THE ELUSIVE NATURE OF INATTENTIONAL DEAFNESS: ASSESSING THE INFLUENCE OF VISUAL ATTENTION ON BACKGROUND MUSIC PERCEPTION IN TV PROGRAMMES

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ABSTRACT

Evaluating the audibility level of background music in TV programmes is a significant challenge as some music industry copyright regulations arrange music remuneration accordingly. Besides the loudness level, other characteristics, such as sensory attention, may influence its perception, raising or lowering its audibility threshold. Yet, there is limited literature exploring this particular problem. Our study examines how visually motivated attention impacts the perception of background music in TV programmes, contributing to *inattentional deafness*—the failure to perceive auditory stimuli due to visual perceptual load. We conducted two experiments based on forced-choice and detection tasks focused on assessing the influence of visually motivated attention on background music perception in TV programmes. Experiment 1 shows that participants may experience inattentional deafness when visually motivated, but not strongly enough to support our hypothesis. Hence, we refined our methodology in Experiment 2 with a dual-task paradigm to guarantee forced visual-motivated attention. Analysis via a one-way ANOVA demonstrates a statistically significant influence of forced visual attention (Task 1) towards the music perception assignment (Task 2). Thus, our findings indicate that the audibility of background music is subject to the visual stimuli load of the TV programme.

1. INTRODUCTION

Music in audiovisual productions represents a substantial source of income for the music industry through copyright retribution. Particularly within TV programmes, multiple types of content include music, whether as a primary auditory element or background accompaniment. Royalty distribution regulations vary across countries and consider several conditions, such as broadcasting time slots and the importance of music in the production.

In 2017, the WIPO (World Intellectual Property Organization) arbitrated that distribution rights of background music in TV programmes should be subject to a 3-level audibility scale [1]: (1) non-audible or inaudible, (2) *barely audible*, and (3) audible. Full distribution rights are granted only when the music is audible. When the music is *barely audible*, 50% of the stipulated royalties are effectively paid, and no royalties are paid when the music is not audible. However, there is no standardised method to evaluate and classify the background music audibility level in the context of TV programmes. Still, collective management organisations, such as SGAE (General Society of Authors and Publishers) in Spain, must estimate this component. This issue is further complicated due to the structure of the broadcasted signal, which is a mixture of music and other sounds (e.g. speech, sirens, applause) emitted by TV broadcasters, together with the visual component of the TV programme (Figure 1 [1]). Thus, the received signal is composed of the visual and auditory components, the latter including both musical and non-musical sources simultaneously.

Despite evaluating background music audibility levels has become a crucial research problem for this particular context, little literature explores this issue [2, 3]. Both identified publications primarily focus on defining an audibility threshold level for the class *barely audible*. Besides music loudness level, many characteristics may influence background music perception, including sensory attention, listening conditions, environmental noise, and masking by other sounds within the mixture such as applause or sirens. All these elements might contribute to raising or lowering music's audibility threshold.

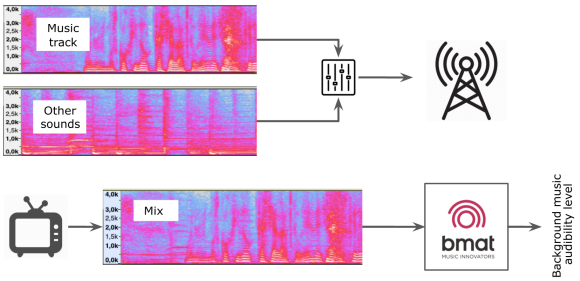

Figure 1. Representation of the broadcasted audio signal.

[1] BMAT is one of the principal companies specialised in monitoring and reporting music usage across various platforms, including radio, television, and online streaming services. More information at: https://www.bmat.com/.

Furthermore, inattentional deafness, defined as the failure to perceive auditory stimuli due to visual perceptual load [4], emerges as an intriguing concept in this discussion, adding complexity to the understanding of how background music is perceived in audiovisual productions. Koreimann et al. [5] support the existence of inattentional deafness in music, highlighting its potential impact on music perception within audiovisual environments.

