Action observation modulates both the desire to move and the perception of 'groove' while listening to percussive music

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Abstract

Listening to music typically provokes spontaneous movements and, when accompanied by positive emotional states, a sense of being 'in the groove'. However, it is unclear if seeing the music maker can modulate these auditory effects. We investigated the impact of incidental action observation on auditory processing. Across trials, participants (N = 36) rated either high- or low-groove drum beats, while observing a point-light display (PLD) of the drummer. The 'task-irrelevant' PLD was either synchronised with the audio ('fully-corresponding' condition), or was incompatible across three conditions: 'static' PLD; corresponding but 'asynchronous' PLD (0.5s time-shifted); or a 'non-corresponding' drum PLD (*e.g.* low-groove audio with high-groove PLD). Participants rated each audio drum track for: (a) the desire to move; and (b) perceived groove (7-point Likert scales). While the desire to move was greater for high- compared to low-groove music in three conditions, this effect was absent in the non-corresponding condition. This rating was also greater for fully-corresponding over asynchronous and non-corresponding trials. Perceived groove was greater for high- over low-groove audio, and higher for fully-corresponding, over the other three visual conditions. Thus, incidental action observation modulated auditory processing, necessitating a multimodal account of music perception.

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Background

Listening to music often provokes spontaneous movements, such as head-bobbing and foot-tapping, in time with the rhythm. Synchronising such sensorimotor processes with the external rhythm can also be enjoyable, promoting a feeling of being ‘in the groove’. Groove is defined as wanting to move the body in relation to musical features, in conjunction with a positive emotional experience (Janata, Tomic, & Haberman, 2012). Previous studies have investigated musical factors promoting groove (*e.g.* syncopation, Witek, Clarke, Wallentin, Kringelbach, & Vuust, 2014; timing deviations, Keil & Feld, 1994). However, it is not yet clear if seeing the musician can also modulate these audio-based effects.

Passively observing everyday rhythmical actions can bias the cycle time of subsequently executed rhythmical actions (*cf.*, Eaves, Turgeon, & Vogt, 2012). Therefore, since sensorimotor processes can become entrained to visual as well as auditory rhythms, we predicted that observing a drummer would modulate concurrent auditory processing of percussive music. More specifically, a musician’s performance visually conveys both instrumental actions (responsible for sound), as well as expressive movements (linked to expressive intention). While these action categories influence many perceived musical qualities, including intelligibility, tempo, rhythmical complexity and expertise (*e.g.* Rodger, Craig, & O’Modhrain, 2012), the effects of this biological motion on both groove perception and the desire to move have not previously been studied.

Aim

Our primary aim was to quantify the impact of incidental action observation on the auditory processing of high- and low-groove music.

Method

Participants

Thirty-six adults (25 female, mean age = 26.22, *SD* = 8.97) volunteered for the experiment, with normal or corrected-to-normal sight and hearing. We obtained written informed consent prior to their participation, and received ethical approval from York St. John University.

Task and Design.

First we familiarised participants with PLDs and the experimental task. Across trials, participants viewed a fixation cross (1s), followed by the combined audio-visual stimulus (10s). At stimulus offset participants submitted two ratings: (a) 'To what extent did you feel the *audio* made you want to move?' (*c.f.* Witek, Clarke, Wallentin, Kringelbach, & Vuust, 2014), and (b) 'To what extent did you feel the *audio* grooved?' using a 7-point Likert scale (1 = not at all; 7 = very much so). We defined groove as: 'The urge to move in response to music, combined with a positive emotional state'. Finally, to ensure attention to the display was equitable across trials, participants reported whether the drummer was moving or static. Trials with incorrect responses were omitted (1.7%).

