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FACTORS CONTRIBUTING TO REPORTED REACTION TO COMBINED NOISE SOURCES

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ABSTRACT
The often noted paradox that people report less reaction to a combined noise source than to its component noises separately may represent a methodological artifact. The present study assessed the role of question phrasing and response scale in producing the paradox. 150 undergraduate psychology students identified three outside noises which they hear regularly where they live. They then rated their annoyance with each of these noises separately, their annoyance with the noises in pairs "whether or not they occur at the same time", and their annoyance with the noises in pairs "when they occur at the same time". Responses were made either on a 10-point "opinion thermometer" or on an open-ended numeric response scale. For each of these conditions, it was assessed whether the "combined noise sources" paradox occurred. The combined noise source paradox was reduced but not eliminated by the "when" wording condition, suggesting that the question wording may contribute to the paradox, although it ultimately remains regardless of wording.

1 - INTRODUCTION

Reaction to noise (annoyance, disturbance, dissatisfaction) is an important effect of noise exposure, and regulations are often based on predicting the effects of a given noise exposure.
Although people are usually exposed to noises from several sources simultaneously and any noise being regulated is typically part of a soundscape, our understanding of reaction to combined noises is lacking. Thus, our predictions of responses to a combined noise source, and regulations based on them, are imperfect.
Whilst several models have been proposed for integrating reaction from single noise sources to predict reaction to the combination of the sources [for reviews see 1,2,3,4], none provide exact agreement with subjectively rated reaction to the combine source. Specifically, people report less reaction to a combined noise source than to the sum of reaction to its component noises separately (the "combined noise paradox"). Further, people often report less negative reaction to the combined noise sources than to the most annoying single noise [3,4,5].
We propose to assess whether these paradoxical findings are an artifact of the way in which respondents are asked to rate their reaction to the combined noise sources [6], rather than a genuine finding which should be taken into account by a model for predicting reaction to combined sources. Both question phrasing and response scale may contribute to inaccurate results.
First, respondents may interpret the question, "How annoyed are you by noise A and noise B", in unexpected manners. These include:

1. Ratings of overall noise may be taken to reflect, or may emphasise in the respondents considerations, time when both or several noise sources are apparent at once. This may emphasise the relative rarity of such occasions.

2. Ratings of overall noise may be taken to mean average reaction to the various noises. As Berglund and Nilsson [7] pointed out averages fit some of the data.

3. The overall ratings may be taken to mean over all time, and thus include rating of annoyance when the noises are not present. The emphasis thus placed on the quiet times may reduce ratings of reaction.

Of course, any one of these possibilities may not account for the data because different subjects may make different interpretations, or may change the meaning of the response scale as the interview proceeds.
Second, response scale may artifactually produce the combined noise sources paradox as illustrated by the following, simple, two-source example (taken from the respondents point of view). Suppose that the respondent first rates the aircraft noise as 8 on a 0-10 scale of annoyance, and rates the road noise as 6 on the same scale. Such a person's immediate response to rating the overall noise may be to call it a 14 (8 plus 6). However, this is clearly disallowed on a 0-10 scale. Even if the ratings are done with the overall rating first, the problem may still arise if the respondent has been forced by previous answers and the not unlikely (even if inexpressible) assumption of interval level measurement to rate the second rated noise source too low, compared with their real reaction. Thus the demands of the situation may disallow a simple additive model which may otherwise have been adopted [see 6]. This may force the respondents to reinterpret the required ratings.
We tested the role of question wording and response scale in producing the "combined noise sources paradox", with a view to bettering understanding, and thus regulation, of reaction to noise from combined sources.

