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Temporal trends in aircraft noise annoyance

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Several recently published studies have investigated potential temporal trends in aircraft noise annoyance. Some of these studies suggest that people nowadays react more strongly to aircraft noise – by as much as an order of magnitude – than they did in the 1960s. Other studies have failed to detect such a trend, or attributed it to differences in survey methods, noise estimation methods, airport operations, and other factors that do not affect energy-weighted exposure levels. This paper analyzes Community Tolerance Level (CTL) values from 57 studies on aircraft noise annoyance conducted between 1961 and 2014 for trends over time.

Conclusions of analyses of temporal trends were found to be highly dependent on classification of studies based on the occurrence or anticipation of a step change in the noise exposure situation. Most studies of community reaction to actual or anticipated step changes in aircraft noise exposure have been conducted relatively recently, and report less tolerance for noise. Inclusion of such studies in temporal trend analyses produces questionable conclusions about increases in aircraft noise-induced annoyance over time. The current study found no evidence suggesting a need to revise existing dose-response curves to reflect a putative trend toward greater sensitivity to noise exposure in recent decades.

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1 INTRODUCTION

People's annoyance with aircraft noise near airports has been measured repeatedly over the past half-century via social surveys conducted at more than 500 interviewing sites, mainly in North America and Europe. Meta-analyses of these data have been facilitated by increasing numbers of studies that have adopted common noise reaction questions and annoyance scales (Fields et al., 2001). Despite differences in survey methods and circumstances of noise exposure among many studies, several authors have attempted to discern consistent trends over the decades in the course of studies intended to yield a universal exposure-response function. The latest revision of ISO 1996-1 (2015) summarizes many of these efforts.

Guski (2004), for example, found that a quarter of survey respondents were highly annoyed at a noise exposure level of L_{dn} = 68 dB in 1965, but the same percentage of respondents were highly annoyed at L_{dn} = 61 dB in 1990. Guski used a second order polynomial regression (r^2 = 0.40) to 18 data sets compiled by Miedema and Vos (1998). A linear regression line (r^2 = 0.38) fitted to the same data sets indicates a decrease in tolerance for aircraft noise exposure of 0.31 dB/year. The term Highly Annoyed (HA) denotes the upper 25-30 percent of the annoyance scale.

The HYENA study (HYpertension and Exposure to Noise near Airports) was an EU funded research project involving six partners throughout Europe. The primary objective was to study the connection between hypertension and exposure to aircraft noise, but as part of the study noise-induced annoyance due to aircraft and road traffic noise was assessed in subjects that lived in the vicinity of six major European airports. The HYENA consortium concluded in a summary paper (Babish et al. 2009) that "Annoyance due to aircraft noise has increased over the years", and recommend that the EU standard curve for aircraft noise should be modified. This conclusion in a relatively recent study involving the opinions of more than 4800 respondents is often cited (e.g. by Janssen and Guski, 2014) as a demonstration that annoyance due to aircraft noise has indeed increased over the years.

A closer examination of the HYENA report reveals, however, that two of the airports were excluded in the analysis reducing the number of respondents to about 3200. Furthermore the questionnaire was not constructed according to the ICBEN recommendations (Fields et al., 2001). Instead of asking for a general assessment of the aircraft noise situation, the interview contained questions addressing annoyance during specific time periods: day-time and night-time. Berglund and Nilsson (2000) have shown that total annoyance cannot be assessed on the basis of assessment of separate sources. Similarly general annoyance cannot be assessed on the basis of assessment of separate time periods (Vincent et al. 2000). The HYENA survey findings can therefore not be directly compared with the EU dose-response curve, as Babish et al. recommend.

In a new report, Janssen and Guski (2015) analyzed the findings of 32 aircraft noise annoyance surveys from 1961 to 2005 contained in the TNO database. Janssen and Guski focused on the percentage of survey respondents describing themselves as highly annoyed at an exposure level of L_{dn} = 55 dB. They found that for this exposure level % HA had increased from about 10 percent in 1960 to about 30 percent in 2000. They also found that the sound level necessary to induce 25 percent highly annoyed had decreased from about L_{dn} = 65 dB in 1970 to about L_{dn} = 55 dB in 2000.