We used a two-factorial repeated measures design, manipulating auditory information (high- or low-groove audio drum track) and the style of visual information presented in the PLD ('fully-corresponding', 'static', corresponding but 'asynchronous', or 'non-corresponding' with the audio track). We used five different drum patterns for both the high- and the low-groove audio: two excerpts of each pattern were provided within each visual presentation condition, creating eighty experimental trials. We added five 'filler' trials to both the high- and the low-groove conditions in each of the four visual conditions, creating forty filler trials not included in the main analysis. The total 120 trials were pseudo-randomised into five blocks of twenty-four trials. Each block was balanced for experimental/ filler trials and trials from each groove and visual presentation condition. Within each block, trial order was randomised and there was a two-minute break between blocks.

Materials

Five high-groove and five low-groove tracks were selected from over 150 songs rated previously for perceived groove (Janata, Tomic, & Haberman, 2012). We carefully matched pairs of songs across the two groove conditions for instrumentation, time signature and tempo. We then recorded a professional drummer playing the pattern for each song, while a metronome paced each track via headphones. The drummer had fifteen years' professional drum training with experience of session work, recording and live musical performance.

To create the audio tracks we used an audio recorder (Zoom H2). For the visual stimuli we created a PLD of the same performance, tracking spatiotemporal positions using 3-D motion capture software (Nexus 1.2.103) linked to six motion-sensitive infra-red cameras (MX13) sampling at 100 Hz. We tracked his positional data in 3-D from joint-centre markers (ankles, knees, shoulders, elbows, wrists) on both sides of the body, plus both temples on the head. These landmarks either passed through the greatest range of motion, or illustrated the rhythmical/ expressive features of the performance. Data were visualised, using motion capture software, as points of white light moving against a black background.

The PLDs were aligned with the relevant audio track using video editing software (TechSmith). For fully-corresponding trials, corresponding audio and visual stimuli were fully time-synchronised. For static trials the same audio clips were presented while the PLD showed a static image of the drummer. For asynchronous trials, corresponding audio and visual stimuli were presented together but were time-shifted such that the drummer’s PLD lagged behind the audio by 0.5s. For non-corresponding trials, auditory stimuli from one groove category were paired with visual stimuli from the alternative category (*e.g.* high-groove audio with low-groove visual). Since pairs of songs were carefully matched across the two groove categories for time signature and tempo, the audio and visual stimuli were accurately time-synchronised despite differences in their biological motion patterns. Since two excerpts of each audio track were presented for each of the four presentation conditions, we took two steps to ensure that participants' ratings were not biased by their previous experiences. Firstly, we presented only the drum instrumentation for each song, omitting all characterisation from the other instruments in the original recordings. Secondly, we created 'filler' stimuli to increase the range of audio excerpts that were assessed.

The experiment was generated using E-Prime software running on a laptop computer (Dell Latitude E5540) situated on a desk approximately 60 cm in front of participants. Sound was presented via a speaker system (Harman/Kardon) connected to the laptop. The volume setting was fixed across participants.

Results

Data analysis

We ran a 2 (audio groove: high or low) × 2 (visual presentation style: fully-corresponding, static, asynchronous, or non-corresponding) analysis of variance (ANOVA) on the mean scores for both dependent measures: (a) the desire to move; and (b) the perception of groove in the audio track. Where appropriate, we adjusted these for any violation of the homogeneity of variance assumption using the Greenhouse-Geisser correction.

To what extent did you feel the audio made you want to move?

The two-factorial ANOVA revealed a significant main effect of groove condition, $F(1, 35) = 9.87$, $p < .010$, $\eta_p^2 = .22$ (see Figure 1). Participants reported a stronger desire to move after listening to high-, compared to low-groove audio (3.35 vs. 3.17, respectively). The main effect of presentation style was also significant, $F(2.42, 84.77) = 7.66$, $p < .001$, $\eta_p^2 = .18$. Pairwise comparisons revealed that desire to move was significantly stronger for fully-corresponding, compared to both asynchronous and non-corresponding trials (both $p < .010$). Desire to move was also greater in the static compared to the asynchronous condition ($p < .010$). All other comparisons were non-significant. The two-way interaction between groove condition and presentation style was significant, $F(2.02, 70.85) = 3.22$, $p < 0.05$, $\eta_p^2 = .08$. Pairwise comparisons showed that participants reported a stronger desire to move when listening to high-, compared to low-groove audio in all visual conditions ($p < .050$) apart from the non-corresponding condition ($p < .050$).

