

# Effects of sound overlap on driving distractions

## Abstract

The study analyzed the impact of audio stimuli on driver distraction in a simulated environment, revealing that overlapping audio, high-loudness audio, and discontinuous audio like game sound effects significantly increase distractions, while the impact of voice content depends on personal interest. This provides valuable insights for car audio system design to reduce the impact of overlapping sound on driving safety.

## Introduction & Background

Modern cars' multiple in-car entertainment systems may lead to sound overlap, thereby distracting the driver and increasing driving risks. This study, based on the theories of attentional resources, dual-task interference, and cognitive load, explores the impact of the mixture and overlap of multiple sound sources (such as music, calls, game sounds) on driver attention, as well as the extent of driver attention dispersion caused by different types and volumes of sound overlap.

## Research Question & Hypothesis

Research question 1: What is the level of driver attention dispersion caused by the overlap of entertainment sounds?

Hypothesis 1: The overlap of entertainment sounds exacerbates the driver's auditory distraction.

Research question 2: When there is an overlap of in-car audio, which disturbing factor, loudness or rhythm, has a greater impact on distraction?

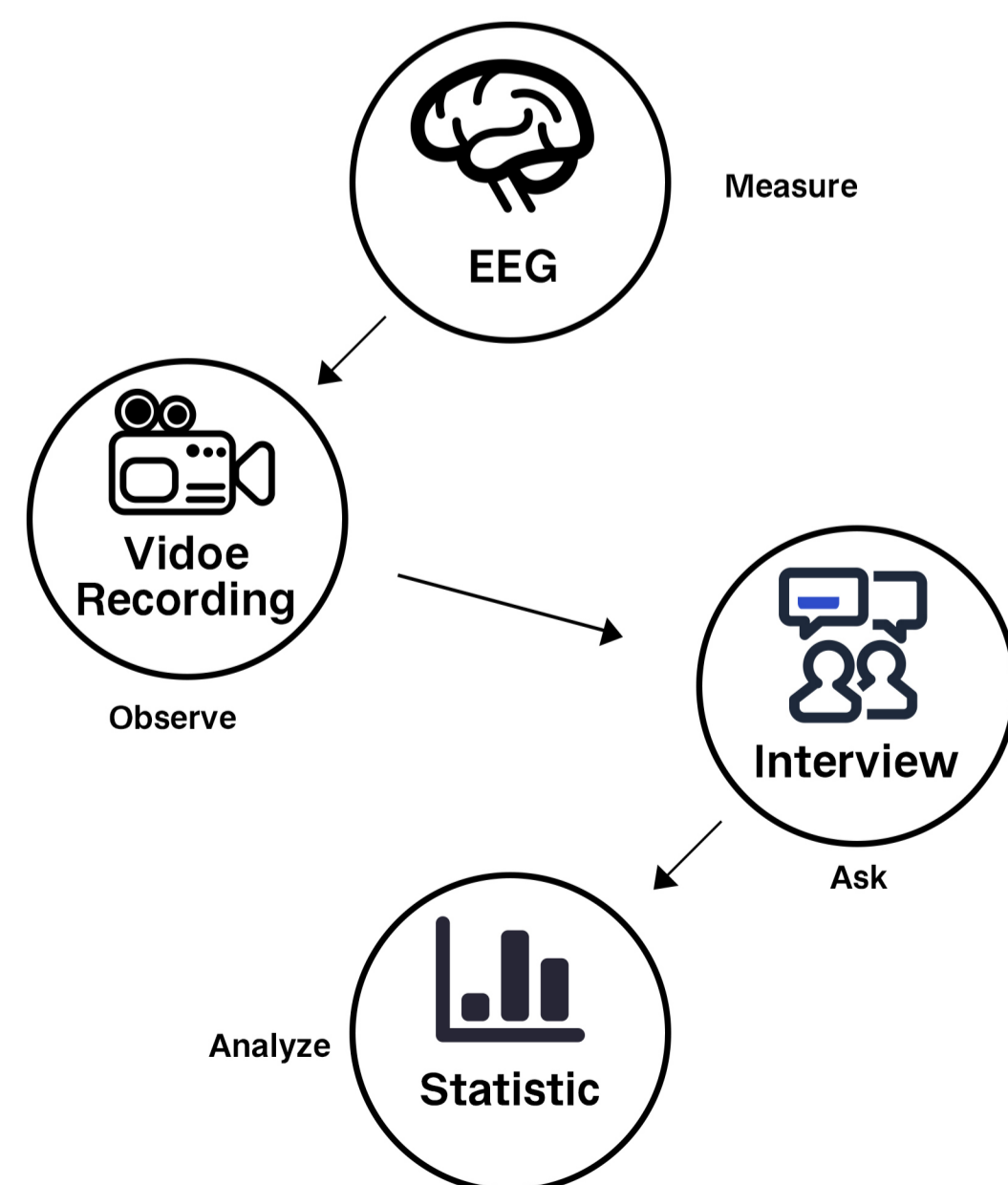
Hypothesis 2: When there is an overlap of in-car audio, high-amplitude audio attracts more driver attention.

