Supplementary Material

S1 Direct-to-Reverberant Ratios

The direct-to-reverberant ratio (DRR) values of room impulse responses (RIR) for all used reverberation times T_{60} are shown in Figure S1.1. Source-receiver configurations are defined by the source type (S for speech source, N for noise source), where the index denotes the angular position around the head, and the ear (L for left ear, R for right ear).

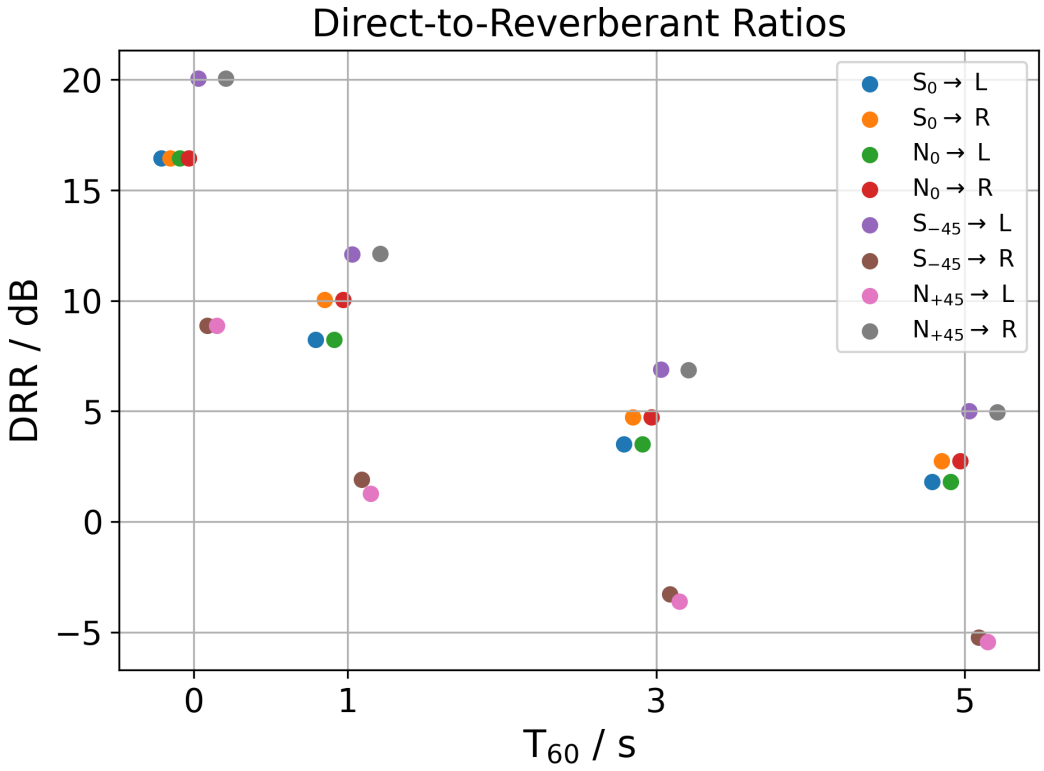


Figure S1.1: DRR values in dB depending on reverberation time T_{60}. Symbols at the same T_{60} are slightly shifted horizontally for readability.

S2 Instruction Sheets

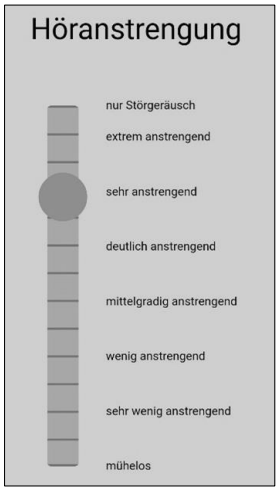
Instruction sheets, which were handed out to the participants prior to the hearing experiment, are shown in the original version in German in Figure S2.1. A translated version in English can be seen in Figure S2.2.

Instruktion

Willkommen und vielen Dank, dass Sie an unserer Studie teilnehmen! Im Folgenden erklären wir Ihnen, wie der Hörversuch abläuft und was Sie dabei tun sollen.

