Estimating the magnitude of the change effect

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INTRODUCTION

Conventional wisdom is that human response to a step change in transport noise should be able to be predicted from existing synthesized exposure-response curves. However most, if not all, of the human response measurements used in these syntheses would have been conducted at sites at which the prevailing noise environment had changed little over preceding years. Exposure-response curves derived from these studies thus reflect human response to noise in situations of *steady-state*, *constant* or *unchanging* noise exposure. These same curves are now used extensively, in noise impact assessments, to estimate likely response of a population experiencing a change in noise exposure.

There are now a significant number of studies which have examined human response where there has been a *step change*, or *abrupt change*, in noise exposure). The results suggest, though not invariably, that response may be different where there has been an increase or decrease in level, to that predicted from steady-state curves (van Kamp & Brown 2003; Brown & van Kamp 2005). In other words, human response to change in exposure may include a *change effect* as well as an *exposure effect* and the change effect manifests itself as an *excess response* that persists over time*.* The focus of this paper is the magnitude of the effect in those situations in which a change-effect has been observed.

Previously, excess response has been described by various terms such as *exaggerated response* (Huybregts 2003), *overreaction* (Fields 1993; Job 1988; Schreckenberg & Meis 2007; Breugelmans et al. 2007) or *overshoot* (Guski 2004). Lambert et al. (1998) use the term *new infrastructure effect*. However, in the psychological literature *overreaction* is defined as an exaggerated response or a reaction with unnecessary or inappropriate force, emotional display, or violence. We suggest that terminology which carries such connotations be abandoned in favor of the more neutral term *excess response*. Kastka et al. (1995a) and Baughan and Huddart (1993) have previously used a related term, *excess effects*.

There is continuing interest in response to change (Anotec Consulting 2003; Huybregts 2003; Guski 2004; van Kempen & van Kamp 2005; Klæboe et al. 2006). Driving much of this interest is the predicted growth in land and surface traffic, the new infrastructure to accommodate this growth, and community response and health effects associated with these changes (for example, Egan et al. 2003). Examples where step changes in exposure will occur are the new runways being planned at major EU airports such as Frankfurt, Schiphol and Heathrow.

SOME CHARACTERISTICS OF CHANGE IN NOISE EXPOSURE

A step change in noise exposure may occur through different mechanisms. Type 1 changes result from a new or eliminated source, or change in intensity of the source (changes in traffic flow rates, road bypass construction or change in runway configurations, for example). Type 2 changes result from some (usually noise path) mitigation intervention. In Type 2 changes, there are no changes in the transport source flow rates or source noise emissions, just in exposure of the respondents (for example, the erection of barriers along roadways or railways).

Dimensions of the change in exposure include the direction of the change - increase or decrease; the magnitude of the change; and whether the change is a step change or whether it is gradual; and if gradual the rate of change. Some noise exposure changes may be temporary (such as shutting a runway for maintenance) whereas others are permanent.

ESTIMATES OF THE MAGNITUDE OF THE CHANGE EFFECT

Seven reviews of change studies have been conducted: Fields (1994); Vallet (1996); Horonjeff & Robert (1997); Schuemer & Schreckenberg (2000); Stansfeld et al. (2001); Fields et al. (2000); and Huybregts (2003). We focus in this paper on the quantitative estimates of the magnitude of the excess-response change effect made by Horonjeff and Robert (1997) and build on their results (using their methodology) by incorporating change-effect results from more recent studies.

The review by Horonjeff and Robert (1997) - itself built largely on the work of Fields (1994) - identified 23 change studies in 51 citations, covering road (12 studies), rail (2) and air (9) transport sources. Of interest in this paper was their synthesis of the magnitude of change-effects measured in the studies they reviewed. Such a synthesis required them to make approximations (described in the original paper) to overcome the difficulties presented by different acoustic measures, response scales, and available baseline responses from which to estimate the change-effect. The latter ranged from locally-derived baseline exposure-response curves, control site exposure-response curves, to synthesized exposure-response curves (mostly Schultz 1978).