Research question 3: Passengers use speakers for various entertainment activities like music, movies, games, news, and short videos. These can be categorized as pure audio or audio with language content. Which type of secondary listening interference causes more distraction?

Hypothesis 3: Discontinuous secondary task audio triggers more intense driving distraction.

Hypothesis 4: Audio with language content is more distracting than pure audio.

## Research Methodology



## Main Task

Participants are required to follow traffic rules and avoid collisions. Participants use their own accounts on music platforms such as Spotify, QQ Music, or NetEase Cloud Music to play music they usually enjoy while driving. This music playlist is the primary listening task.

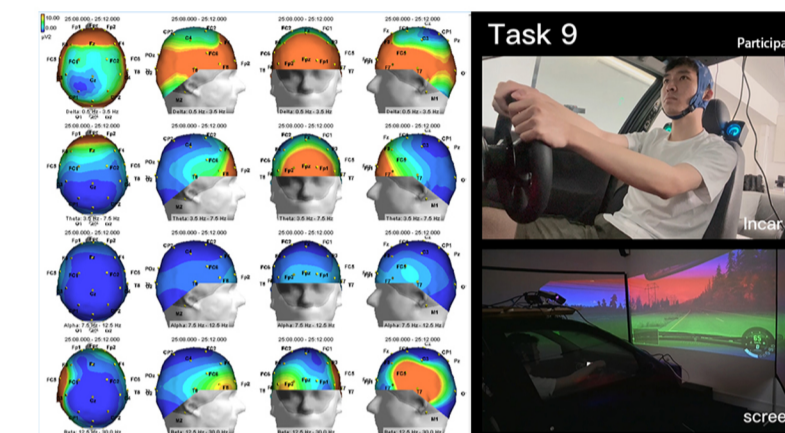
## Secondary Audio Tasks

Name	Audio type	Loudness (dB)	Tempo	Content
Audio 1	Music	40	Medium	Lyric
Audio 2	Music	60	Medium	Lyric
Audio 3	Music	80	Medium	Lyric
Audio 4	Music	60	slow (bpm 70)	Lyric
Audio 5	Music	60	Medium (bpm 100)	Lyric
Audio 6	Music	60	Fast (bpm 130)	Lyric
Audio 7	Pure music	60	Fast	None
Audio 8	Game sound	60	Fast	None
Audio 9	Conversation	60	slow	Ordering dialog
Audio 10	News	60	slow	News

Audio 1, Audio 2, and Audio 3 control the loudness variable. Audio 4, Audio 5, Audio 6 control the tempo variable. Audio 6 through Audio 10 compare the effects of different audio types on auditory interference. Audio 8 is discontinuous audio.

## Distraction event statistics

Based on the results of the literature review it was determined that the auditory distraction sign was theta wave enhancement in frontal regions and alpha wave attenuation accompanied by beta wave enhancement in temporal regions. The number of auditory distractor events per participant across tasks was counted based on the distractor sign.