Brooker (2009), on the other hand, has noted that although there are some indications of a decrease in tolerance for noise exposure over the last 25 years, reported trends tend to be weak, and could also be attributed to sampling and/or methodological differences among studies. Van Kempen and Van Kamp (2005) proposed several explanations for a reduced tolerance for aircraft noise, but found persuasive evidence to be lacking. Janssen et al. (2011) observed that the annoyance scale used was an important source of heterogeneity in annoyance response, but ruled it out as a satisfactory explanation for the observed trend.

An extended database was therefore compiled of aircraft noise annoyance survey outcomes. Fidell et al. (2011) compiled a list of 43 studies conducted during the period 1961 to 2007 in their initial CTL analysis. These were combined with nine additional studies analyzed by Janssen and Guski but not included among the studies analyzed by Fidell et al. To complete the dataset, the findings of three post-2007 studies from Vietnam (Nguyen et al., 2011, Nguyen et al., 2012, Gjestland et al. 2015) and two studies from Norway (Gelderblom et al., 2014) were added. The entire dataset consisted therefore of 57 surveys on aircraft noise annoyance studies conducted between 1961 and 2014. All 57 studies were analyzed for systematic temporal trends in community tolerance for aircraft noise exposure.

2 METHOD

Comparisons of the results of diverse surveys are facilitated by the use of a single-number summary index. Guski (2004) adopted the noise level at which 25 percent of the exposed population was highly annoyed, for this purpose. Janssen and Guski (2015) used the percentage highly annoyed at an exposure level of L_{dn} = 55 dB. The current analysis uses the Community Tolerance (CTL) method (Fidell et al. 2011) to derive a single number index, as described in Annex H of the current revision of ISO 1996-1 (2015). A CTL value calculated from the findings of a specific survey is the noise level at which 50 percent of the exposed population regard themselves as highly annoyed. CTL values serve to anchor a loudness-like predictive function of fixed form to the abscissa.

3 TREND ANALYSIS

CTL values were calculated for all the 57 surveys included in the current meta-analysis. Figure 1 shows the results of a simple linear regression analysis on the entire dataset, with only study year as a sole predictor variable. The negative slope of the regression line suggests lesser tolerance for noise exposure over time. The - 0.18 dB per year gradient of this trend is unlikely to have been observed by chance alone (p = 0.009). In itself, this suggests that community tolerance for aircraft noise is now 8 dB lower than in the early 1960s. Similarly, the sound level necessary to highly annoy half of a noise exposed population in 1970 is 5.5 dB lower in 2000. This is about half the difference found by Jansen and Guski, but both studies show lesser tolerance for noise exposure in later years.

