Interior noise of an aircraft cockpit: Affective reactions and human performance

Johan Lindvall
University of Gothenburg, Sweden
johan.lindvall@psy.gu.se

Abstract

This study examined the effect of interior noise of an aircraft cockpit on affective reactions and rated human performance. Affective reactions were characterized by a combination of the two orthogonal dimensions, valence (unpleasantness-pleasantness) and activation (arousal) that form a circumplex structure. Human performance was measured by asking participants to rate how they believed their performance on various tasks would be affected by the noise. Recordings of interior aircraft sounds from the cockpit of a Boeing 737-700 during climb, level flight, descent and with or without speech were used. Half of the sounds were modified to correspond to what is experienced with an ANR (active noise reduction) headset. The result showed that ANR modified sounds were more pleasant, less activating and having less negative effect on rated performance. Furthermore, the noise experienced during descent was rated as having a more negative effect on human performance compared to level flight. ANR was less effective in the climb phase and the effect of ANR was moderated by the presence of speech. Finally, valence explained a significant part of variation in human performance.

Aim

To learn more about:
• The effect of interior noise of an aircraft cockpit on affective reactions and rated human performance.
• The effect of active noise reduction (ANR).
• The effect of different sound pressure levels between different flight phases.
• The effect of presence of speech.

Method

23 participants, with no pilot license, rated their affective reactions and believed performance after listening to recordings of 12 interior aircraft sounds. Recordings of interior aircraft sounds from the cockpit of a Boeing 737-700 during climb, level flight, descent and with or without speech were used. Speech was a combination of ATC- and crew communication. The microphones used for recording were placed by the ears of the first officer. Half of the sounds were modified to correspond to what is experienced with an ANR headset. Sound pressure levels ranged from 73 to 85 dB(A) for sounds without ANR and from 56 to 70 dB(A) for ANR modified sounds. Affective reactions were measured by ratings of valence (unpleasantness-pleasantness) and activation (arousal). Two bipolar scales were used, each defined by three adjective pairs. Sleepy-awake, dull-peppy, and passive-active defined the activation scale. Displeased-pleased, sad-glad, and depressed-happy defined the valence scale. The scales ranged from –4 over 0 to 4 where –4 corresponded to the left adjective, 0 to a neutral state, and 4 to the right adjective (Västfjäll, Friman, Gärling, & Kleiner, 2002). Human performance was measured by asking participants to rate how they believed their performance on various tasks would be affected by the sound. Eight questions were constructed in order to tap concentration, mental performance, decision-making, ability to organize work tasks, psychomotor performance and information processing. The scale ranged from –5 over 0 to 5 where –5 corresponded to negative influence on performance, 0 to not at all, and 5 to a positive influence.

Result

Affective reactions

Within subject ANOVAs with 2(ANR/no ANR) x 2(speech/no speech) x 3(flight phases) were performed on the measures of valence and activation. A significant main effect of ANR on valence was found (F = 9.98, p < .01) where ANR modified sounds were more pleasant (M = 0.51) than sounds without ANR (M = -0.54). A significant main effect of ANR on activation was found (F = 9.80, p < .01). Sounds without ANR were rated as more activating (M = 0.51) than sounds with ANR (M = -0.45). Figure 1 shows the affect circumplex.