The Horonjeff and Robert (1997) synthesis was in terms of a decibel-equivalent estimate (see Fields 1990) of the magnitude of what they called the *abrupt-change effect*. This is the change, in decibels, on an appropriate exposure-response curve, *additional* to the change in exposure between the before and after conditions necessary to achieve the observed change in response. Their synthesis included air, road and rail sources, Type 1 and Type 2 changes, and changes in exposure ranging from 18 dB decreases to 15 dB increases. While there was wide variation in the results, the majority of the data points included in their review supported the existence of an excess-response change effect.

Horonjeff and Robert (1997) also found that nine studies designed to measure the decay of the excess response generally failed to find evidence of decay - that is, there was no evidence of *adaptation* or *habituation* of the change effect. Most first post-change interviews were conducted three to seven months after the change (one at 0.5 months, one at 12 months), with last post-change interviews conducted 16 to 96 months after the change.

MORE RECENT ESTIMATES OF THE CHANGE EFFECT

In a wide review conducted by the present authors of all studies that included a change in noise exposure, several were identified whose results could be included in this synthesis of estimates of the magnitude of the change-effect.

Two of the seven sites in a Fidell et al. (2002) study of change in aircraft noise levels experienced sufficient increase in exposure to allow decibel equivalent change-effects to be estimated (we used the FICON (1992) exposure-response curve to estimate the change-effect from the reported data). Nilsson and Berglund (2006) and Öhrström (2004) reported studies of decrease in road traffic noise exposure, the first from the placement of a barrier, the second from a reduction in traffic flow. These authors suggested that there was no excess response to the change indoors, but our reanalysis (using the Miedema & Oudshoorn (2001) and Miedema & Vos (1998) exposure-response curves respectively) suggests that there was a large change-effect at three of the “sites” (actually three “distance from roadway categories” - change in noise exposure of more distant categories could not be estimated from the paper) in the barrier study, and at the one site in the traffic reduction study. Kastka et al. (1995a) revisited the barrier sites reported previously (Kastka & Paulsen 1979), reporting new data and readjusting their steady-state exposure-response baseline. Kastka et al. (1995a) examined residents’ responses in 1988 and 1976 to barriers that had been constructed after the first survey. We have calculated decibel-equivalent changes at their seven barrier sites (using their noise disturbance score and their before exposure-response relationship - Table 10 in Kastka et al. (1995a). At five of the sites there is a small excess response, but an under-reaction, one large, at two sites.

A recent longitudinal study of response to noise around Schiphol Airport incorporates the most comprehensive and purpose-designed study of change to date, though detailed results are not yet widely reported (Ministry of Transport, Public Works and Water Management 2005). Surveys of effects of aircraft noise exposure were conducted around Schiphol in 1996, 2002 and 2005 (Houthuijs et al. 2007). A new runway at the airport was opened in February 2003, and a panel of 640 persons, whose exposure was likely to change as a result of the new runway, was selected from the 2002 survey group. This panel was resurveyed annually over the 2 1/2 years following the change, with half of the panel surveyed in northern hemisphere springs and half in autumns, giving six data points subsequent to the change (Breugelmans et al. 2007). In total, 478 respondents completed four panel interviews, one before the change and three after the change. The panel was made up of three subgroups: one experiencing an increase in exposure, one a decrease, and one as control experiencing negligible change. Results from the first (before change) panel round were used to derive a baseline exposure-response relationship based on noise exposure (L_{den}) over the previous 12 months.

Breugelmans et al. (2007) reported significant excess response for the subgroup experiencing the increase in exposure. Excess response was observed from the second round of surveys and continued throughout the study. There was a drop in the penultimate round but a return to large excess-response in the latest round. The subgroup experiencing the decrease in exposure, and the control group experiencing negligible change, did not exhibit excess response in any of the survey rounds.