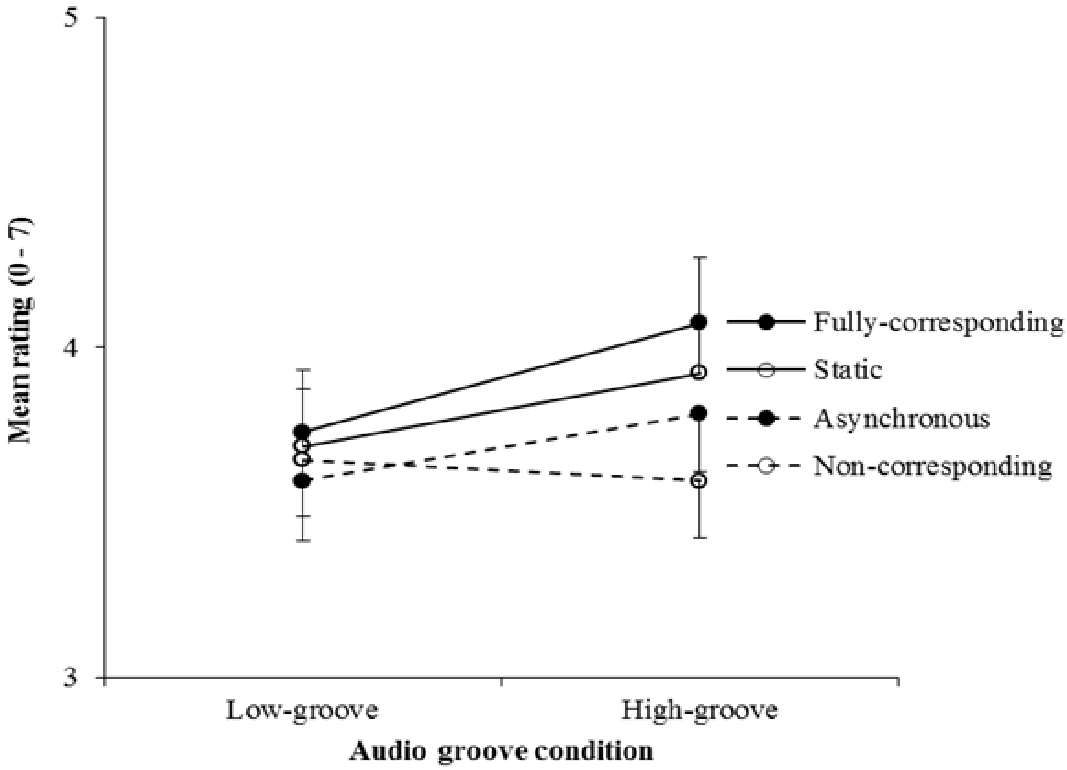

Figure 1. Mean ratings for desire to move in response to the audio for the two factors: audio groove and visual presentation style. Error bars show standard error of the mean.

To what extent did you feel the audio grooved?

The two-factorial ANOVA revealed a significant main effect of groove, $F(1, 35)=10.90$, $p < .010$, $\eta_p^2 = .24$ (see Figure 2). Participants reported experiencing a stronger sense of groove for the high-, compared to low-groove audio (3.45 vs. 3.26, respectively). The main effect of presentation style was also significant, $F(1.84, 64.48) = 4.30$, $p < .010$, $\eta_p^2 = .11$. Pairwise comparisons showed that perceived groove was significantly higher for the fully-corresponding condition, compared to the other three visual conditions ($p < .050$). All other comparisons were non-significant, as was the two-way interaction.

