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NOISE FOR DINNER – TOWARDS A COMPREHENSIVE STATISTICAL MODEL OF THE ACOUSTICAL AND OVERALL QUALITY OF RESTAURANTS

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ABSTRACT

Studies on noise in restaurants have shown a multitude of potential negative effects, for example related to mood, overall satisfaction, intended revisit, the ability to communicate and the actual behaviour in the room. In this paper, we investigated the complex interplay between room acoustics, soundscape evaluation, non-acoustical aspects of a restaurant visit and overall restaurant quality. Based on acoustical measurements and reports from 142 persons visiting 12 restaurants in Berlin, we propose a structural equation model including both acoustical and non-acoustical factors and yielding a good overall fit. The model, for instance, suggests that the A-weighted sound level negatively impacts the assessment of overall restaurant quality, while the effect of soundscape pleasantness on overall restaurant quality is mediated by the restaurant's perceived atmosphere. Moreover, the reverberation time was found to be effective predominantly through its effect on sound strength, which leads patrons to increasingly raise their speech level to ensure intelligibility. These results thus emphasize the need to design actively the restaurant's acoustical atmosphere beyond pure loudness reduction which involves a specific trade-off between comfort and liveliness, depending on the desired character of the place.

Keywords: *Noise, Restaurant acoustics, Room acoustics Soundscape, Structural Equation Modelling, Hospitality industry*

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1. INTRODUCTION

Studies on noise in restaurants have shown a multitude of potential negative effects, for example, related to mood, overall satisfaction and intended revisit [1], or the ability to communicate and the actual behaviour in the room [2, 3]. However, restaurant owners and managers are reluctant to use room acoustics measures, not only because of the costs but also because they fear that room-acoustical modifications would compromise their restaurants' liveliness. This highlights the fact that restaurants are vibrant social places whose design is subject to competing requirements. Therefore, in this paper, we discuss the complex interplay between room acoustics, soundscape evaluation, non-acoustical aspects of a restaurant visit and overall restaurant quality. More concretely, the major aim of this contribution is to present a comprehensive structural equation model (SEM) that incorporates both acoustical and non-acoustical quality factors to predict overall restaurant quality.

2. METHOD

Our contribution is based on data and findings by Steffens et al. [4]. Here, we collected data from 12 randomly selected restaurants in Berlin to establish a first version of a comprehensive Structural Equation Model on the acoustical and overall quality of restaurants. Patrons dining in the restaurants were asked to fill out a questionnaire on a tablet PC during a three to four-hour period on a regular service day. A total of 142 participants filled out the questionnaire, with a mean age of 34.7 years. Most participants were female and had an academic degree.

The questionnaire used in the study included person-related items such as age, gender, education, Big Five personality traits, hearing impairment, mealtime, visitation motifs, and frequency of visits. It further obtained several items related to restaurant quality as well as soundscape pleasantness and eventfulness (ISO/FDIS 12913-2). LAeq15' measurements were performed using an NTI XL2 acoustic analyzer. As taking measurements of reverberation time in the occupied state would have disturbed guests and employees, measurements were conducted in an empty restaurant using a self-constructed omnidirectional source. Third-octave band measurements from 125 to 4000 Hz were used to obtain values of $T_{20,\mathrm{m,empty}}$, which were then used to calculate the reverberation time in occupied state $T_{20,\mathrm{occ}}$ at the moment of the questionnaire's completion. The number of guests was assessed by manual count approximately every 15 minutes, and occupancy between these measurement intervals was estimated through linear interpolation (see [4], for more detailed information).

3. RESULTS

Non-acoustical factors were aggregated utilizing a Principal Component Analysis (PCA) which revealed a feasible three-factor solution with the factors 'product'. 'atmosphere', and 'service'. We assumed that all three factors would positively contribute to overall 'restaurant quality' which combined items related to 'willingness to recommend restaurant', 'repeat visit', and 'recommend' through a Confirmatory Factor Analysis (CFA). We further expected a direct influence of the A-weighted sound pressure level on soundscape pleasantness and restaurant quality as well as a direct influence of soundscape pleasantness on restaurant quality. However, the first SEM model did not fit well, so modification indices were obtained which suggested removing the direct effect of soundscape pleasantness on restaurant quality and instead adding a regression path to atmosphere, as well as adding a path from product to soundscape pleasantness. These modifications were supported by previous literature, and the modified SEM yielded acceptable to good model fit indices, $\chi^2(78) = 859.3$, $p < .01$, RMSEA = 0.072, SRMR = 0.095, CFI = 0.942. The final model (see Figure 1) therefore confirms an effect of the $L_{A,eq,15}$ on overall restaurant quality, but does not provide empirical support for the assumed direct effect of soundscape pleasantness on restaurant quality. Instead, the model suggests that this effect is mediated by the atmosphere of the restaurant.