In this study, we aim to explore the effects of inattentional deafness on the perception of background music in the context of TV programmes. We introduce two experiments based on force-choice and detection tasks [6], reviewed and approved by the Institutional Committee for Ethical Review of Projects (CIREP) at Universitat Pompeu Fabra [2] . In both experiments, we use real broadcasted TV content and implement a condition to motivate visual attention, trying to induce inattentional deafness in the subjects. Despite sharing the hypothesis and research purpose, the methodology for inducing inattentional deafness differs between the two experiments due to the insufficiency of Experiment 1 in supporting our hypothesis. Thus, we refined our approach in Experiment 2 by adopting a dual-task paradigm to guarantee forced visually motivated attention. Detailed descriptions of the methodology followed in each experiment are provided in Section 3.1 and 4.1, respectively. Our findings indicate that the audibility of background music is subject to the visual stimuli load of the TV programme, which is significant to the estimation of the audibility level of background music. Therefore, this characteristic should be taken into account when assessing the audibility level for copyright retribution, when following the 3-level audibility scale.

2. BACKGROUND AND RELATED WORK

2.1 Inattentional deafness

The perception of the loudness of auditory signals is naturally subjective. Each subject's perception can vary due to individual features such as attention and awareness. Attention involves directing the mind towards processing information aligned with the goals of the current task [7], while awareness refers to acknowledging that an event, an object or a sensory pattern is happening or exists [8]. Auditory scene analysis enables the human auditory system to discern and perceive sound events in the environment as distinct auditory objects [9]. For instance, when talking with someone in the street, where there are external noises, we can focus our attention on the voice and isolate the street noises, i.e. car engines and other people talking. The voice, hence, becomes the foreground, whereas the rest of the sonic input is treated as background, receiving much less attention. However, multiple factors can influence the perception of a sound within a TV programme, from masking by another auditory stimuli (e.g. applause or voice) to external environment noise and sensory attention, among others.

Focusing on sensory attention, the concept of inattentional deafness, defined by Macdonald and Lavie [4], occurs when individuals fail to perceive auditory stimuli because of the attention given to the visual stimuli. Multiple investigations demonstrate the influence of visual stimuli on inattentional deafness through different experiments [4, 10–12]. As exposed by Koreimann et al. [5], inattentional deafness in music is defined as the inability to consciously perceive characteristics of the music stimuli when the attention is motivated towards a particular element of the piece (i.e. timpani beats). Their investigation sustains the existence of inattentional deafness in music and that the human auditory system is more influenced by attentional distraction than previously thought. In addition, they point out the potential impact of inattentional deafness in music perception within the audiovisual domain.

2.2 Related Work

Estimating background music audibility levels within TV programmes considering the arbitration by WIPO remains relatively underexplored in the literature. There are two significantly related works targeting this particular research scope.

On the one side, López and Ramallo [2] propose that the feasible solution is to build a deterministic system that converges to the average estimate of listeners' audibility, despite considering several elements that may influence the perception of background music, such as environment noise, musical sensitivity of the listeners and listening environment. Their study consists of a manual annotation of 88 artificial 10-second clips of video composed of the voice of two popular Spanish news hosts (one male, one female) and added, in the background, songs of different music genres. Participants must adjust the loudness level to be marginally audible. Consequently, the authors establish the *barely audible* threshold around -30 dB LUFS and propose a linear regression to adjust the perceived loudness level. Nevertheless, they conclude that, when working with real broadcasted content, where voice and music are mixed, it is required to use source separation techniques to estimate the music loudness level. However, our own examinations suggest that these techniques are still far from providing excellent results that can be trusted in such a sensitive application scenario.

