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Inattentional Deafness Under Dynamic Musical Conditions

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ABSTRACT

While inattentional blindness is a modern classic in attention and perception research, analogous phenomena of inattentional deafness are less well-known. In music, inattentional deafness has never been demonstrated under controlled experimental conditions, despite of indirect evidence for related effects. We tested inattentional deafness with real music in both musicians and non-musicians. Participants listened to the first 1'50" of Richard Strauss' *Thus Spake Zarathustra*, with the experimental group having the task of counting the number of tympani beats and the control group just listening. The unexpected event was an e-guitar solo during the last 20s of this sequence. In Study 1, among non-musicians, only a single person in the experimental group noticed the e-guitar, while 52% of the control group did. In amateur musicians, results were less extreme, but structurally equivalent: When engaged in a simple parallel task, only 38% explicitly noticed the strange guitar, with 68% doing so in the control group. In Study 2, findings were extended to an easier stimulus setting. Results demonstrate that inattentional deafness exists in the musical realm, in close correspondence to known blindness effects with dynamic visual stimuli. The striking effects in the musicians' group shed a new light on the role of attentional processes in music perception and performance.

I. INTRODUCTION

> "It is a well-known phenomenon that we do not notice anything happening in our surroundings while being absorbed in the inspection of something; focusing our attention on a certain object may happen to such an extent that we cannot perceive other objects placed in the peripheral parts of our visual fields, although the light rays they emit arrive completely at the visual sphere of the cerebral cortex."
> *Rezsö Bálint, 1907* (translated in Husain & Stein, 1988, p. 91; cited from Simons & Chabris, 1999, p. 1059)

Inattentional blindness is a modern classic in attention and perception research. First demonstrated as a phenomenon by Neisser (1979, not using the term yet), it means that if people are engaged in a simple attention task, such as counting the occurence of a certain event in a visual scene, they tend to overlook pretty obvious unexpected events of long duration in this scene. The most impressive demonstration of the inattentional blindness effect comes from Simons and Chabris (1999; see also Most, Simons, Scholl, Jimenez, Clifford, & Chabris, 2000; Simons, 2000; Simons & Jensen, 2009) showing that people counting the number of passes in the "white" team in a leisurely student basketball scene are often blind for a person in a black gorilla costume walking across the scene, and even beating his chest when in the middle of the ensemble. The effect is so striking that persons not doing the simple counting task while watching the film cannot believe that anyone could ever miss the gorilla. The scenario even works under very "dirty" conditions, as with audiences of several hundred people in lecture halls. (Somewhat unfairly, Simons and Chabris received the Harvard-based "Ig Nobel Prize" in 2004 for this work, awarded for scientific achievements that "first make people laugh, and then make them think", as the "missed gorilla" setting seems so bizarre at first sight. Still, the paper quickly brought them real fame via psychology textbook chapters on human perception and attention.)

Most empirical studies on inattentional blindness have been conducted in the visual domain (hence the name). However, phenomena of inattentional unawareness are by no means restricted to vision. (For an excellent overview, including also tactile designs, see Mack & Rock, 1998, who also coined the term "inattentional blindness", but usually work with static stimuli.) The acoustical analogy of inattentional blindness, *inattentional deafness*, is less well-known than its visual counterpart, although inattentional deafness in the narrow sense as well as related phenomena are quite well-described (mostly not referring to the label, though; cf., e. g., Wood & Cowan, 1995a, b, or Spence & Read, 2003, for a multisensory / cross-modal example). Inattentional deafness can basically be conceptualized as the opposite of the classic "cocktail party effect" (Cherry, 1953): If the unattended stimulus comes through (bottom-up), we are observing the cocktail party effect; if the stimulus remains unnoticed (although it would easily be noticed in a non-distracted attention setting), we are observing inattentional deafness.