2 - DESIGN

A 3×2 factorial design was employed. Question wording was manipulated to 3 levels within subjects in an effort to standardize subjects interpretation of the combined noise sources reaction question. Subjects were asked to rate their reaction to noise pairs "whether or not they occur at the same time", "when they occur at the same time", and without any such direction. Of course, subjects also rated each noise on its own. Response scale was manipulated to 2 levels between subjects. Approximately half of the subjects responded by writing zero (indicating that they are "not at all bothered, disturbed, or annoyed") or a number greater than zero which indicates how bothered, disturbed, or annoyed they are. For these subjects, no upper limit number was specified. Remaining subjects responded by writing a number from zero (again indicating that they are "not at all bothered, disturbed, or annoyed") to 10 (indicating that they are extremely annoyed). The presence of the combined noises paradox was tested under each of these conditions.
The two different orders in which subjects completed the pair ratings with 3 different directions (without specific instruction then when then whether versus without specific instruction then whether then when) was counterbalanced across subjects. The order in which they considered single noise sources versus paired noise sources was also counterbalanced.

3 - METHOD

Subjects: 150 Psychology 1 students volunteered to participate in an experiment on "reactions to noise" by signing up on a standard recruiting sheet posted on a Departmental notice board.
Materials: Subjects complete a questionnaire in which they were first required to record 3 outside noises which they hear regularly at home. Subjects rated their reaction to each of these noises. Subjects also asked to rated their reaction to 3 noise pairs (noises 1 and 2, noises 1 and 3, noises 2 and 3) "whether or not they occur at the same time", "when they occur at the same time", and without any such direction. Different versions of the questionnaire were produced to achieve the counterbalances outlined above. Finally, subjects responded to several questions assessing demographic variables (e.g. age, gender).
Procedure: The different versions of the questionnaire were randomly distributed around the desks before the subjects arrived. Subjects completed the questionnaire independently while seated in a quiet room with other subjects, and supervised by a female experimenter. Before they began the questionnaires they were greeted, assured of their anonymity (and instructed not to record their name on the questionnaires), and asked to complete the questionnaires as accurately and honestly as possible after reading all instructions carefully. The importance of completing the questionnaires in order was emphasised. Subjects were debriefed before leaving.

4 - RESULTS

For each question wording, mean ratings of reaction to pairs of noises was lower than the mean sum of ratings for the same noises separately (lowest significant $t_{81}=3.34$, $p=.001$).
Raw ratings for the single noises, and noise pairs, were rescaled in order to achieve equivalent variance across the two response scales. For each pair rating, the combined noise sources paradox was assessed by

computing the difference between the sum of rescaled ratings for the single noises and the rescaled pair rating. For each question wording, a mean paradox index was computed by averaging these difference scores for the three pairs. The 3 resulting mean paradox indices were analysed employing a repeated measures 3 × 2 × 2 × 2 ANOVA, in which the 3 indices (reflecting the 3 question wordings) were the repeated measures factor, and the response scale and the two counterbalances were the between subjects factors.

Question wording had a significant main effect ($F_{2,146}$=40.59, p<.001). The combined noise sources paradox was significantly reduced when subjects considered pairs of noises "when they occur at the same time" (t_{80}=6.52, p<.001), but increased when they considered pairs of noises "whether or not they occur at the same time" (t_{80}=-2.11, p=.038), compared to the case in which they received no such direction. The prediction that for subjects who rated single noises first, the paradox would be reduced when the open-ended response scale is employed compared to the zero to 10 scale was not confirmed ($F_{1,39}$=2.79, p=.052), although the low p-value suggests that the difference may have been significant in a larger sample.

The extent of the paradox was not significantly influenced by whether subjects considered the "when" question wording before or after the "whether" question wording ($F_{73,1}$=.07, p=786), nor by whether subjects rated the single noises before or after the paired noises ($F_{1,73}$=2.30, p=.134).