On the other side, our previous investigation in this topic [3] explored the blurry limit between audibility and inaudibility, intending to define *barely audible*. We carried out two experiments based on broadcasted TV content to assess the audibility threshold levels of the class *barely audible* and understand the effects of the listening conditions. We estimated the sound-to-music ratio for *barely audible* to be between -22.7 dB LUFS and -36.4 dB LUFS when watching the content from a television. Our findings suggested that background music perception is affected by loudness level, listening condition, music sensitivity and type of TV content. Thus, we believe there is considerable

[2] The proposed experiments approach was reviewed and approved by the Institutional Committee for Ethical Review of Projects stating compliance with the ethical principles in research involving humans and personal data protection regulations (guided by Regulation (EU) 2016/679 of the European Parliament and of the Council of 27 April 2016 on the protection of natural persons with regard to the processing of data and on the free movement of such data, and repealing Directive 95/46/EC (General Data Protection Regulation)).

scope for future research to consider multiple characteristics that might influence background music perception.

With the present study, we aim to complement our previous work by exploring the effects of inattentional deafness on background music perception. We acknowledge the potential significance of this phenomenon within our research scope.

3. EXPERIMENT 1

3.1 Methodology

In Experiment 1, we aim to investigate how directing attention to visual stimuli affects the perception of background music. We hypothesise that forcing attention to the visual stimuli will make background music less noticeable due to inattentional deafness.

We designed an experiment with a between-subjects approach based on two conditions: *active*, where the participants were explicitly instructed to focus their attention on the visual part of the video, and *passive*, where participants were inclined to view the clip without any specific instruction to direct their attention. Participants were randomly assigned to one of the two conditions.

The experiment involved a force-choice task and used 68 10-second video clips of real TV programmes. After viewing each clip, participants were asked to answer a yes-no question about the content, referring to the image, speech or music within. Questions were carefully balanced on yes-no responses and considered both the type of question and direction of sensory attention (visual or auditory) to minimize bias and avoid guiding participants towards our research goal. Specifically, questions were divided into 50% related to visual modality and 50% to auditory modality. The latter category was further divided into 41.2% for speech and 58.8% for music (representing 20.6% to speech and 29.4% to music of the total questions). Experiment 1 was conducted online and was available in English and Spanish.

3.1.1 Material and Tools

For this experiment, we used 10-second clips of video recorded between 28th June 2021 at 13:15 and 7th July 2021 at 10:15. Spanish stimuli were retrieved from five Spanish TV channels: *TV1*, *TV2*, *LaSexta*, *Cuatro* and *Antena 3*. Instead, English stimuli were obtained from three TV channels in the UK: *BBC*, *Channel 5* and *CBBC*; and three from the US: *CBS*, *NBC* and *Fox*. These stimuli were extracted from BMAT's database and cannot be openly shared as they are subject to confidentiality regulations. The experiment was built with lab.js [3] and distributed through the Pavlovia platform [4].

3.1.2 Participants

A total of 85 subjects participated in the experiment (EN=43, ES=42). One English-version participant was excluded from the study because of a greater number of errors than any other participant. An equal number of valid participants in both language groups was then achieved. Both attention categories (active and passive) had an equal distribution of participants, with 21 participants in each condition per language. A two-way ANOVA supports there is no statistically significant difference between languages ($F(1, 1)=2.381$, $p=0.127$). Hence, results are analysed together. Moreover, 30 participants completed the experiment through Prolific [5] platform and were compensated with 5€. The rest of the participants were volunteers. Two independent one-way ANOVA on the number of errors ($F(1, 82)=0.003$, $p=0.960$) and the reaction time ($F(1, 82)=0.62$, $p=0.805$) demonstrate that there is no statistically significant difference between the behaviour of the participants depending on their origin. Therefore, all retrieved data are analysed together.

Regarding headphone usage, participants predominantly used in-ear or circumaural headphones (77.9%). A smaller representation used supraural headphones (4.3%), while only 7.1% used noise-cancelling headphones. Most participants reported their environmental noise as *weak* or *moderate*, with only 3.6% experiencing *strong* noise, none reporting *very noisy* conditions, and 9.5% perceiving their environment as *inaudible*. On average, the experiment duration was 25 minutes.