Testablauf

1. **Vorbereitung:**
   - Sie erhalten von uns ein Smartphone, das Sie während des Tests verwenden, sowie Kopfhörer, welche Sie **während der gesamten Messung tragen müssen**.
   - Zusätzlich bekommen Sie einige beschriftete Zettel, wobei es sich um **verdeckte Fragebögen** handelt. Bitte **sehen Sie sich diese nicht an**, bis Sie dazu aufgefordert werden!
2. **Ablauf des Tests:**
   - Sie werden Märchenabschnitte von je **fünf Minuten** vorgespielt bekommen, wobei von Zeit zu Zeit verschiedene Störfaktoren auftreten werden.
   - Nach jedem Abschnitt müssen Sie auf dem zugehörigen Fragebogen vier Fragen zum Inhalt beantworten.
   - Der Test beginnt mit einem **Trainingsabschnitt**, damit Sie sich an den Ablauf der Messung gewöhnen können.
   - Anschließend folgen **sechs Abschnitte** aus einem weiteren Märchen, die von einem anderen Sprecher vorgelesen werden.
3. **Ihre Aufgabe:**
   - Während Sie die Märchen hören, bewerten Sie bitte **fortlaufend**, wie anstrengend es für Sie ist, dem Sprecher zu folgen.
   - Auf dem Smartphone verwenden Sie dafür einen **Schieberegler**, der die Höranstrengung abbildet. Versuchen Sie diesen, wenn möglich, durchgehend gedrückt zu halten und die ganze Zeit Ihrem Empfinden nach anzupassen
   - Neben dem Schieberegler sind Kategorien von **„mühelos“** bis **„extrem anstrengend“** sowie **„nur Störgeräusch“** zur Orientierung abgebildet. Die letzte Kategorie können Sie verwenden, falls Sie keine Sprache hören sollten.
   - Sie können den Schieberegler auf eine beliebige Position auch zwischen den Kategorien verschieben.
   - **Wichtig:** Es gibt keine richtigen oder falschen Einschätzungen. Bewerten Sie immer Ihr aktuelles Empfinden!
   - Nach jedem Abschnitt werden Sie auf dem Smartphone aufgefordert, einen der Fragebögen umzudrehen und zu beantworten.



4. **Pausen:**
   - Zwischen den Abschnitten sind **Pausen erlaubt**. Bitte nehmen Sie sich eine kurze Pause, falls Sie diese benötigen, bevor Sie mit dem nächsten Abschnitt fortfahren.

Wichtige Hinweise:

- Während des Hörversuchs sind keine Rückfragen vorgesehen, außer es handelt sich um technische Probleme. Sollte etwas unklar sein, folgen Sie den Anweisungen auf dem Smartphone!

Wenn Sie sich alles durchgelesen haben, setzen Sie sich bitte die Kopfhörer auf. Nehmen Sie sich das Smartphone und folgen den dortigen Anweisungen!

Figure S2.1: Original instruction sheets for participants in German.

Instruction

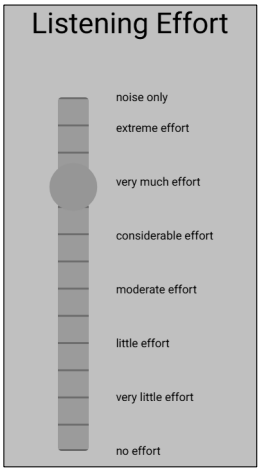
Welcome and thank you very much for participating in our study! Below, we will explain how the listening experiment works and what you have to do.

Test Procedure

1. **Preparation:**
   - You will receive a smartphone, which you will use during the test, as well as headphones, **which you must wear throughout the entire measurement**.
   - Additionally, you will receive some labeled pieces of paper, which are **sealed questionnaires**. **Please do not look at these until you are instructed to do so!**

2. **Test Procedure:**
   - You will listen to chapters of a tale of **five-minutes** each, during which various disturbances will occur from time to time.
   - After each chapter, you must answer four questions about the content on the corresponding chapter.
   - The test begins with a **training section**, so you can get used to the measurement process.
   - Afterwards, there will be **six sections** from another tale, read by a different speaker.

3. **Your Task:**
   - While listening to the fairy tales, please **continuously** rate how effortful it is for you to understand the speaker.
   - On the smartphone, you will use a **slider**, which maps listening effort. If possible, try to keep it always pressed and adjust it according to your perception.
   - Next to the slider, there are categories ranging from **"no effort"** to **"extreme effort"** as well as **"noise only"** for orientation. You may use the last category if you do not hear any speech.
   - You can move the slider to any position, even in between the categories.
   - **Important:** There are no right or wrong answers. Always rate your current perception!
   - After each chapter, you will be prompted on the smartphone to turn over one of the questionnaires and answer it.