In music, to the best of our knowledge, inattentional deafness has never been demonstrated under controlled experimental conditions, despite of indirect evidence for related effects. Repp (1996) has shown that pianists' errors are difficult to hear even for a jury of other pianists currently practicing the same piece, as the errors and ommissions usually happen in non-dominant voices, and not, for instance, in the melody lead. Our aim was to test inattentional deafness with real music under more extreme conditions, in both musicians and non-musicians. By definition, inattentional deafness means that striking and unexpected musical events remain unnoticed in familiar pieces of music due to an easy explicit task engaging attentional resources.

II. METHOD

A. Design

The gorilla-costumed person suddenly appearing in the video by Simons & Chabris (1999) was here replaced by an e-guitar solo intruding several bars of the opening of Richard Strauss' orchestral tone poem *Also sprach Zarathustra (Thus Spake Zarathustra, op. 30)*. All participants were presented with the first 1'50" of the well-known piece, *Einleitung, oder Sonnenaufgang (Introduction, or Sunrise)*. The experiment was neutrally framed as a "perceptual study in music psychology". The participants' task in the experimental group was to count the number of tympani beats in the piece, while the control group was instructed to just listen. The music was presented from a digital source via loudspeakers, with the e-guitar's onset at 1'16" (lasting for 20s).

Afterwards, methodically following Simons & Chabris (1999), all participants were successively asked (a) if they had noticed anything peculiar, (b) if they had noticed any unfitting instruments or sounds, and (c) if they had noticed the e-guitar. If they answered any of these questions with "yes", they were immediately inquired what exactly had been perceived, how it had sounded, and when it had happened (beginning, middle, or end of the sequence).

The counting of the tympani beats was chosen as the attentive task for the experimental group due to (1) its relative simplicity, requiring no formal music training, and (2) the tympani's spectral distance to the e-guitar, directing attention to the bass voices of the orchestra. (Remember that the strongest effect in the gorilla study was observed when the passes in the team with the *white* T-shirts had to be counted in order to draw attention away from the black gorilla costume; cf. Simons & Jensen, 2009, for effects of task difficulty).

B. Materials

The e-guitar improvisations were recorded by a locally renowned *bona fide* professional jazz guitar player on a semi-acoustic guitar, linked to a standard guitar amplifier (Mesa Boogie, Quad Preamp). They were cut and mixed into a commercial standard recording of the orchestra piece (Chicago Symphony Orchestra, Sir Georg Solti, Decca 1994) using the *Samplitude Professional 8.0* software. The two versions, main take and alternate take, actually used for the experiment were chosen out of seven different takes which varied in distinctiveness / embeddedness, loudness, and use of the bottleneck technique, based on the experimenters' pre-selective judgment and a pilot study for task difficulty. Compared to the main take selected for Study 1, the alternate take (with bottleneck) selected for Study 2 is clearly less embedded and therefore has a lower task difficulty. Audio files (MP3) of both versions are available for download for demonstration purposes at the following URLs:
http://www.uni-klu.ac.at/psy/cognition/download/zarathustra/version_1.mp3 [main take, Study 1]
http://www.uni-klu.ac.at/psy/cognition/download/zarathustra/version_2.mp3 [alternate take, Study 2]

C. Sample

A total of 125 subjects initially participated in Study 1, with 6 being excluded post-hoc due to not knowing the piece, 3 due to hearing impairments, and 1 due to reporting a result of the counting task (experimental group) more than three standard deviations apart from the group average (cf. Simons & Chabris, 1999). Hence, the experimental data of N = 115 subjects were finally analyzed (age 18-63 years, M = 26 years, 64% female). Of these, n_1 = 58 were non-musicians, and n_2 = 57 were amateur musicians (or music students and musicians of higher qualification) with a minimum of either {7 hours of weekly instrumental practice during the last 3 or more years} or {3 hours of weekly instrumental practice during the last 5 or more years}.

In Study 2, performed with the easier alternate take in order to get additional information about task difficulty effects, all 50 participants were non-musicians, with 3 being excluded due to not knowing the piece. Thus, the data of N = 47 subjects (age 19-51 years, M = 26 years, 70% female) were finally analyzed here.