Overall, these more recent studies show magnitudes of change-effect excess response in line with those reported in the original synthesis by Horonjeff and Robert (1997).

DISCUSSION

The results for the airport studies were, in general, quite different to those for the roadway studies. With the exception of our estimate of large excess response in the studies by Fidell et al. (2002) and by Breugelmans et al. (2007), the change-effect in the airport studies was very small - in some cases, an under-reaction - compared to the predominance of excess response in the roadway studies. While this may demonstrate a difference in response to change between aircraft noise and roadway noise, another and perhaps more obvious, explanation is that the difference may be an artifact of the nature of the particular noise changes that occurred at most of the airports studied.

Horonjeff and Robert (1997) had also noted that most of the airport studies they reviewed either involved temporary changes in noise exposures (Fidell et al. 1985; Raw & Griffiths 1985; Gjestland et al. 1995) or small changes of 3 dB or less in noise exposure; Fidell & Jones 1975; Fidell et al. 1985). Some airport change studies (Fidell et al. 1996; Kastka et al. 1995b) and some road change studies (Stansfeld et al. 2001) also had the acoustic characteristic of a gradual change in noise exposure. As Fields et al. (2000) has previously noted, these are very different situations to where there is an abrupt or step change in exposure.

Because of the potentially confounding effect of the limited magnitude and different nature of the changes that occurred in the various airport studies for which data is available, it would be inappropriate to draw conclusions from these studies about response to change around airports. Further studies involving change at airports that do not have these constraints (as, for example, the Schiphol study reported by Breugelmans et al. (2007) and Houthuijs et al. (2007)), will be necessary to examine whether there might be any difference between response to change for different transport modes. The same applies for situations, for any mode, where there has been a gradual change in exposure as against a step-change.

Studies of both Type 1 and Type 2 changes were included in the reviews, and there is some evidence that people may respond differently in Type 2 changes, reporting less response and little or no change-effect (Griffiths & Raw 1986). Langdon and Griffiths (1982) re-examined the results of Kastka and Paulsen's (1979) longitudinal study of barriers and found under-reaction, explaining this as due to the differential effect of noise reductions by barriers rather reductions of the noise source. However, as noted above, using the new data for these sites from Kastka et al. (1995a) there was a small excess response at the majority of the sites, but an under-reaction at two sites. Vincent and Champelovier (1993) reported that noise annoyance shows only a small reduction for a 9 dB drop of noise levels resulting from barrier construction at their one site. No excess response to change was also suggested in the longitudinal study by Lambert (1978) of the effect of a single barrier. While Nilsson and Berglund (2006) reported no excess response in a barrier study, reanalysis by the current authors suggests that there was. Baughan and Huddart (1993) also note that the change-effect may not be present in Type 2 changes

While Fields et al. (2000) concluded that studies aimed at evaluating the effect of noise-shielding interventions (barriers, double glazing), rarely lead to findings of an excess response, evidence of the presence and direction of change-effects in Type 2 studies to date is ambiguous. A reasonable conclusion at this stage is that the results of Type 1 and Type 2 studies should be separated in any future analysis of change studies given the mixed evidence above regarding excess response in Type 2 studies.

Type 1 step changes in roadway noise

Given the conclusions above regarding airport change studies and Type 2 change studies, it is reasonable to separately examine change-effects in a subset of change studies - those where (a) the source was road traffic and (b) where the nature of the change in exposure was a Type 1 change.

Figure 1 shows the magnitude of the change effect for Type 1 change studies of roadway sources only. These are situations where the change in noise exposure has resulted from changes in the roadway source itself - the construction of new roadways, either as new sources or providing traffic relief on existing roadways, or some other change in traffic flow. All available studies demonstrate, with remarkable consistency, an excess response in situations of both increments and decrements of noise exposure: respondents whose noise exposure has increased report more annoyance than expected from steady-state studies; respondents whose noise exposure has decreased report less annoyance than expected from steady-state studies. The effect is present even for quite small changes in noise exposure.