3.2 Results

Participants answered on average 75.4% of the forced-choice questions correctly. However, according to the question type, the average amount of errors is diverse: 19.8% for image questions, 17.4% for speech questions and 37.6% for music questions. Notably, the error rate for the music-specific questions is higher than the other two categories. When considering attention groups (active or passive), performance is similar in both cases; including speech and music-based questions, which we hypothesised would show a worse performance in the active experimental condition. Indeed, no statistically significant difference is observed when performing a one-way ANOVA between the two attention groups ($F(1, 5710)=0.094$, $p=0.759$). Hence, our hypothesis is not supported by these results. Despite this situation, our results show that the reaction time in the active group was faster than for the passive group (active=2872.1ms, passive=3363.3ms) and this difference is statistically significant ($F(1, 5642)=16.596$, $p=4.7\text{x}10^{-5}$).

At the end of the experiment, we included a subjective question to know how much background music the participants perceived. Even though six out of the 68 presented clips did not have background music (8.8%), for most participants 60% of the clips had background music. Hence, around 30% of background music tends to be ignored or not acknowledged by the participants.

We suspect that our approach to induce inattentional deafness in the active group was not powerful enough and, to truly focus attention on non-auditory stimuli stronger manipulations than an instruction in the beginning of the experiment should be used. Consequently, we proposed a

[3] https://lab.js.org/

[4] https://pavlovia.org/

[5] https://www.prolific.com/

new and refined experiment to observe the influence of visually motivated attention on the perception of background music in TV programmes: Experiment 2.

4. EXPERIMENT 2

4.1 Methodology

In the present investigation, Experiment 2 intends to explore the impact of visually motivated attention on the perception of background music in the context of TV programmes, with a different approach than Experiment 1. We hypothesise that focusing participants' attention towards the visual component may diminish music perception due to inattentional deafness.

Experiment 2 was based on a dual-task paradigm with two consecutive detection tasks. The first task (Task 1) involved an attention distraction, where the participants were instructed to press the spacebar once they detected a specific visual element within a clip of video, such as a yellow shirt or a dog. With this task, we aimed to force and guarantee continued visually motivated attention to induce inattentional deafness. Then, the second task (Task 2) consisted of an attention and perception evaluation, where participants answered to three true-or-false statements each related to a different characteristic of the video: image, speech and music. All statements were balanced in true and false responses. This approach ensured that participants remained unaware of the experiment's primary goal: assessing background music perception.

This experiment comprised 65 10-second video extracts from Spanish TV, with 55 including background music and 10 without. In addition, at the beginning of the experiment, three extra clips were presented to familiarize participants with the task. To maintain consistent auditory conditions within subjects, the experiment was carried out on-site and exclusively in Spanish.

4.1.1 Material and Tools

Each experiment session took place in a designated room with an average ambience noise of 35.8 dBA. The room was displayed to recreate a living room ambience with a TV and a sofa from which the participants completed the experiment. On average, participants' ears were positioned approximately 2.06 meters away from the TV and the volume was set approximately at 58 dBA. The experiment was directly supervised by one of the responsible researchers.

For this experiment, we also used 10-second segments from the TV programmes recorded between 28th June 2021 at 13:15 and 7th July 2021 at 10:15. The clips of video were selected from the same five Spanish TV channels as for Experiment 1. However, we chose different clips for Experiment 2 to not use the same audiovisual stimuli as in Experiment 1. We used the same tools as in Experiment 1 to design, implement and distribute the experiment.

4.1.2 Participants

Experiment 2 was completed by 27 participants, all of whom were volunteers and native Spanish speakers. However, two of them had to be discarded due to technical issues during the experiment that disrupted the session recording. Another participant was excluded from the analysis due to poor performance, particularly in Task 1, where their accuracy was below 50%. As their performance did not meet the minimum threshold, we cannot guarantee that they maintained the intended focus on the visual content. Thus, we consider the results of 24 valid participants.

In addition, some technical disruptions prompted a few participants to encounter minor issues during their sessions. Specifically, nine subjects did not visualise one clip, and one subject did not visualise two clips (is, 11 missed evaluations). However, all non-visualised clips were different. While these technical issues occurred, we believe that the impact on our overall interpretation of the results is minimal. This issue has been taken into account and participants' average performance has been adjusted accordingly.