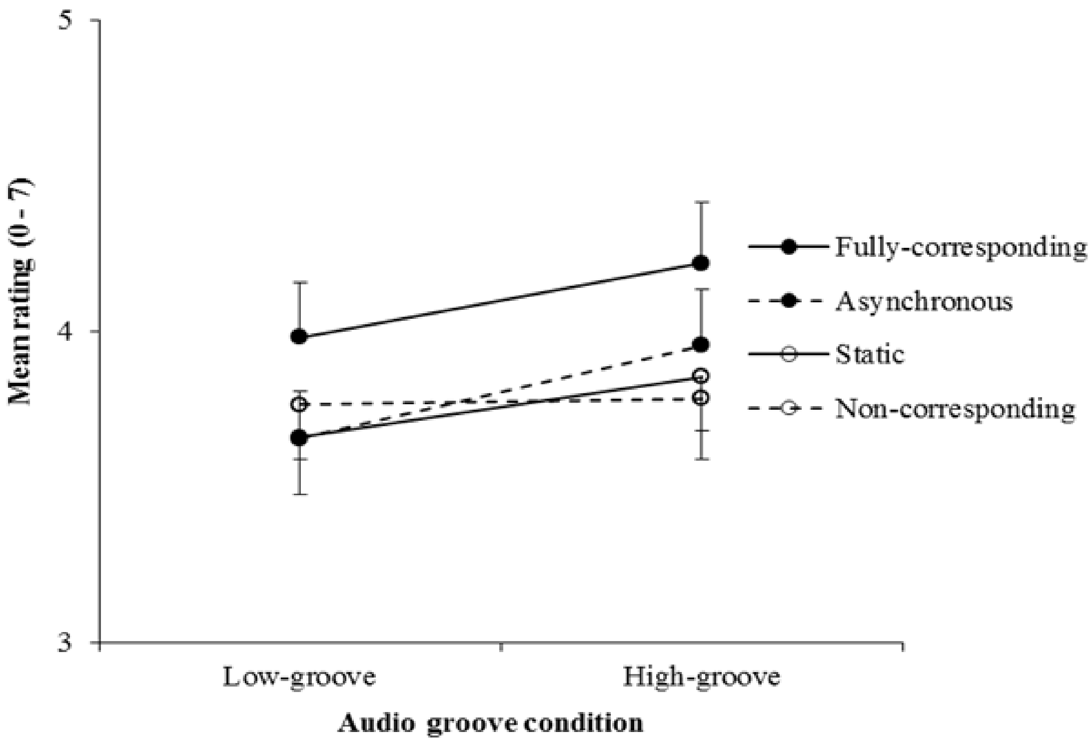

Figure 2. Mean ratings for the perception of groove in response to the audio for the two factors: audio groove and visual presentation style. Error bars show standard error of the mean.

Conclusions

Ratings in both dependent measures were higher overall after listening to high- compared to low-groove music, as found previously (Janata, Tomic, & Haberman, 2012). Moreover, these scores were clearly modulated by incidental action observation. Relative to the fully-corresponding and static trials, desire to move was reduced in the asynchronous and non-corresponding trials, suggesting that dynamic visual cues have an inhibitory or suppression effect on the desire to move, specifically when these conflict in some way with the auditory rhythm. A specific suppression effect was also found for high-groove audio processing paired with low-groove visual cues. In contrast, groove perception was elevated in the fully-corresponding condition, relative to the other three visual conditions.

Most likely, our audio-visual stimuli generated covert motor activations in the perceiver. On this premise, the perceived correspondence between the temporal-spatial patterns presented across modalities presumably underpinned our effects – that is, in terms of the covert sensorimotor synchronisation achieved for each audio-visual combination. Thus, in a general sense, strong correspondence across modalities facilitated both groove perception and the desire to move. In contrast, a weak correspondence attenuated these ratings. Accordingly, these data necessitate a multimodal account of music perception, and have implications for practitioners in musical therapy and training.

Notes

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