COMMUNICATION BETWEEN NATIVE AND NON-NATIVE SPEAKERS OF ENGLISH IN NOISE

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1 Introduction

Communication between multilingual speakers in noisy environments can be problematic for both civilian and military operations. Pilots and air-traffic controllers communicate in high-workload situations, often in their second language [1]. For military personnel, battlefield communication in multi-national operations can be further complicated by extreme noise exposure from armoured vehicles, weapons and aircraft flyovers. The wearing of tactical communication and protection systems (TCAPS) provides users with hearing protection and integrated radio communication, but could interfere with face-to-face communication. To date, there have been few studies of the communication effectiveness of non-native speakers in noise wearing hearing protection devices (HPDs), particularly among those with a range of linguistic backgrounds. With two official languages in Canada and a culturally diverse population in the Canadian Armed Forces, this study of communication between native and non-native speakers was conducted in the interest of improving battlefield communication.

2 Methods

2.1 Participants

Ethics approval was obtained from the Human Research Ethics Committee (HREC) of Defence Research and Development Canada (DRDC). Twenty-four normal-hearing men and women, military and civilian, participated. The average age was 33.9±9.3 years (range: 21 to 53). Half of each gender subgroup of 12 were native monolingual English speakers (NA) and half were non-native speakers (NN) who learned English after the age of 10 years.

2.2 Test Facility and Materials

Responses on the language experience and proficiency questionnaire (LEAP-Q) [2] were used to confirm group assignment. The experimental sessions were conducted in the noise simulation facility at DRDC, Toronto Research Centre, which is a large, semi-reverberant room (10.55 x 6.10 x 3.05m^3). Two tests of speech intelligibility were presented: the modified rhyme test (MRT) [3] and the speech perception in noise test (SPIN) [4].

2.3 Experimental Protocol

Each participant completed two experimental sessions in same gender pairs, in which they alternated as a talker and listener. The NA participants were paired with another NA in one session and an NN in the other session. Similarly, the NN participants were paired with an NN in one session and an NA in the other. Thus there were four groups of talker-listener pairs: NA-NA, NA-NN, NN-NA and NN-NN. The linguistic backgrounds of the NN-NN pairs were mismatched to avoid a possible interlanguage intelligibility benefit [5].

The MRT and SPIN tests were administered for two modes of communication: face-to-face (F2F) and radio. In the F2F condition, the talker and listener were seated facing each other at the ends of a two-meter long table. An earmuff-style TCAPS device (3M™ Peltor™ LiteCom Plus [3M, St. Paul, MN]) was worn by each participant with the radio turned off. Participants were instructed to maintain a "normal" voice level of 55 dBA; this was practiced during a training run held prior to the experimental sessions. The background noise was a recording of a light-armoured vehicle (LAV III) driving on a highway. Three levels of the background noise were used: 55, 60 and 65 dBA, giving approximate speech-to-noise ratios of 0, -5 and -10dB, respectively. In the radio condition, a visual barrier was placed in the middle of the table so that the participants could not lip-read. The headset was turned on and used for communication. The talker used the push-to-talk mode to transmit the MRT word ("the word is ___") or the SPIN sentence to the listener. The background noise was presented at 80 dBA. Each participant pair alternated being a talker and a listener for the radio condition, and the three F2F conditions.

3 Results

3.1 Language Experience

Based on the responses to the LEAP-Q, the average age of English acquisition for the NN group was 10.9±3.7 years and the number of years of schooling or work in English was 13.7±6.7 years. Their self-ratings of English speaking, understanding and reading comprehension were 7.8±1.2, 8.6±0.8 and 8.8±0.7, respectively, out of a possible 10. The reported first languages included Chinese, Serbian, Spanish, French and Russian.

3.2 F2F Condition

The results of the MRT for the three background noise levels in the F2F condition are shown in Figure 1. The MRT results (combined for NA and NN listeners) are shown as percentage of correct responses, separated by trials

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with contrasting initial and final consonants. An analysis of variance (ANOVA) showed main effects of background noise level ($p<0.001$), talker (NA versus NN; $p<0.04$), and consonant ($p<0.001$). The interaction of talker by consonant was significant ($p<0.03$).