4.2 Results

Experiment 2 employed a dual-task paradigm intending to direct participants' attention to the visual component of the audiovisual stimuli while observing the impacts of this focus on music perception. In Task 1, participants were instructed to detect a specific element on the video and press the space bar when it appeared. On average, participants completed Task 1 with 75.6% accuracy, indicating their focus on the visual component while watching the clips.

Task 2 involved three true-or-false statements referring to the image, speech and music components of the clips. The error rate varied depending on the type of assignment-task, with a 25% error rate for image statements, 25.5% for speech and 35.5% for music. Notably, statements related to music-specific characteristics exhibited a 10-point higher error rate compared to the other two categories. On average, participants required approximately 8 seconds to decide whether the presented statements were true or false (M=7.75, SD=3.12).

To observe the influence of Task 1 over Task 2, we conducted three one-way ANOVA considering the errors of both tasks. That is, Task 1 errors as independent variable and each Task 2 characteristic-specific errors as dependent variables. In Table 1, we depicted the results of this analysis. With this statistical analysis, we detected statistically significant differences on the errors for both auditory related-tasks, (speech: $F(1, 1550)=3.976$, $p=0.046$; music: $F(1, 1550)=1.700$, $p=0.006$), due to the differential attention load induced in the visual and auditory domains.

In addition, we analysed the effects of completing Task 1, whether correct or incorrect, on Task 2. Specifically, we examined the error rates of Task 2 depending on Task 1 performance. Considering the results reported in Table 2, we noticed that image-specific questions exhibit the same error rates regardless of Task 1 performance. Instead, both auditory domain-related statements showed improved accuracy when Task 1 was incorrect. Specifically, for speech-specific statements, performance increased by 5 percentage points, and for music-specific statements, by 7 per-

Table 1. One-way ANOVA demonstrating the effects of Task 1 on the errors in each of the different characteristic-specific categories in Task 2. A statistically significant difference is considered when $p < 0.05$ (in bold).

		Sum of squares	Df	Mean Square	F	p
T2-Image	Between groups	0.005	1	0.005	0.029	0.865
	Within groups	290.995	1550	0.188		
	Total	291.000	1551			
T2-Speech	Between groups	0.755	1	0.755	3.976	**0.046**
	Within groups	294.204	1550	0.190		
	Total	294.959	1551			
T2-Music	Between groups	1.700	1	1.700	7.462	**0.006**
	Within groups	353.098	1550	0.228		
	Total	354.798	1551			

Table 2. Task 2 characteristic-specific error rates concerning Task 1 error rates (where 0 indicates correct responses and 1 indicates errors). The *Mean* row indicates the average error rates per each category within Task 2.

T1	**T2-Image**	**T2-Speech**	**T2-Music**
0	0.25	0.27	0.37
1	0.25	0.22	0.3
Mean	0.25	0.26	0.35

centage points. This is aligned with the results reported in Table 1, where a statistically significant difference is demonstrated for the auditory domain assignments.

Similarly to Experiment 1, at the end of the experiment, participants were asked to indicate the percentage of videos they thought contained background music. For most participants, the median perceived percentage of videos containing background music was 65%. However, it is noteworthy that approximately 85% of the videos contained background music. This discrepancy highlights a tendency for participants to underestimate and ignore background music in TV programmes.

5. DISCUSSION

In the context of audiovisual productions, specifically for broadcasted TV programmes, we aimed to study the influence of visually motivated attention on the perception of background music audibility due to inattentional deafness. For this particular case study, we presented two experiments intending to explore the effects of inattentional deafness on music perception.

Experiment 1 wanted to observe the presence of inattentional deafness by assessing the differences between a group actively motivated to pay attention to image contents of a video, and a passive group, which did not receive any specific instruction. However, results between the two groups do not present statistically significant differences, and participants' performance is similar independently of the assigned group. Despite not demonstrating any significant effect of attentional motivation on background music perception, we observe an influence of attentional motivation on reaction time depending on the attention group. Consequently, we consider that our methods could be improved and we propose a redefined experiment.