4. **Breaks:**
   - **Breaks are allowed** between sections. Please take a short break if you need one before continuing with the next chapter.

Important Notes:

- No questions are intended during the listening experiment, unless there are technical problems. If something is unclear, please follow the instructions on the smartphone!

Once you have read everything, please put on the headphones. Take the smartphone and follow the instructions provided there!

Figure S2.2: Instruction sheet translated to English.

S3 Participant's Scores

Participant's scores for the questionnaires are shown in Figure S3.1. Scores were determined by awarding one point per question answered correctly, while answering incorrectly or with "I don't know" was neither rewarded nor punished.

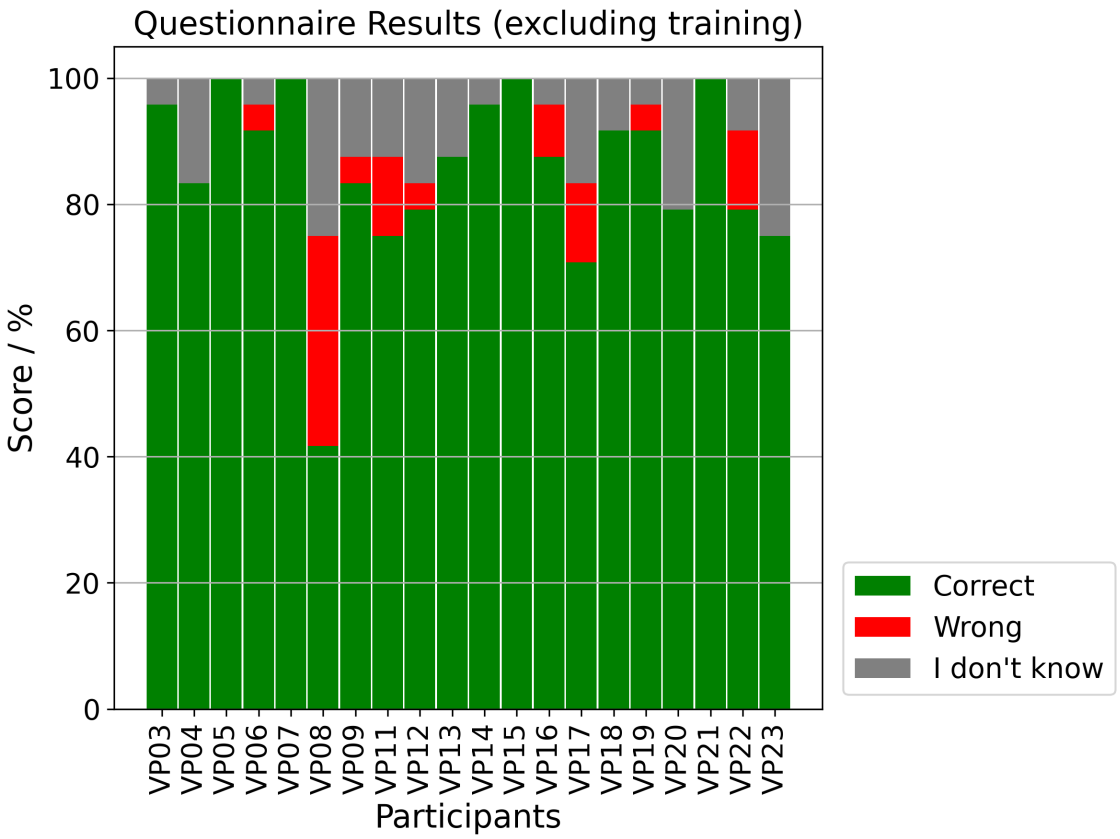


Figure S3.1: Participant scores shown as bar plots with relative portions of questions answered correctly, wrongly, or with "I don't know".

S4 Steady-state SNR vs LE

The steady-state subjectively perceived LE as a function of SNR for the *SNR only* profile in S_0N_0 and $S_{-45}N_{+45}$ is shown in Figure S4.1. The median of model predictions is shown as connected circles.