III. RESULTS

A. Study 1 (Main Take)

1) Non-Musicians. The results for the non-musicians subsample are given in Figure 1. The e-guitar was explicitly mentioned by *just a single person* in the experimental group, while it was spontaneously noticed by 52% (15 out of 29) in the control group. This between-groups difference, in accordance with the main hypothesis on inattentional blindness in music, is significant with χ^2 (2) = 18.8, p < .001, and a contingency coefficient of CC = .50.

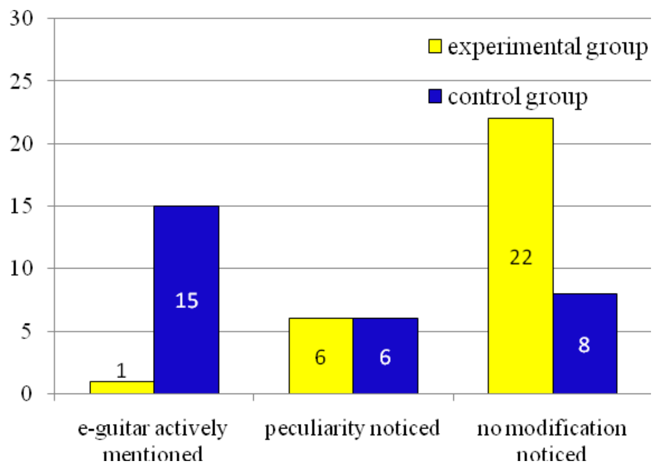

Figure 1. Results in the non-musicians group. Yellow ... experimental group (counting task), blue ... control group (no task).

2) Amateur Musicians. In the amateur musicians' group, results were less extreme, but structurally equivalent. Figure 2 gives an overview of the experimental data.

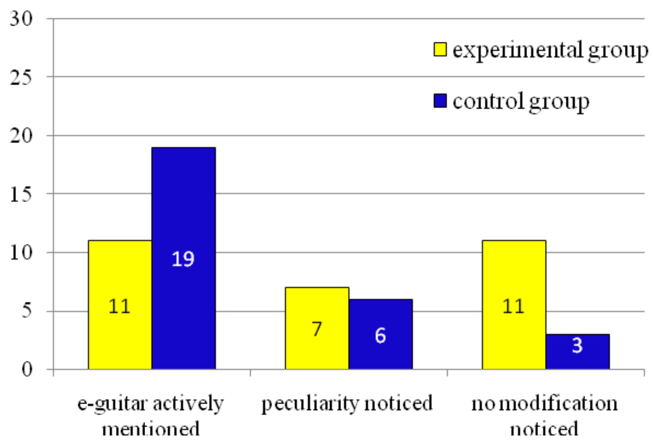

Figure 2. Results in the amateur musicians group. Yellow ... experimental group (counting task), blue ... control group (no task).

When engaged in a simple attentive parallel task, only 38% (11 out of 29) of the amateur musicians did explicitly notice the strange guitar, while 68% (19 out of 28) did in the control group. Again, the between-groups difference is significant with χ^2 (2) = 6.8, p = .034, and a contingency coefficient of CC = .33.

3) Expertise-Related Differences. General differences in performance level between the non-musicians group and the musicians group are displayed, aggregated across experimental conditions, in Figure 3.

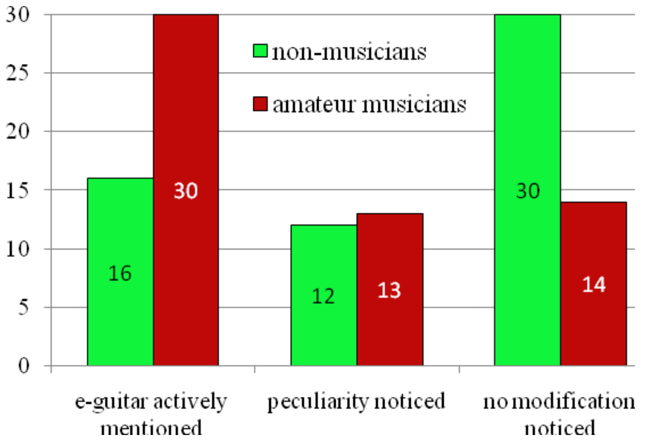

Figure 3. General performance differences of non-musicians vs. amateur musicians, conditions pooled. Green ... non-musicians, red ... amateur musicians.