We modified our methodology in four key aspects. Firstly, we introduced a dual-task paradigm approach based on two consecutive tasks: (i) visual attention distraction and (ii) perception evaluation. This approach aimed to enhance participants' focus on the visual stimuli of the presented clip, inducing more forced visual attention rather than trusting a basic instruction as in Experiment 1. Secondly, we designed Task 2 to include three statements related to the image, speech, and music characteristics of the clip, providing more insights into music perception compared to the single-question format used in Experiment 1. In Experiment 1, only 29.4% of the clips included a music-specific question. Instead, in Experiment 2, we have an evaluation of music perception per every displayed clip. Thirdly, we conducted the experiment onsite to ensure a homogeneous environment across participants and to have more control over the experiment setting conditions. Finally, we focused our study on exclusively Spanish TV content. Since this investigation takes into account the 2017 arbitration by WIPO affecting SGAE and, it is developed within the scope of Spanish funding, we decided to prioritize Spanish TV programmes. We limited participants to be Spanish native speakers living in Spain. With this restriction, we wanted to reduce any variability due to different divergences in popular TV content. These modifications were made to correct the experimental design of Experiment 1.

Findings in Experiment 2 demonstrate the presence of inattentional deafness as the two auditory domain-related queries in Task 2 are detrimentally affected by the attentional focus required by Task 1. Not only does this indicate that Task 1 fulfilled the goal of inducing inattentional deafness in the participants, but it also shows the relevance of this phenomenon on auditory perception. For background music perception, a one-way ANOVA analysis shows a statistically significant difference in the music perception assignment (Task 2) due to the directed attention to the visual component (Task 1). Moreover, our results indicate that performance on auditory-related statements in Task 2 is subject to the accuracy of Task 1. That is, when Task 1 was error-prone, participants obtained better results for speech and music statements in Task 2, whereas performance remained stable for the image-related statements.

Considering all the modifications to our methodology approach and the results obtained, we can be certain that those were effective. We were able to validate our hypoth-

esis and demonstrate the effects of inattentional deafness in the context of broadcasted TV. These findings suggest that background music audibility within a TV programme context is subject to inattentional deafness. In addition, our findings expand the range of scenarios where inattentional deafness has been reported, contributing to its consolidation as a perceptual phenomenon deserving more research attention. These results question the structure of copyright distribution regarding the three audibility level categories established by WIPO.

The research reported here indicates how multidimensional and complex auditory perception in an audiovisual context can be. Regulations and arbitrations regarding music rights distribution should be very cautious in proposing artificial constructs that, when measured at the reception place (or its proxy) cannot be determined with the right precision. In this sense, our research prompts for promoting and using metadata at the source, when direct methods of estimation can be easily obtained. In our case, TV stations could easily provide a speech-to-music ratio that, even not being the only factor to be considered, would provide a solid ground to decide on the *barely audible* case. Nonetheless, we believe that contextual variables influencing background music perception should be taken into account when assessing background music audibility within audiovisual productions, specifically for TV programmes.

6. CONCLUSION

We present a study focused on assessing the effects of inattentional deafness of background music perception in the context of TV programmes. Evaluating the audibility level of background music is significant within the music industry, as some copyright regulations set music remunerations accordingly. Literature demonstrates that many characteristics may influence music perception, beyond its loudness level. We expand previous investigations by focusing on inattentional deafness in background music perception. We proposed two experiments based on force-choice and detection tasks. Our first experiment did not demonstrate strongly enough the phenomenon of inattentional deafness of background music. Therefore, we redefined our methodology to guarantee forced visually motivated attention to induce inattentional deafness. Our results demonstrate the presence of inattentional deafness, as the auditory-domain assignments present statistically significant differences concerning the induced attention to the visual component of the clip. In addition, our findings show statistical significance when perceiving background music in TV programmes.

Thus, the present investigation contributes to untangling the assessment of background music in TV programmes by determining inattentional deafness due to visual stimuli a significant characteristic to take into account. We believe that copyright regulations considering rights distributions based on the three auditory levels proposed by WIPO (audible, *barely audible* and inaudible) should consider other phenomena and circumstances that influence perception in addition to the loudness level, such as sensory attention and inattentional deafness.

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