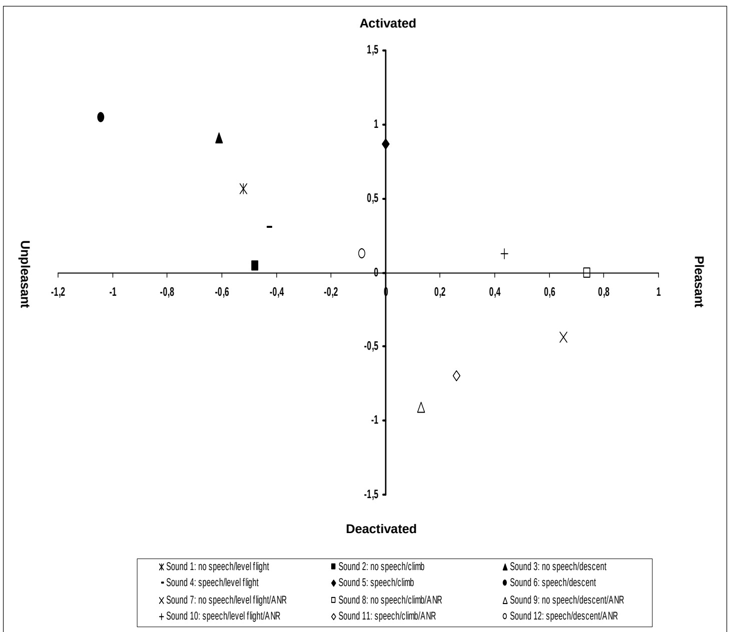

Figure 1. The affect circumplex and the means for affective reactions to 12 interior sounds of an aircraft cockpit.

Human performance

All questions about human performance were highly correlated with each other, therefore, the items were summed together to form one single measure of rated human performance. A multiple regression analyses was performed with activation and valence as independent variables and rated performance as dependent variable. Valence explained a significant part of variation in human performance (β = 0.66, t = 14.29, p < .01). The overall explained variance was R^2adj = 0.44.

A within subject ANOVA with 2(ANR/no ANR) x 2(speech/no speech) x 3(flight phases) was performed on the measure of rated human performance. A significant main effect of ANR was found (F = 15.70, p < .01) where sounds without ANR (M = -1.70) had a more negative effect on rated performance than sounds with ANR (M = -0.72). A significant main effect of flight phase (F = 3.56, p < .05) was found (climb: M = -1.12, level flight: M = -1.06, descent: M = -1.45). Bonferroni corrected comparisons revealed that the only difference was between level flight and descent. Figure 2 shows mean performance for each of the 12 sounds.

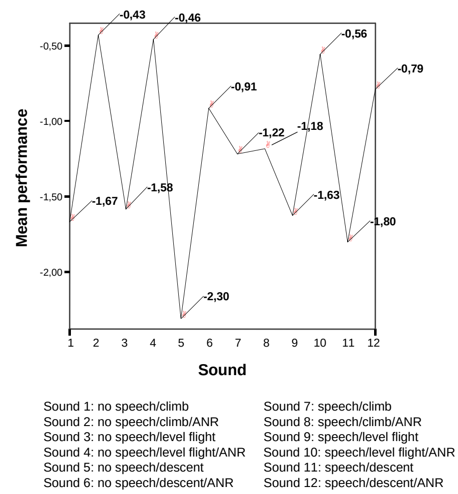

Figure 2. Mean performance for each of the twelve sounds.

Two significant interactions were found. First between ANR and flight phase (F = 3.50, p < .05) where ANR was less effective in the climb phase compared to level flight (Figure 3). And second, between ANR and speech (F = 8.41, p < .01) where the effect of ANR was moderated by the presence of speech (Figure 4).

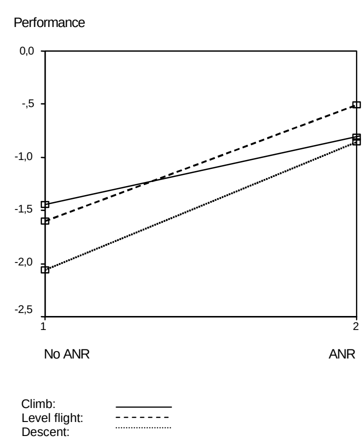

Figure 3. The interaction between ANR and flight phase.

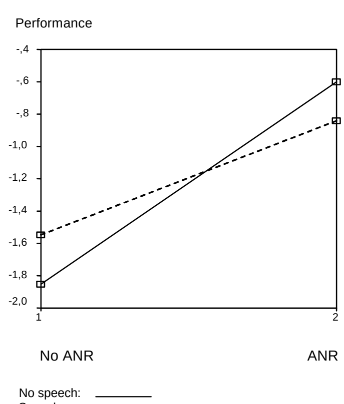

Figure 4. The interaction between ANR and speech.

Reference

Västfjäll, D., Friman, M., Gärling, T & Kleiner, M. (2002). The measurement of core affect: A Swedish self-report measure. *Scandinavian Journal of Psychology, 43,* 19-31.