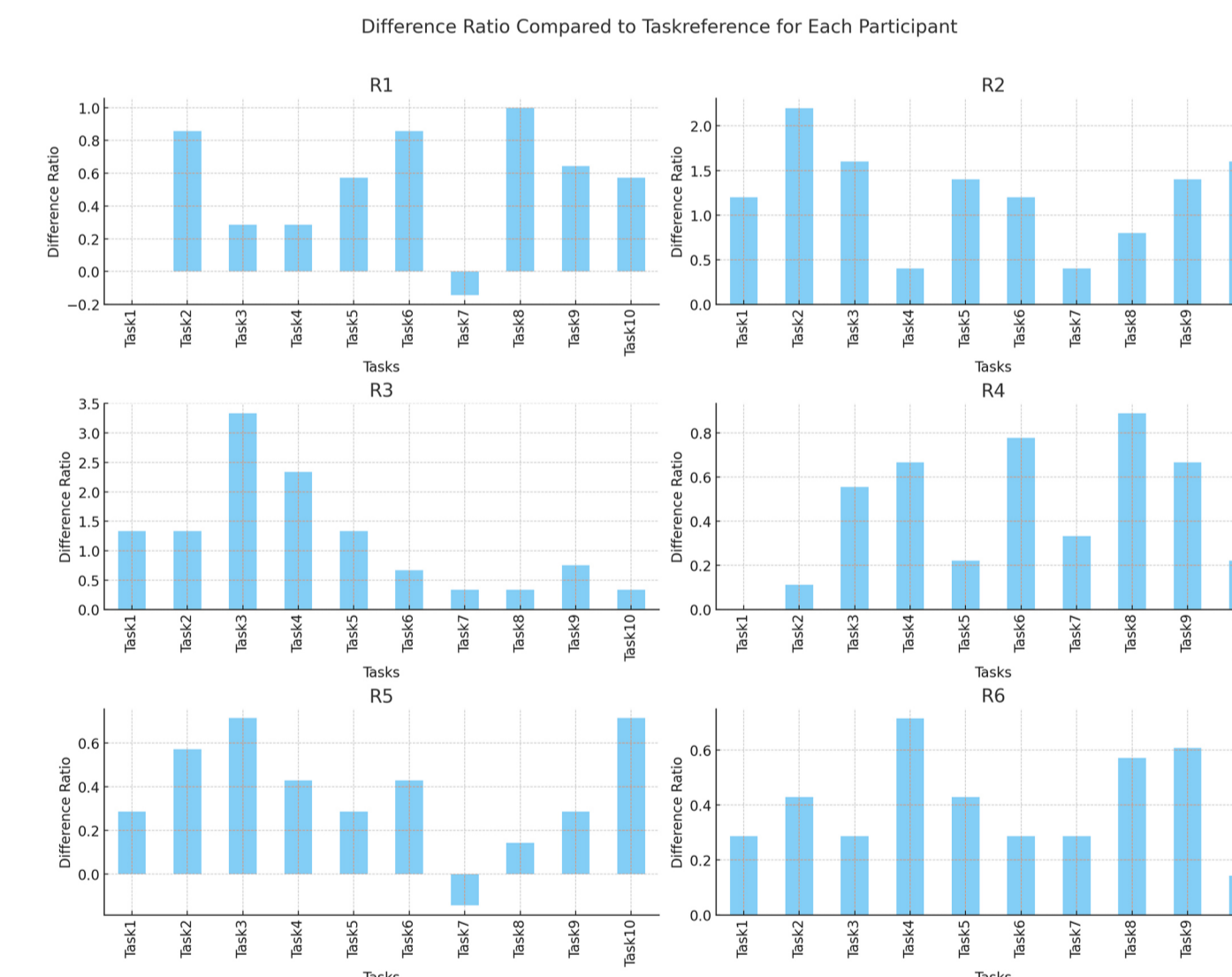


Distraction feature extraction

Participants	Task reference	Task1	Task2	Task3	Task4	Task5	Task6	Task7	Task8	Task9	Task10
R1	7	7	13	9	9	11	13	6	14	11.5	11
R2	5	11	16	13	7	12	11	7	9	12	13
R3	3	7	7	13	10	7	5	4	4	5.25	4
R4	9	9	10	14	15	11	16	12	17	15	11
R5	7	9	11	12	10	9	10	6	8	9	12
R6	7	9	10	9	12	10	9	9	11	11.25	8

Distraction event statistics

## Results



As loudness increased, distracting events increased for most participants, showing that increasing secondary audio loudness had a strong correlational effect with driving distraction.

Participants' responses to changes in the tempo of the secondary audio were inconsistent, suggesting that changes in tempo have little effect on distraction and that changes in distraction levels are more likely to be influenced by the audio content itself.

Discontinuous audio resulted in significantly higher levels of increased distraction than continuous audio, indicating that pure music does not cause strong driving distraction.

Whether audio with verbal content, such as dialog, causes higher levels of driving distraction may depend on the driver's personal preferences and interests.

## Hypothesis Testing

Support Hypothesis 1: Overlap increases distraction. Partially support Hypothesis 2: High volume causes distraction. Support Hypothesis 3: Discontinuous audio causes more distraction. Inability to fully support task 4: Audio of verbal content causes more distractions.

## Advice

Developing a Smart In-Car Sound Management System that manages each sound source via voice recognition, adopts personalized strategies, and has adaptive adjustment features to minimize distractions.

Implementing a Car Headrest Sound System with active noise reduction technology can limit sound within a certain range, providing a clearer, more personalized audio experience, reducing the noise level inside the car, and reducing the driver's psychological burden.

In the future, the results of the present study could be used to further investigate the effects of sound overlap on distraction in both long-distance and short-distance driving.