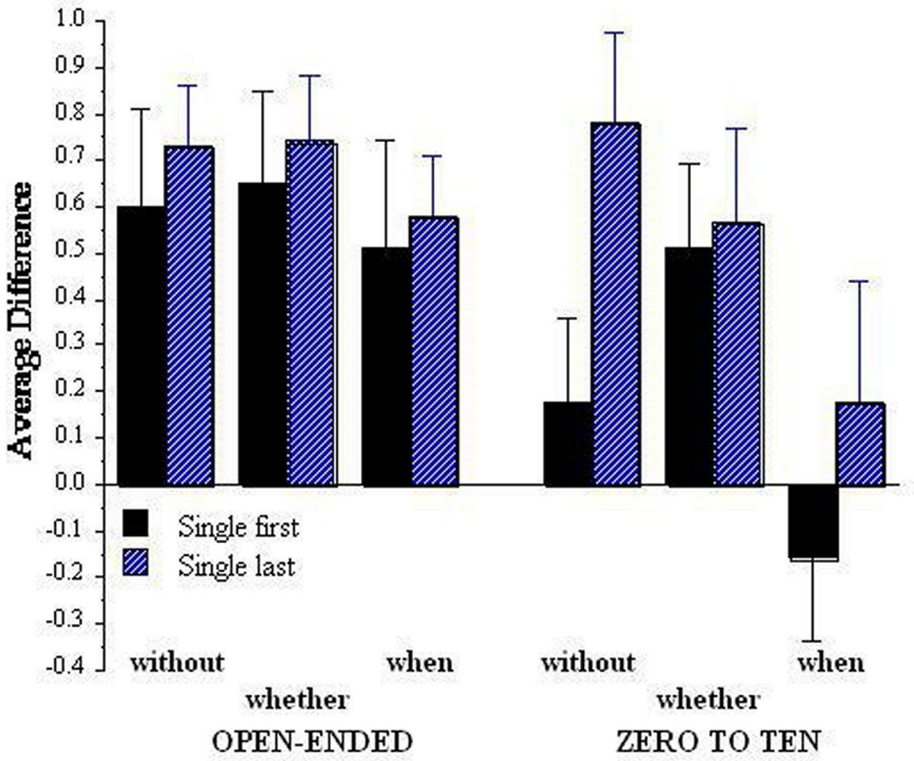

Figure 1: Average difference between the sum of rescaled ratings for the single noises and the corresponding rescaled pair rating, for each question wording (without specific instruction, "when", "whether"), for each response-scale (open-ended, zero to ten), with single ratings made before versus after paired ratings (with S.E.M bars).

Question wording interacted significantly with response scale ($F_{2,146}$=12.14, p<.001). The reduction of the paradox for the "when" question wording appeared to be greater for the zero to 10 compared to the open-ended response scale. The counterbalance of the order of considering single versus paired noises interacted significantly with question wording ($F_{2,146}$=5.28, p=.006), and with the counterbalance of the "when" versus the "whether" question wording ($F_{1,73}$=6.25, p=.015). Three-way interactions were not considered.

5 - DISCUSSION

The present findings support the suggestion that the combined noise sources paradox arises in part from subjects' misunderstanding of the phrasing employed to ask them about their reaction to multi-sourced noises.

The extent of the paradox when subjects rated paired noises "when they occur at the same time" was significantly lower than the paradox elicited using the typical wording with no elaboration. In contrast, the paradox when subjects rated paired noises "whether or not they occur at the same time" exaggerate the paradox.
The hypothesis that the combined noise sources paradox is an artifact of typical closed-ended response scales (e.g. the zero to 10 scale), was not supported by the present findings. For subjects who rated single noises before they rated the paired noises, the paradox for the open-ended response scale was not significantly lower than the paradox for the zero to ten scale. Nonetheless, the low p-value (.052) suggests that the response scale may have a genuine influence, which may be observed in a larger sample.
Clearly, the phrasing employed in asking subjects to rate their reaction to combined noise sources can substantially influence their responses. Further, the phrasing typically employed is ambiguous, and it is likely that different subjects interpret it in different, unknown, ways. In future, combined noises reaction question should be phrased in a much more specific and explanatory manner. Resulting data will be less opaque and will provide a batter basis for understanding noise reaction in the multi-source environments characteristic of modern cities.

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