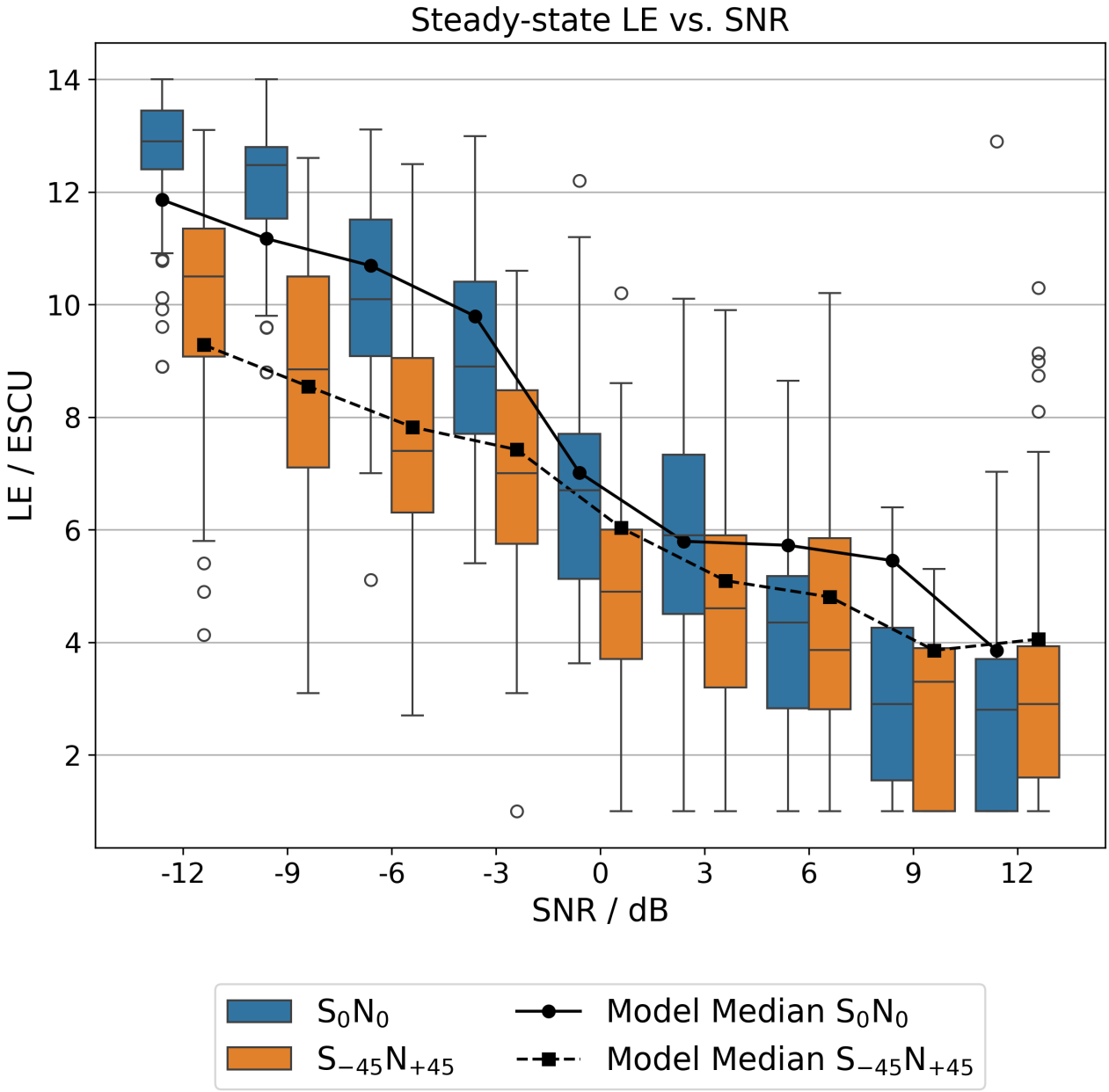


Figure S4.1: Steady-state LE in ESCU grouped by SNR for sources coming from the front and being lateralized alongside the median of predicted LE by the model.

S5 Linear Regression Analysis on Binaural Benefit

A linear regression analysis on the binaural benefit values for participants and for the model was performed, using the same values, which can also be seen in Figure 8. The comparisons of model predictions and experimental data are shown as scatterplots in Figure S5.1 for the *SNR only* profile and in Figure S5.2 for the T_{60} *only* profile.