To further clarify the relationship between the $L_{A,eq,15}$ and $T_{20,\mathrm{occ}}$, and the number of guests N_{guests}, we computed a linear mixed-effects model which revealed both significant main effects of $T_{20,\mathrm{occ}}$ ($b = 0.59$, $p = .006$) and N_{Guests} ($b = -0.72$, $p < .001$), as well as an interaction effect of $T_{20,\mathrm{occ}}$ x N_{Guests}, ($b = 0.84$, $p < .001$) on $L_{A,eq,15}$ ($R^2_{\mathrm{marginal\ (total)}} = .534$), confirming the amplification of the sound level through reverberation (sound strength) dependent on the number of guests. Finally, a mediation analysis following the approach by Preacher and Hayes [5] revealed that the effect of $T_{20,\mathrm{occ}}$ on soundscape pleasantness was fully mediated by $L_{A,eq,15}$ (see Figure 2) and thus that no effect of the reverberation time beyond sound level amplification could be observed.

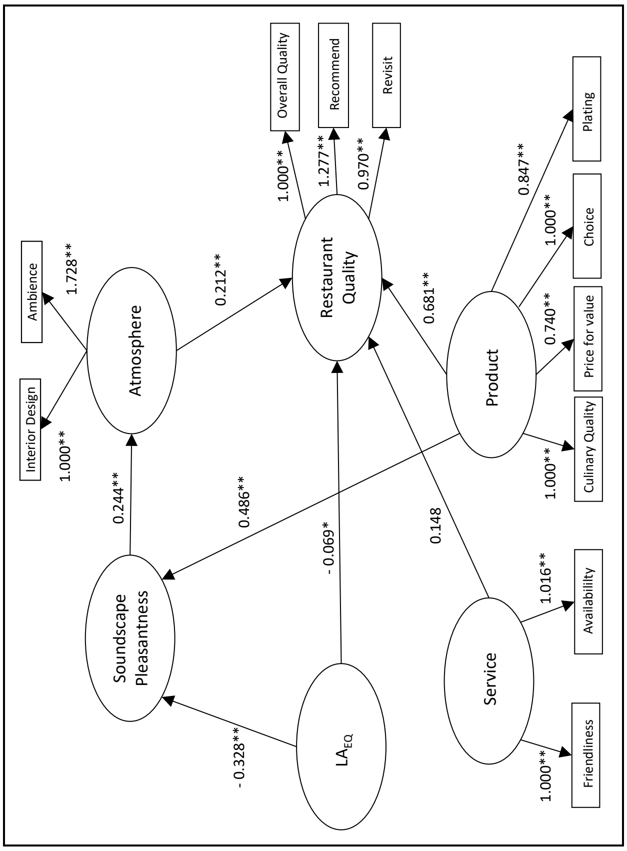

Figure 1: Structural equation model predicting overall restaurant quality through acoustical and non-acoustical factors [4, p. 9). *Note*: The estimates represent standardised regression coefficients β, and the asterisks indicate the significance of the respective effects, *: p <.05, **: p <.01, as obtained by the SEM routine of the Lavaan Package in RStudio.

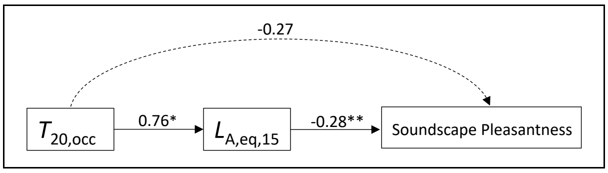

Figure 2: Mediation analysis on acoustical parameters predicting soundscape pleasantness ([4], p. 9).

4. DISCUSSION AND CURRENT WORK

Results of the proposed and empirically supported structural equation model suggest that high A-weighted sound pressure levels can have a direct negative impact on restaurant quality, corroborating previous research (e.g. [1]). Additionally, the model revealed that soundscape pleasantness does not have a direct effect on restaurant quality, but rather influences it indirectly through the perceived atmosphere. This underscores the importance of actively designing the acoustic atmosphere of a restaurant beyond just reducing noise levels which involves a specific trade-off between comfort and liveliness, depending on the desired character of the place.

Therefore, current work deals with the validation and extension of the proposed model. Therefore, the model will be tested first against new (unseen) data from further restaurants in different German cities. Also, a taxonomy of restaurants will be performed based on theoretical and empirical considerations. Here, a promising approach was already proposed by Rindel [6], who distinguishes between different sound classes, namely fine restaurants (A), banquet halls (B), bistros, food courts, and other restaurants (C), and cafeterias, canteens, and pubs (D). Accordingly, we aim to establish separate, context-sensitive statistical models for these classes for which we expect differing model coefficients regarding the relative importance of the influencing factors. Also, we aim on obtaining more potentially relevant variables, such as behavioural measures (e.g., duration of stay or money spent), room- and psycho-acoustical metrics, vocal effort, or perceived privacy. Finally, we are interested in the temporal dynamics of restaurant acoustics and their effects throughout common opening hours, for example resulting in feedback loops of (or potential recoveries from) single Lombard effects due to a varying number and an increased exuberance of the patrons (e.g., due to alcohol consumption).

5. ACKNOWLEDGMENTS

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