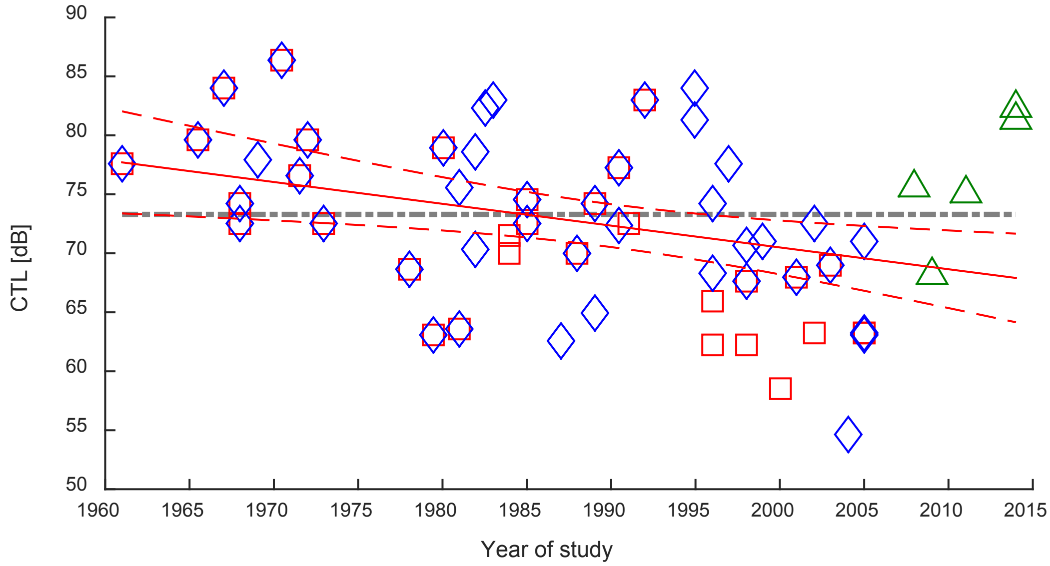

Figure 1. CTL-values for 57 aircraft noise annoyance studies conducted between 1961 and 2014 (diamonds: Janssen and Guski, squares: Fidell et al, triangles: Vietnam and Norway. The solid red line (R^2 = 0.10) shows the linear fit of all data, including confidence intervals (dashed lines). The gray dash-dot line shows a constant CTL of 73.3 for comparison with the EU guideline

Even though the trend noted above is unlikely to have been observed by chance alone, it is a very weak one, which leaves nearly 90% of the variance in the relationship between aircraft noise exposure and CTL values unexplained. In other words, the mere passage of time accounts for only about a tenth of the uncertainty in the observed changes in CTL over the decades. Other, unidentified factors account for far more of the variance in the relationship between the predictor and predicted variables.

Some of the analyzed studies were conducted near airports that had experienced sudden changes in the aircraft noise situation. Noise exposure was stable or increased gradually at many airports, but new runway construction, changes in runway utilization, fleet changes, flight path changes, extension of operating hours, increases in numbers of night flights, and similar factors created abrupt changes in the noise exposure in some neighborhoods at other airports. Such abrupt changes can temporarily affect annoyance prevalence rates (Fidell et al., 1985; Brown and van Kamp, 2008). Likewise, it has been previously suggested that when residents expect an abrupt change, public debate and fear for the unknown also cause noise annoyance to temporarily increase (Van Kempen and Van Kamp, 2005).

The studies were classified by the presence of a recent or expected high rate of change in aircraft noise exposure, in the manner of Janssen and Guski. Information in the Wyle catalog (Bessarab et al., 2009) was used for this purpose, along with other published results as available together with direct contact with relevant researchers.

The analysis described earlier was then repeated for two data sets. One data set was composed of findings from high rate of change airports, while the other data set included only low rate of change airports. A total of 57 surveys were included in this analysis. The results of these analyses are plotted in Figure 2.

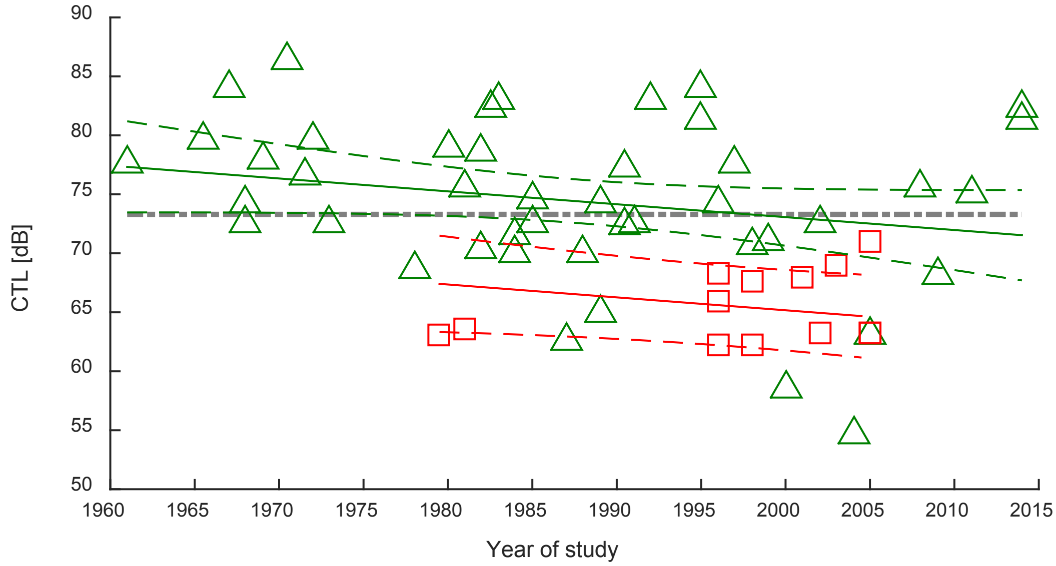

Figure 2. CTL-values for 57 aircraft noise annoyance studies conducted between 1961 and 2014 categorized by high rate of change (red squares) or lack thereof (green triangles). The solid red and green lines show their respective linear fits (R^2=0.29), including confidence intervals (dashed lines). The gray dash-dot line shows a constant CTL of 73.3 dB for comparison with the EU standard curve.