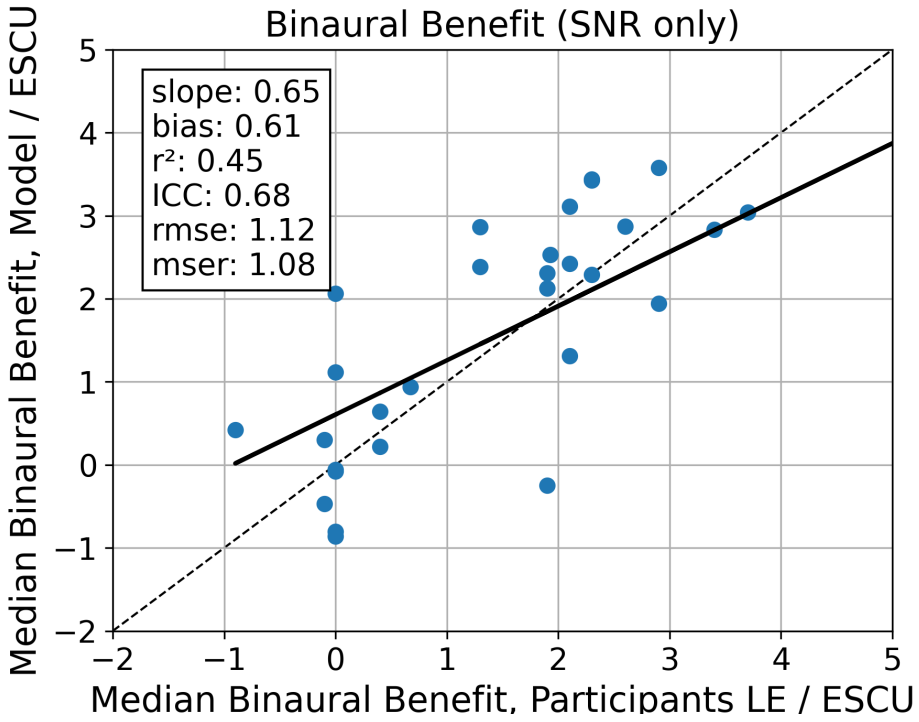


Figure S5.1: Linear regression analysis on binaural benefit for the *SNR only* profile.

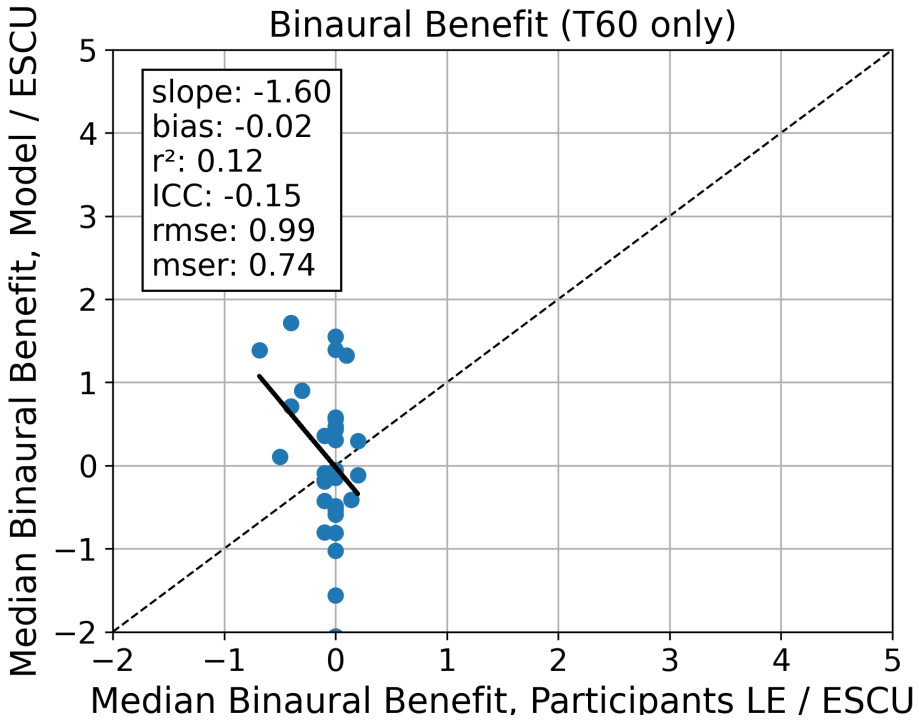


Figure S5.2: Linear regression analysis on binaural benefit for the T_{60} profile.

