Do “Groove” Inducing Sounds Need to be Perceived as Music for Individuals to Show Movement?

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Do “Groove” Inducing Sounds Need to be Perceived as Music for Individuals to Show Movement?

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Abstract

Since rhythm can be found anywhere in the world, generated by humans, animals, and machines, a question arises about what makes us move to music. If an individual knows that the sounds they hear are music, do they move differently than if they do not think that the sounds are music? To address this, we designed an experiment with two between-subjects conditions in which all participants will be administered the same musical stimulus. One group of participants will be told that the stimulus is music, whereas the other group will be told that the stimulus is merely ambient sound that a musician did not create. Before this experiment could be conducted, it was first necessary to run a pilot study ensuring that this stimulus could cause individuals to move when it was construed as music—without evidence of movement to the stimulus under these conditions, we could not test whether this movement was affected when participants no longer believed the stimulus was music. The pilot study found that our stimulus evoked movement within participants, setting the stage for the additional preliminary testing necessary before the planned full experiment can be implemented.

Keywords: Groove, Music Perception, Video Analysis
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Introduction

Throughout the wide span of music perception research, several studies have examined how music causes people to move. The desire and tendency to move when listening to music is called “groove” (Janata et al., 2012). For example, when individuals turn on their car radios to hear music, they may move their heads to it. This phenomenon can be found at music concerts, social events, and almost anywhere there is music. Groove has been widely associated with music, leading to research to see what musical and sound factors cause it.

Groove needed an empirical definition to help guide research, a working definition based on how it is conceived of in the general population. This operationalization was necessary because there was no clear reference to identify what elicits groove. The fields of musicology and cognitive sciences tended to have different operational definitions of this concept (Janata et al., 2012). The lack of consistency of a definition within the various disciplines led Janata et al. (2012) to design a survey with open-ended responses collecting data on what people believe groove is. The importance of their methods was mostly how they considered people’s perspectives on an open-ended basis. Since music has been within society for years, everyone has their own experiences with music. Gathering everyone’s experiences and analyzing them collectively can guide us to a more objective sense of what groove is.

The survey in Janata et al.’s (2012) study led to the researchers achieving their goal of defining groove. The study found that groove is associated with pleasure and movement caused by music (Janata et al., 2012). Thus, the researchers would establish the definition that groove is the part of music that makes people feel a pleasurable desire to move (Janata et al., 2012). Since people feel pleasure when they experience groove, it, along with some indication of movement in response to music, can be used to measure the feeling of groove. However, this definition is
silent on exactly how music evokes this pleasure and desire to move, driving the authors to investigate what may produce groove.

Having established a working definition of what groove entails, Janata et al. (2012) conducted a study to see if tempo, familiarity, and genre affect groove. Tempo refers to the overall speed of the music, typically measured in terms of the number of beats played within a minute (BPM). Data from this study would prove that tempo and genre affect groove, with higher tempo songs and music from genres such as Soul/R&B producing the most movement (Janata et al., 2012). The other genres presented in their study were jazz, rock and folk, but the findings with Soul/R&B gave initial evidence towards syncopation’s effect on groove. The music that makes up the latter genre tends to have relatively high syncopation; thus, the researchers highlight syncopation as a contributor to groove.

Syncopation is best defined as a “distinctive rhythmic effect produced by a class of violations of temporal expectation. Specifically, where an event coinciding with a relatively weak metrical moment fails to be followed by an event on an ensuring stronger metrical moment” (Huron, 2006 p. 421). These strong metrical moments can be referred to as “strong” beats, and the weak metrical moments can be referred to as “weak” beats. An example of a written syncopated rhythm is in Figure 1, and the link to the accompanying audio recording is in Appendix A. Most commonly, this technique is used to create a transition between different sections of a song in terms of the content of lyrics or the narrative being conveyed. The first

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1 In music, “beats” are referred to a unit of time and the rhythmic timing is decided by these beats. This temporal regulation defines the pace of an individual musical composition. It is often referred as “meter” which is best described as the equal temporal measurement followed throughout a piece of music.
study by Janata et al. (2012) supported the previous operationalization, with their data highlighting syncopation and tempo as factors that affect the feeling of groove.

Interestingly, with the response to Soul/R&B music, it was found that participant’s movements did not vary between the two tempo levels (fast vs. slow) of different musical stimuli. However, there was an effect of tempo on the feeling of groove within the other genres presented (Janata et al., 2012). This may prove that syncopated rhythms are more critical to groove than tempo and that there may be a maximum amount of groove to be felt. The researchers’ data also answered questions about non-musical factors affecting groove. In the case of familiarity, when analyzed in a mixed effect model, it was found that it did not significantly affect groove. There was also a significant finding that enjoyment was related to feeling groove, supporting the hypothesis that groove is pleasurable.