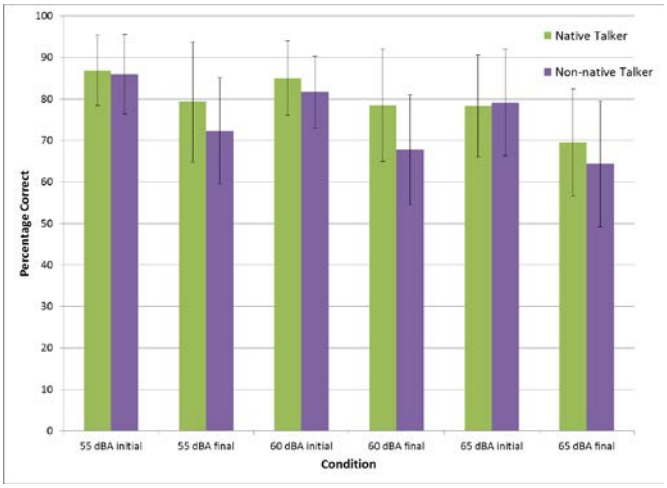

Figure 1: Mean percentage correct for MRT F2F and standard deviation, shown separately for initial and final consonants.

The results for the SPIN (combined for NA and NN listeners) are shown in Figure 2, separately for sentences with high and low contextual cues. An ANOVA showed main effects of background noise level ($p<0.001$) and contextual cues ($p<0.001$) and a between-subjects effect of listener ($p<0.006$).

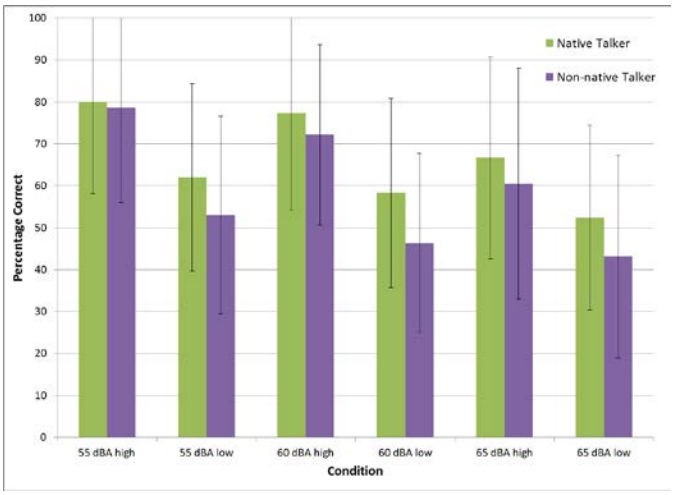

Figure 2: Mean percentage correct for the SPIN F2F and standard deviation, shown separately for low and high contextual cues.

3.3 Radio Condition

The results of the MRT and SPIN for the radio condition are summarized in Table 1. For the MRT, an ANOVA showed main effects of talker ($p<0.003$) and consonant position ($p<0.001$). For the SPIN, there were main effects of talker ($p<0.02$), contextual cues ($p<0.001$) and a between-subjects effect of listener ($p<0.01$).

Table 1: Mean percentage correct and standard deviation for the MRT (by initial and final contrasting consonant) and SPIN (by high and low contextual cues) for the radio condition.

	Native Talker	Non-Native Talker
MRT initial	90.7 ± 9.2	83.5 ± 10.3
MRT final	83.7 ± 11.7	71.5 ± 17.9
SPIN high	92.5 ± 10.2	84.8 ± 17.6
SPIN low	75.8 ± 16.4	67.2 ± 22.5

In all F2F and radio conditions, NN listeners performed more poorly overall on the SPIN than NA listeners.

4 Discussion

Based on the LEAP-Q responses for self-rating of English proficiency and years of education and work experience in English, the NN group can be described as highly proficient. Regardless, NN listeners performed more poorly than NA listeners on the SPIN test in both the F2F and radio conditions, but not on the MRT. This outcome may have been due to the fact for the SPIN, test listeners must recognize the final word, while for the MRT, response alternatives are provided. This suggests that it may be beneficial for NN workers to communicate with a limited vocabulary. Both NN and NA listeners had difficulty understanding NN talkers. Our future studies will investigate the benefits of linguistic training options in a military context. Previous studies have shown that listeners can be trained to improve speech understanding in noise [6].

References

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