S6 Original LEAP as back-end

The correlation analysis, which was conducted to produce the data for Figure 7, was redone using the original LEAP version as a back-end. A scatterplot displaying the relationship of predicted and subjective LE for this combination of front- and back-end is shown in Figure S6.1.
The correlation results for the T_{60} *only* profiles for the combination of the blind BSIM and original LEAP are shown for speech coming from the front in Figure S6.2 and for lateralized speech in Figure S6.3. For direct comparison, the results for the combination of the proposed model (blind BSIM in combination with the student version of LEAP) are shown for speech coming from the front in Figure S6.4 and for lateralized speech in Figure S6.5.

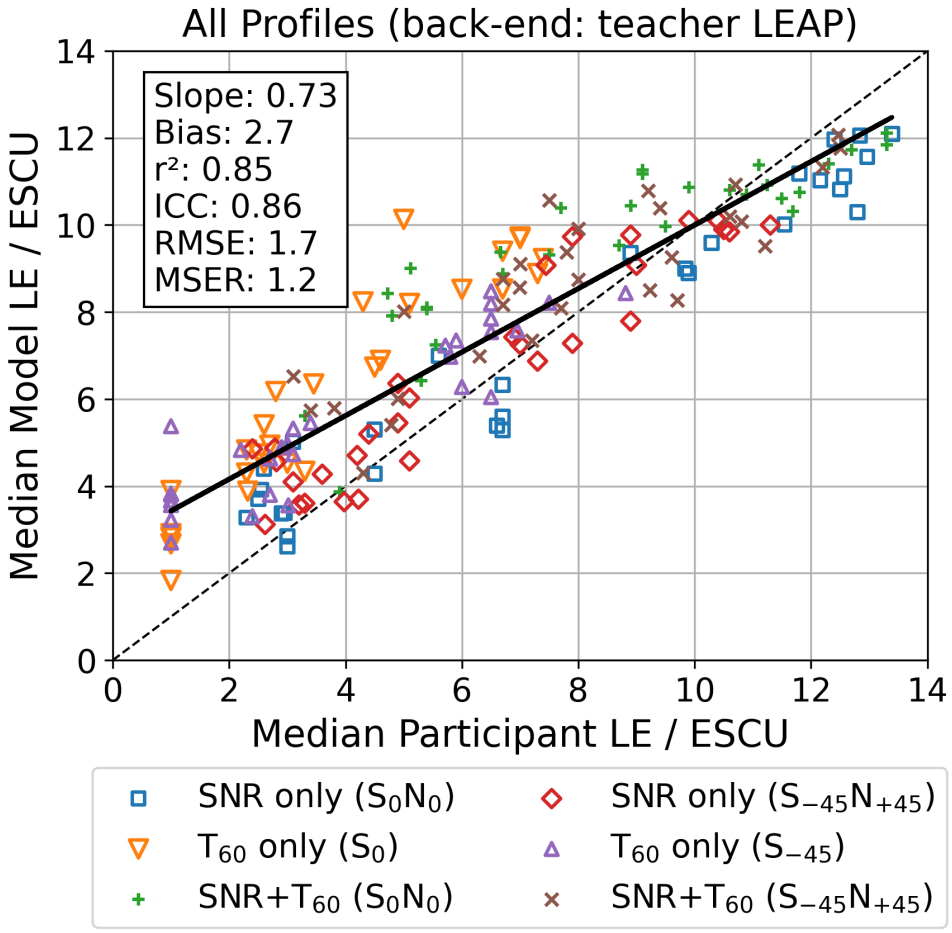


Figure S6.1: Median of predicted LE plotted against the median of subjective LE in ESCU for each section, where the blind binaural front-end was combined with the original LEAP as back-end. Different symbols represent the six different profiles. The black solid line represents the linear regression line, while the black dashed line represents the identity line. The results of the linear regression and correlation analysis are displayed in the top left corner.