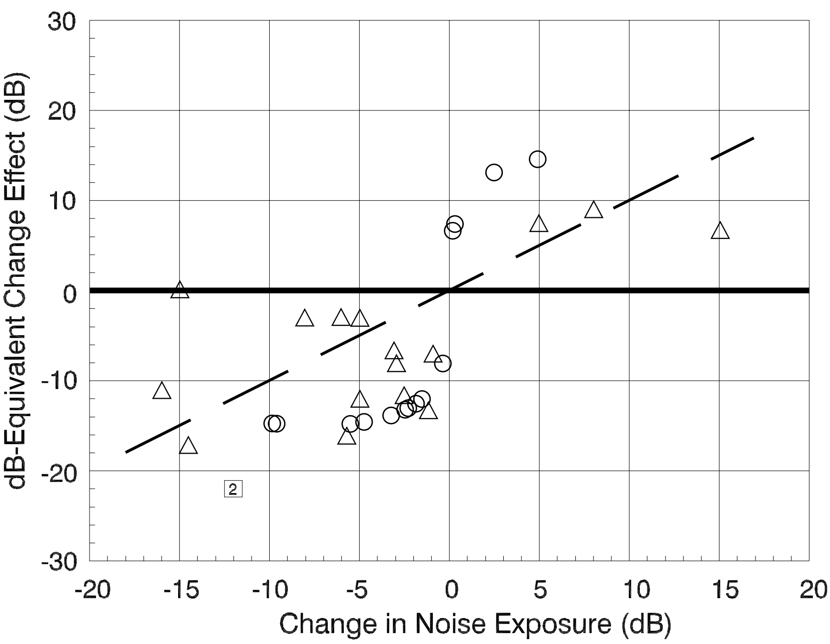

Figure 1: Decibel-equivalent excess response change-effect for Type 1 changes for roadway traffic sources only. The broken line indicates a change-effect of the same magnitude (dB-equivalent) as the change in noise exposure. Data points are from the original review by Horonjeff and Robert (1997) or (those plotted using square symbols) from more recent studies.

The broken line shown in the figure is not a line of best-fit as we have chosen not to suggest a predictive relationship between noise change and its associated change-effect from the studies reviewed - given the differences between the studies in terms of metrics and designs, and the approximations necessary to estimate the change-effect from the data reported in them. However, the broken line (a plot of equal magnitude of change in noise exposure and of change-effect) does show that, in roadway studies with Type 1 changes, the decibel-equivalent magnitude of the excess response tends to be greater (often much greater) than the change in noise levels itself.

CONCLUSIONS

A change-effect is unequivocally present in the results of the road traffic noise studies where the intensity of the road traffic source changes through changes in traffic volume on the source roadways (Type 1 changes). For these types of change situations, the decibel-equivalent magnitude of the excess responses (both the excess benefit arising from reductions in exposure, and the excess disbenefits arising from increases in exposure) can be greater, often much greater, than the change in noise levels itself. For changes resulting from the insertion of barriers or other path mitigation interventions (Type 2 changes), the evidence for a change effect is not clear. The excess-response change-effect does not appear to attenuate over time - even years - after the change.

Consistent evidence of a similar change effect for aircraft noise and railway noise changes is lacking but, rather than this indicating that human response to change is different between different transportation noise sources, we suggest that this may be a result of the nature of the noise changes available in most aircraft and railway noise change studies to date: generally small, gradual or temporary.

As environmental appraisals of transport infrastructure plans are generally conducted in situations where there will be a step change, or an abrupt change, in noise exposure, the presence and magnitude of the excess response warrants consideration of a change-effect in assessing the impact of infrastructure changes, and in policy making with respect to such changes.

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