The red squares mark all 'high rate of change' studies. Green triangles plot the findings for all of the rest of the studies. The slope is – 0.11 dB/year. The CTL_{2015} value of 74 dB ± 4 dB for studies at low rate of change airports, is in good agreement with the average of 73.3 dB reported by Fidell et al. (2011) which corresponds with the EU curve. However, the tolerance for aircraft noise is 8 dB ± 4 dB lower in studies following or preceding a step change, and this effect was statically significant.

Brooker (2009) discusses the quality of earlier aircraft noise annoyance studies. He argues that older studies should not be included in a trend analysis due to unreliable noise data. The noise estimates for older studies are generally much less accurate than those available in modern studies.

The above analysis was therefore repeated for all airport surveys from 1978 and later. (The cut-off year was decided because there is a 5-year gap between two concequtive studies at this point). Figure 3 shows the result of a simple linear regression with only study year as a predictive parameter on the 47 studies completed since 1978. In contrast with the result from the entire dataset, study year did not have a significant impact, and if there is a trend, its effect is no more than 3 dB over 40 years. The model only explains 1 % of the variability of CTL scores.

Figure 4 shows the results of the extended model including categorization based on rate of change. Once again, study year does not significantly contribute to CTL, but splitting the surveys in two sets: high/low rate of change, improves the fit significantly. Now 25 % of the variability in the data has been accounted for.

For studies without a step change, CTL is equal to 73 dB ± 5 dB. This is in perfect agreement with the European guideline. There is 8 dB ± 5 dB less tolerance for aircraft noise around airports where step changes occurred recently or were planned for the near future.

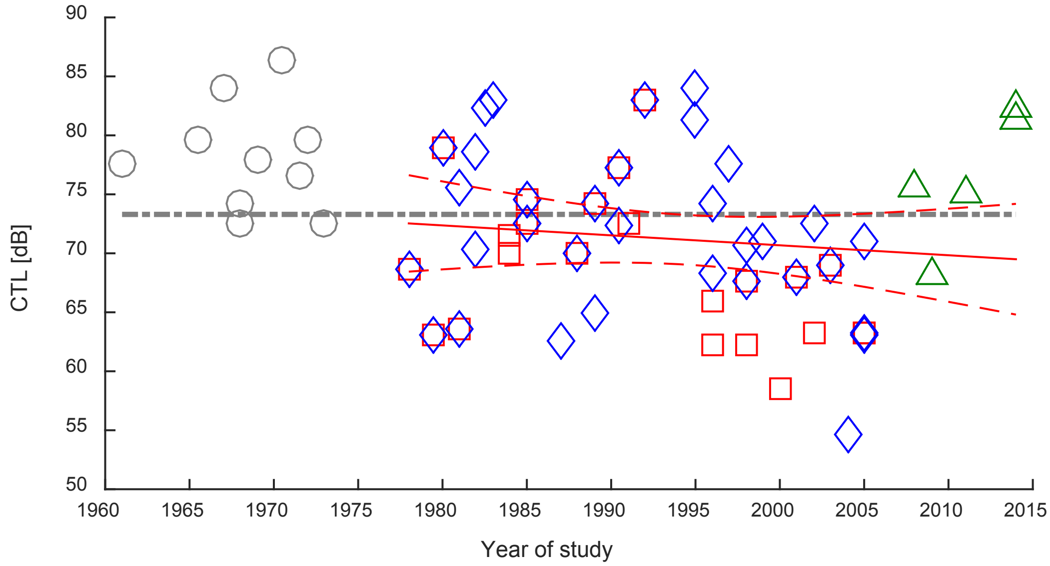

Figure 3. CTL-values for 47 aircraft noise annoyance studies conducted between 1978 and 2014 (diamonds: Janssen and Guski, squares: Fidell et al, triangles: Vietnam and Norway). The gray circles indicate excluded studies from earlier years. The solid red line shows the linear fit of all data (R^2=0.01), including confidence intervals (dashed lines). The gray dash-dot line shows a constant CTL of 73.3 dB for comparison with the EU standard curve.