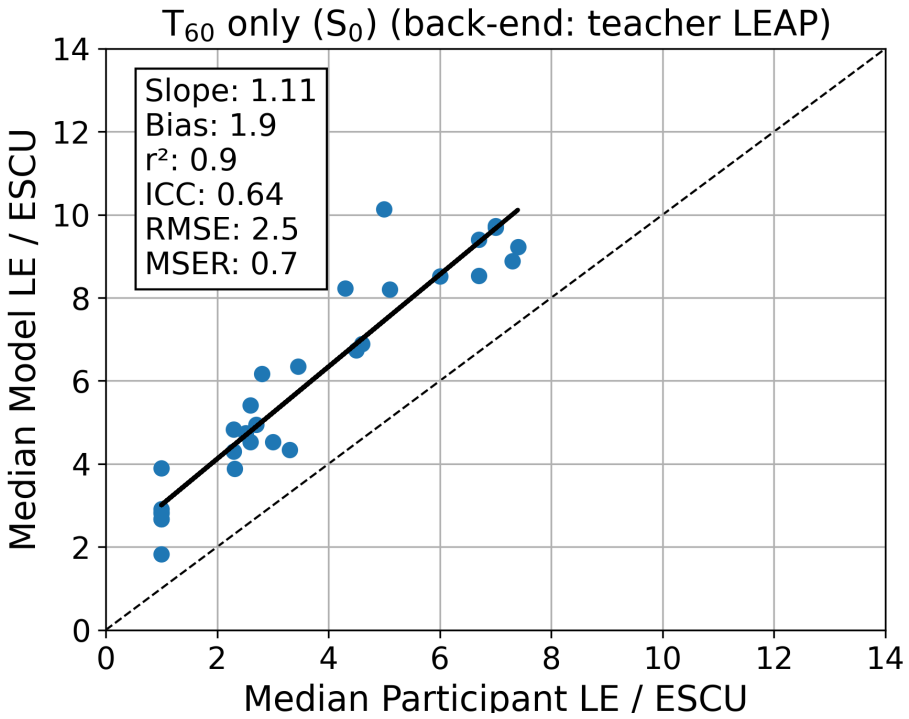


Figure S6.2: Scatterplot alongside correlation metrics for the blind binaural front-end with the original LEAP (teacher version) for the T_{60} *only* profile with speech coming from the front.

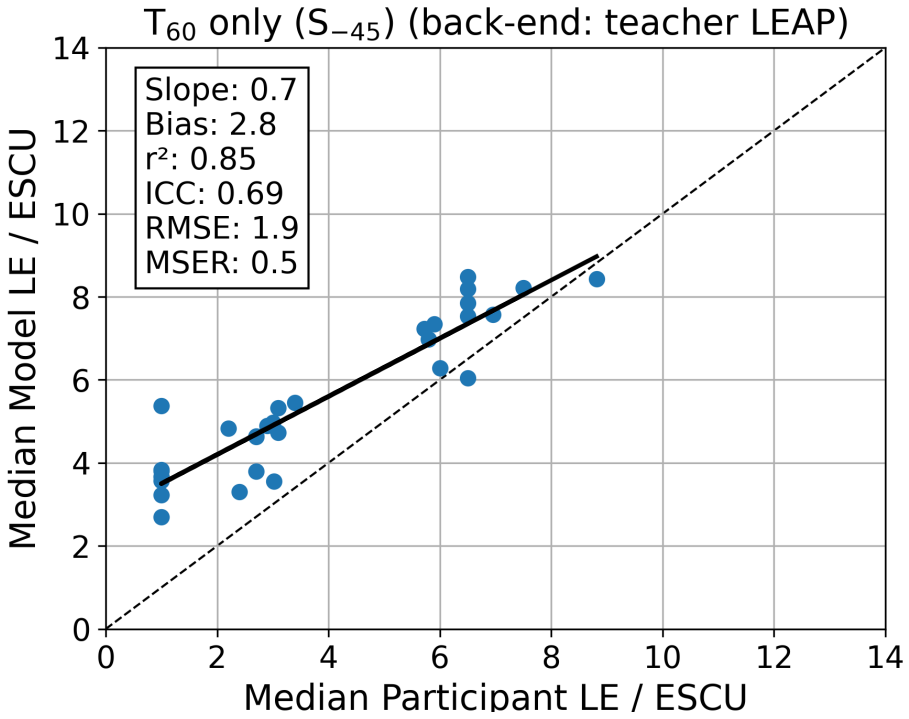


Figure S6.3: Scatterplot alongside correlation metrics for the blind binaural front-end with the original LEAP (teacher version) for the T_{60} *only* profile with lateralized speech.