In sum, Janata et al. (2012) established how syncopated rhythms and tempo affect our desire to move with music. Building upon these findings, Witek et al. (2014) sought out more information regarding how syncopation affects groove. Specifically, they investigated whether there was a specific, objective amount of syncopation that would evoke movement. While doing this, Witek et al. (2014) also compared the amount of pleasure received from the syncopated rhythms. This would support the idea established by Janata et al. (2012) that pleasure is
associated with the movement involved in groove. Thus, Witek et al. (2014) would investigate groove’s relationship with pleasure and syncopation.

To extend the findings of Janata et al. (2012), the stimuli in Witek et al. (2014) were designed with tempo and the amount of repetition to be held constant. However, the amount of syncopation in the rhythms of the various stimuli was experimentally manipulated. Furthermore, they also created another set of stimuli that measured uncertainty within the audio signal to allow for comparison with syncopation; this uncertainty is called “joint audio entropy” (Witek et al., 2014). In other words, they allowed manipulations in the audio to have unexpected breakages that are different than the breakages from the “strong” beats found in syncopation. With this ability to compare the uncertainty created by syncopation to another type of uncertainty with the stimuli, Witek et al. (2014) measured the desire to move, and pleasure received from the stimuli.

Like Janata et al. (2012), Witek et al. (2014) also measured participants’ previous experiences with music, such as music training and dancing. As groove is associated with movement, this procedure enabled seeing the connection between pre-existing motor ability and music. For example, if someone has experience with dancing to music, they may have a more effortless ability to find the rhythm to follow. In sum, this study sought to expand our knowledge of syncopation and groove as an experience with movement by replicating and expanding upon the methods used by Janata et al. (2012).

To measure participant’s groove experience with the stimuli, Witek et al. (2014) administered a questionnaire asking the level of desired movement and the level of pleasure felt while listening to the stimuli. The results of their study suggest that syncopation has an inverted-U-shaped association with desire to move and pleasure: When there is either a less complex or highly complex rhythm, listeners tend not to feel pleasure and desire to move, whereas groove is
maximized at moderate levels of syncopation. That is, there may be a “sweet spot” or objective amount of syncopation that evokes a groove. However, the alternative measure of auditory complexity, joint audio entropy, did not seem to be a predictor of self-reported groove (Witek et al., 2014). Furthermore, when individuals heard a moderate level of syncopation, they felt both pleasure as well as the desire to move with the music.

Interestingly, music training and familiarity were not found to have significant effects on groove, but the experience of dancing to music did have an effect (Witek et al., 2014). That is, if an individual had previous experience with the music, this did not affect how inclined they felt to move with it; however, the relationship with participants’ experience with dancing did show evidence that different individual differences affect groove. This finding conflicts with those made by Janata et al. (2012), which suggested that familiarity did not contribute to groove. Thus, two studies point to similar objective factors that influence the degree of groove felt by individuals but provide conflicting evidence regarding the effect of prior experience with the music on the intensity of groove.

With the establishment of syncopation as a moderator for groove, Witek (2017) sought to explain how syncopation could have this effect. It was proposed that syncopation involves the deemphasis of the primary metric beats, so these “strong” beats are left open without sounds when syncopation is present. Witek (2017) believes these rhythmic openings *invite* listeners to fill them in by moving their bodies. Movement of the body substitutes for the sound that is missing on what would be a strong beat. If this hypothesis is true, it will help explain why syncopation is an objective moderator of individuals’ groove experience.

With the study of syncopation, there also has been research on how lower frequencies affect our groove experience. Lower frequencies (e.g., bass drum, bass guitar) create complex
sound waves that are physically larger in amplitude. With the help of speaker systems amplifying these sounds, individuals can feel these sounds in their bodies. Concert venues typically use speaker systems allowing individuals to feel lower frequencies. Before the work of Hove et al. (2020), there was little research on how the physical sensations felt from bass frequencies affect groove experience; therefore, they conducted two studies to see how audio-tactile sensations affect groove.

In the first study, ten stimuli, previously established by Janata et al. (2012) as particularly likely to induce experiences of groove, were played twice to participants while they were wearing sound-damping ear protection over noise-canceling headphones in a car (Hove et al., 2020). Furthermore, they placed a speaker in the car to allow participants to feel the lower frequencies but not to hear the music itself, given the sound damping (Hove et al., 2020). These methods allowed the participants to be affected by either only what they heard on the headphones or the physical strength of the lower frequencies within the “high groove” stimuli. As in the studies by both Janata et al. (2012) and Witek et al. (2014), participants were given questionnaires to measure the pleasure they felt, their desire to move, and their familiarity with the music they heard (Hove et al., 2020). The researchers also used a video camera to capture the number of spontaneous movements by participants.