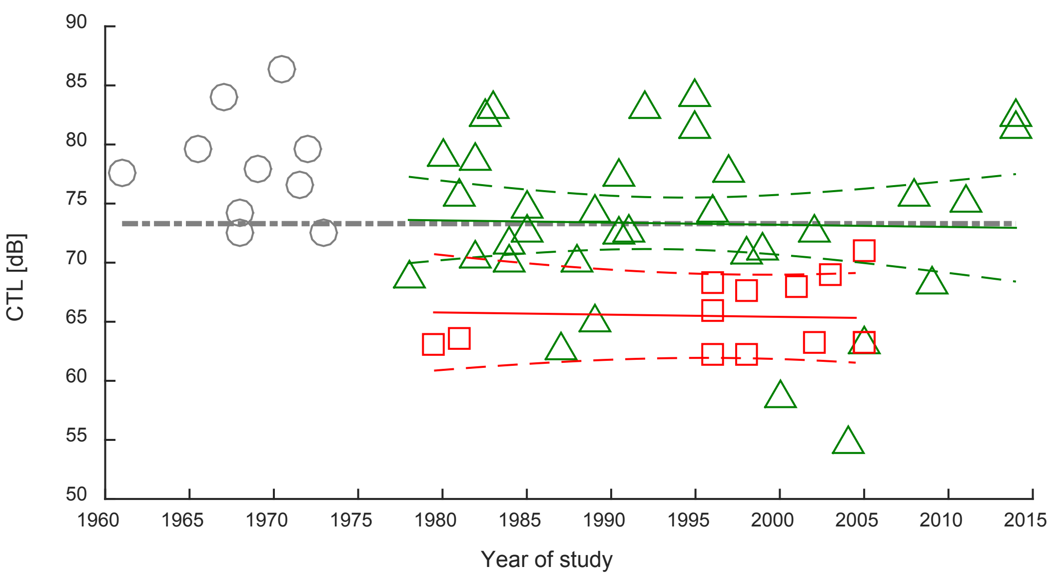

Figure 4. CTL-values for 47 aircraft noise annoyance studies conducted between 1978 and 2014 categorized by high rate of change (red squares) or lack thereof (green triangles). The gray circles indicate excluded studies from earlier years. The solid red and green lines show their respective linear fits R^2 = 0.22,, including confidence intervals (dashed lines). The gray dash-dot line shows a constant CTL of 73.3 dB for comparison with the EU standard curve.

4 CONCLUSIONS

CTL-values derived from 57 studies of aircraft noise annoyance conducted world wide were analyzed for trends over time. The noise exposure at all airports was classified either as having a high or a low rate of change. Surveys that followed a recent permanent step change were classified as 'high rate of change' studies. Studies at airports where a proposed future change had been subject to extensive public debate were also classified as 'high rate of change' studies.

Including airports with both stable and changing noise exposure in the same analysis yielded weak evidence of a decrease in tolerance for aircraft noise exposure from 1961 through 2014. This finding is believed to be misleading, however, and more likely attributed to the distribution of tolerance for aircraft noise at 'high rate of change' surveys over time. With two exceptions, studies completed before 1995 were conducted at airports with low rates of change of noise exposure. In contrast, about 40% of the studies conducted after 1995 can be classified as 'high rate of change'.

The average annoyance response from 'high rate of change' surveys indicated 8 dB ± 5 dB less tolerance for noise in such situations. Excess response to step changes is a well-documented concept (Brown and Van Kamp (2008). No significant change in community tolerance for aircraft noise over time was observed when study findings were classified as either low or high rate of change.

The average community tolerance for noise exposure reported in surveys near airports with relatively stable conditions of noise exposure ("low rate of change" airports) corresponded closely with the mean CTL-value for 43 aircraft noise surveys analyzed by Fidell et al. (2011). The exposure-response curve associated with this CTL-value is almost identical to the exposure-response curve recommended by the European Union (EU, 2002). No evidence was therefore found of a need to update existing exposure-response curves.

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