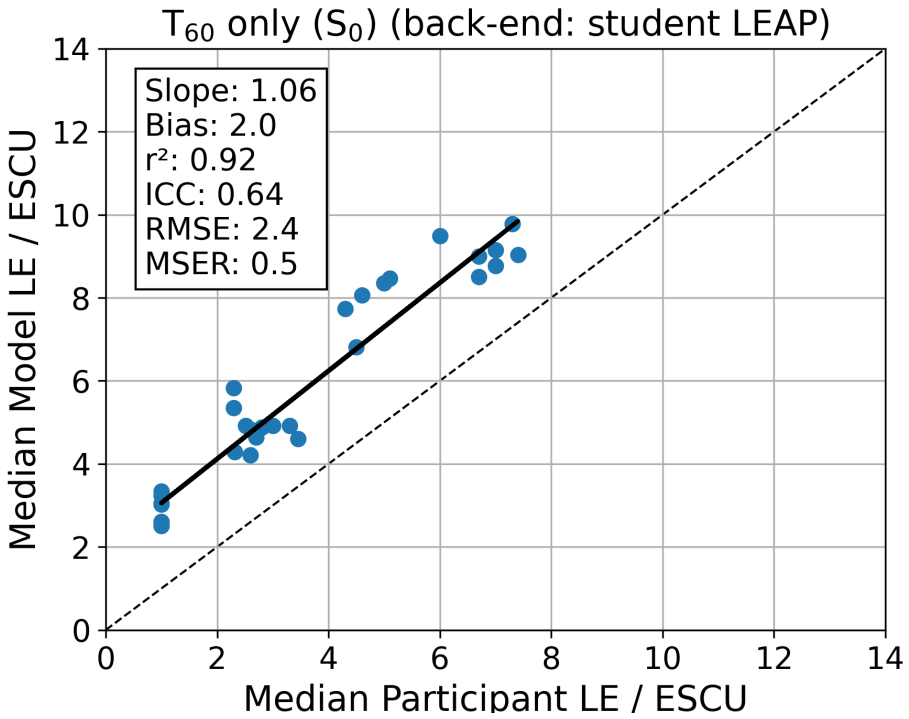


Figure S6.4: Scatterplot alongside correlation metrics for the proposed combination of the blind binaural front-end with the student version of LEAP for the T_{60} *only* profile with speech coming from the front.

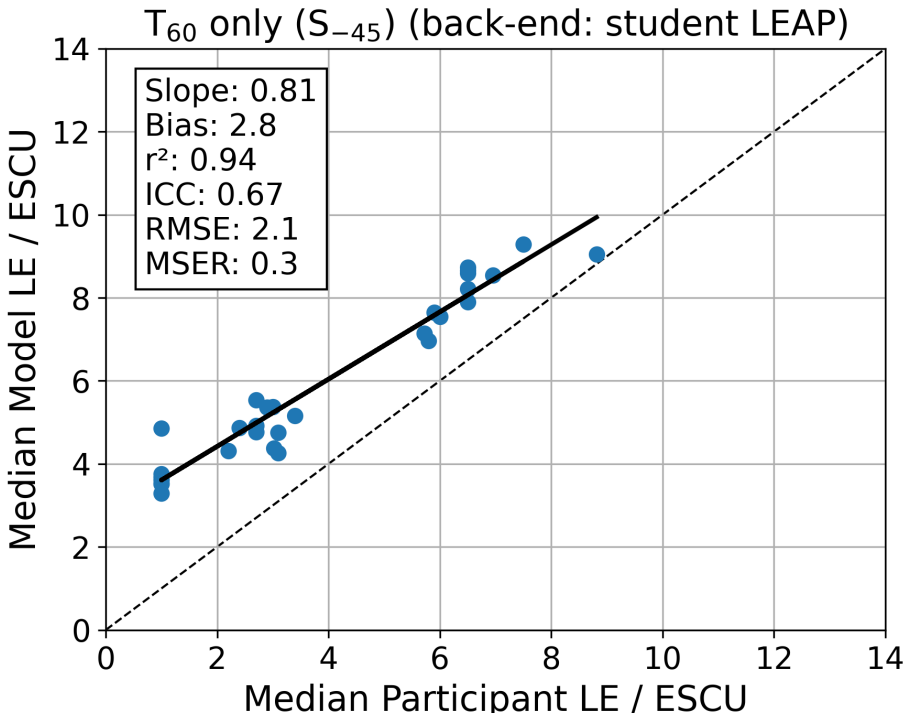


Figure S6.5: Scatterplot alongside correlation metrics for the proposed combination of the blind binaural front-end with the student version of LEAP for the T_{60} *only* profile with lateralized speech.