayed auditory feedback with

PICK H.L. (1980). Delayed auditory feedback with children. *J. Speech Hearing Res.*, 23:802-813.

SIEGEL G.M., SCHORK E.J., PICK H.L. and GARBER S.R. (1982). Parameters of auditory feedback. *J. Speech Hearing Res.*, 25:473-475.

SMITH K.U. and THIERNEY D. (1971). Delayed speech feedback and age. *J. Speech Hearing Res.*, 14:214-219.

TIMMONS B.A. (1982). Physiological factors related to delayed auditory feedback and stuttering: A review. *Percep. Mot. Skills*, 55:1179-1189.

WATERS J.E. (1968).A theoretical and developmental investigation of delayed speech feedback. *Genet. Psychol. Mongr.*, 78:3-54.

ZALOSH S. and SALZMAN L.F. (1965). After effects of delayed auditory feedback, *Percep. Mot. Skills*, 20: 817-823.