Overall, the findings suggested that the sensations created by lower frequencies affect the feeling of groove. Evidence showed that self-reported pleasure and the desire to move were higher when participants were administered lower frequencies that could be felt. The sensation of the lower frequencies elicits a higher feeling of groove, which suggests that tactile stimulation from low-frequencies also facilitates pleasurable impulses to move with music (i.e., an audio-tactile effect). Additionally, familiarity with the music was found to encourage more body
movement. This finding conflicts with the results of Janata et al. (2012), which suggested that familiarity does not affect groove. Overall, from this first study, it can be assumed that lower frequencies’ ability to create physical sensations may affect our feeling of groove.

Hove et al. (2020) conducted a second experiment to see if they could replicate these findings with a different method of creating physical sensations. In this second study, the procedure for measuring the desire to move and pleasure was the same. However, the apparatus for creating physical sensations with lower frequencies was a vibrating backpack. This backpack was synchronized with the musical stimuli to vibrate in tandem with the lower frequencies within the music stimuli, allowing the participants to feel these frequencies more acutely. The results of this second study suggest the same conclusions about the audio-tactile effect as the first study: When participants received the stimuli with the vibrating backpack, they also had higher ratings of pleasure and a greater desire to move (Hove et al., 2020). Therefore, this study, which took place in a different context with another method of delivering physical sensations, strengthens confidence in the previous findings. Thus, audio-tactile sensations from lower frequencies seem to positively contribute to feelings of groove.

Even with tempo, syncopation, lower frequencies, and audio-tactile sensations, held at a constant, the experience of groove may differ between individuals. Senn et al. (2019) aimed to see how individual differences affect the desire to move. The previously mentioned studies presented data on familiarity and music expertise, but there was no focus on how individual differences affect groove. To investigate such effects, they collected groove ratings from published music spanning different genres and release years and collected background information about the participants. Measurements of familiarity, musical expertise, and genre preferences were some of the background information used to explore the effects of individual
differences on groove. This study’s results indicated that familiarity affected the amount of groove felt; therefore, supporting findings of Hove et al. (2020). Furthermore, Senn et al. (2019) showed that personal music preferences and music expertise also affect groove. Combining all of these pieces of evidence, it appears that music experiences across individuals may also influence groove. This study provides evidence that individual differences add to the established moderators of groove: tempo, syncopation, lower frequencies, and audio-tactile sensations.

Building on the contributions of Senn et al. (2019), Kowalewski et al. (2020) conducted two experiments to see how the preference towards the musician, rather than the music itself, may affect the desire to move and the pleasure received from music. Kowalewski et al. measured groove with questionnaires asking participants to rate the pleasantness received from the music. In contrast to the previous research discussed, the likeability of the musician was manipulated instead of intrinsic aspects of the music’s structure. The researchers did this by administering information about the musicians who made the music the participants would hear. With this manipulation, the researchers also used a stimulus with a moderate amount of syncopation which had been established by Witek et al. (2014) to evoke the highest feeling of groove (Kowalewski et al., 2020).

Kowalewski et al.’s (2020) experiment would establish that the preference towards the musician affects the degree of groove. When individuals dislike a musician, they may feel less inclined to move with the music even if a piece of music has a moderate amount of syncopation, low frequencies, audio-tactile feelings, and high tempo. However, their first study left open a possibility that participants made higher groove ratings regarding the music created by more likable musicians simply due to a response bias—even if the music did not truly evoke the desire to move, they may have indicated this simply due to their positive feelings towards the musician.
To rule out this possibility, Kowalewski et al. (2020) conducted a second experiment using similar methods to investigate the effects of the likeability of the musician on groove. However, they changed the stimuli such that all rhythms were high in syncopation—conditions that prior studies had shown were very unlikely to lead to the experience of groove (e.g., Witek et al., 2014). Kowalewski et al.’s (2020) results suggested that liking for the musician had no reliable effect on self-reported groove when the rhythms were high, rather than moderate in syncopation, suggesting that the results of the first study were not merely due to a response bias and may have reflected genuine differences in the desire to move. (The results also replicated Witek et al.’s, 2014, finding that high syncopation musical rhythms are unlikely to elicit groove.) Altogether, Kowalewski et al.’s (2020) results further reinforced the notion that individual differences—here, in terms of liking for the musician—may affect the groove experience.