As expected, across both conditions, amateur musicians performed relatively better in the recognition of the incongruous e-guitar. This global difference between expertise groups is significant with χ^2 (2) = 10.1, p = .006, and a contingency coefficient of CC = .28.

B. Study 2 (Alternate Take)

In Study 2, the alternate take was presented with the aim of gaining information about task difficulty effects (with respect to the conspicuity of the inattended event, as task difficulty does of course also depend on the characteristics and the complexity of the attended task; see above). This study was conducted with non-musicians only (see sample description). The results are therefore directly comparable with those displayed in Figure 1.

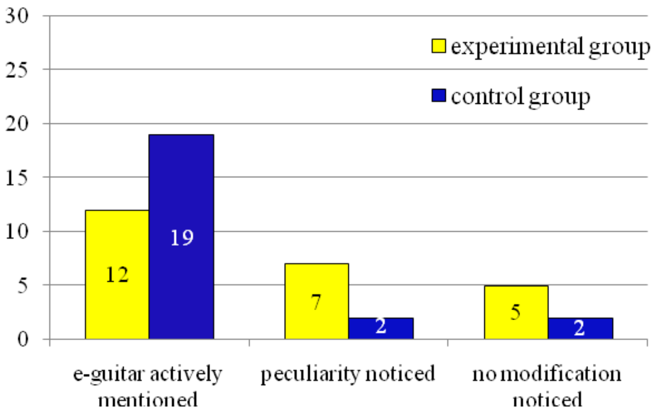

Figure 4. Results for the alternate take; non-musicians only (separate sample). Yellow ... experimental group (counting task), blue ... control group (no task).

As shown in Figure 4, effects of task difficulty (inattended task) are clearly visible. The participants in this experiment generally performed better, i. e., showed less deafness effects, than in Study 1. Still, despite the relatively small sample and the more mixed effects, the treatment factor (counting task vs. no task) only marginally misses significance with χ^2 (2) = 5.6, p = .060, and CC = .33. If one argues that the hypotheses of all experiments reported in this paper are clearly directional (differences are expected in terms of more deafness effects in the experimental groups and less deafness effects in the control groups), then it seems feasible to apply one-sided tests of significance, which would result in $p_{one\text{-}sided}$ = .030 here. In any case, taking the different sample sizes into account, it should be evident that the inattentional deafness effect does not simply disappear here, but is gradually moderated by the difficulty of the attended task (q.e.d).

IV. CONCLUSION

Results demonstrate that inattentional deafness exists in the musical realm, in close correspondence to known blindness effects with dynamic visual stimuli (in film and reality settings). We had expected this for the non-musicians group, but were quite surprised to find that the effect holds, albeit to a more moderate degree, even for a group of amateur musicians (also including music students and other persons of higher musical qualifications). This deafness effect in domain-specific experts seems particulary revealing, since the like has not been done before in the context of inattentional blindness – there is no apparent parallel to this in the sense of "visual experts", although students of film direction may be an interesting choice here.

Another specific feature of the studies presented is that inattentional unawareness effects have been demonstrated under dynamic conditions, and with real-life musical stimulus material. Therefore, the ecological validity of these results is more satisfying than with earlier studies, especially from the visual domain, using static and experimentally simplified stimuli (cf. the work of Simons & Levin, 1998, who brilliantly succeeded at demonstrating person-related change blindness effects in a real-life setting on a university campus).

Altogether, results show close correspondence to the findings from the visual domain, and are just as perplexing: Subjects tend to completely *miss an e-guitar improvisation* in a classical piece of music under simple conditions of attentional distraction. The striking effects also in the amateur musicians' group shed a new light on the role of attentional processes in music perception and performance.

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