It may seem obvious, but it is essential to point out that all the studies discussed up to this point involved the participants perceiving that they were listening to music. When listening to the stimuli, the participants were either explicitly told they were listening to music or were played music that they were familiar with and was construed as such. However, the mere knowledge that one is listening to music may stimulate the decision to move, often leading to actual movement along with the stimulus. For example, if an individual were walking by a factory and incidentally started to hear syncopated rhythms emanating from the machinery inside, with low frequency and a moderate tempo, would they automatically begin moving in synchrony with these sounds, even though they were not explicitly construed as music? It would be important to test whether varying an individual’s knowledge of what they hear may influence their movement to music.
The research involving individual experiences with music preferences may also be related to the idea that syncopation invites a listener to participate in the music (Witek et al., 2014; Witek, 2017). If syncopation invites a listener to participate in the music, but the listener does not realize they are being asked to join, they may not accept that invitation. Furthermore, individuals may not expect they are listening to music, which may prevent the invitation from being expected. If the invitation made by sounds is not to be expected, how would the listener realize they are invited to participate? Returning to the abovementioned example, while walking by the factory from which rhythmic sounds are emanating, the individual is not expecting to be listening to music. Thus, this expectation that the sounds an individual hears are “music” may be a necessary step for movement to be induced by a rhythm.

To investigate how the construal of a potentially groove-inducing sound stimulus as musical or non-musical affects the tendency to move to this stimulus, we designed an experiment that involved participants listening to music created by industrial sounds. In this future experiment, we plan to tell one group of participants that they are listening to music (Musical Condition) and to tell another group of participants, who are listening to the same stimulus, that they are hearing industrial equipment. In the latter condition (Non-Musical Condition), participants will therefore be led to believe they are listening to sounds not created with musical intentions and that only reflect the incidental by-product of the operation of machinery. Based on the idea that a listener needs to believe they are listening to music to perceive an invitation to move, we expect participants to show more rhythmic movement to the stimulus when they believe they are listening to music.

Since this method is novel, we created a pilot study to examine if we could effectively create an “industrial” sounding stimulus that could evoke movement when it was construed as
music. If this stimulus causes participants to move, it will set the stage for a subsequent pilot study testing whether individuals could be deceived into believing that the stimulus was not musical and only caused by machine sounds. Overall, the current pilot study is aimed at testing whether our novel musical stimulus can elicit movement in listeners, a precondition for later administering the full experiment we designed and testing whether removal of the musical label reduces groove.

Methods

Participants

We recruited 28 undergraduate University at Albany students through the SONA online system. Four participants were removed due to technical difficulties with the video recording and phone use during the experiment. Another participant was also removed due to a failure with the experiment’s computer during participation. Overall then, five participants were excluded from the analysis, leaving the data of 23 participants to be analyzed. Fourteen (60.9%) participants identified as female and 9 (39.1%) as male. All participants reported having normal hearing and were given course credit for participation.

Materials

Stimulus Development

The stimulus tested in this pilot study was a musical recording made with industrial sounds. The sounds used were sampled industrial noises from the city of Albany, New York, and online from www.zapsplat.com. The sampled sounds included those of a hammer, a jackhammer,
and trucks. We edited the audio samples in Audacity (Audacity Team, 2021) and exported the audio as WAV files. These audio files were then imported into Studio One 5 (PreSonus Team, 2022) to create a stimulus plausibly mimicking a factory.

For the rhythm, we wrote a pattern with the industrial equipment samples in Studio One 5’s VST Impact (PreSonus Team, 2022) to create the instances each sample would play. The pattern was set to have repeated and syncopated rhythms due to the importance of these features to groove (Janata et al., 2012; Witek., 2014). The stimulus was written to have a tempo of 115 BPM to ensure the BPM was near that of stimuli used in prior studies (Janata et al., 2012). Additionally, a synthesized bass in Studio One 5’s VST Mai Tai (PreSonus Team, 2022) was added to help induce movement. This was due to previous research showing that lower frequencies help generate movements (Hove et al., 2020). The pattern was then repeated to be one minute long to make the beat repetitive over a long enough period to observe movement.

Now with an established rhythm, we used a reverb effect to emulate the large ceilings commonly found in a factory. With reverb, we included an ambient track that captures the soundscape of a factory. This track was balanced with the rhythm in a way that the rhythm was still present but meshed with the soundscape of a factory. Refer to Appendix A for the recording of the industrial groove stimulus.

Next, there were five “non-groove” stimuli developed with industrial sounds. The goal of creating these stimuli was not to induce movement in the participants but rather to merely

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2 Audacity® software is copyright © 1999-2021 Audacity Team. Web site: https://audacityteam.org/. It is free software distributed under the terms of the GNU General Public License. The name Audacity® is a registered trademark. Furthermore, this software is an audio editor.
3 Uncompressed Audio Files
4 A digital audio workspace that is used in audio production.
emulate the sounds of an industrial worksite. This design choice was aimed at maintaining the cover story in the later study. These stimuli were produced in Audacity (Audacity Team, 2021), which allowed the sounds to be layered over each other. No rhythm was included in these stimuli. After producing these five stimuli, two of the minor rhythmic stimuli were chosen to be used in the study. This selection was to ensure that we had little to no rhythm in these stimuli. If there was a clear rhythm within these stimuli participants may discover the study’s true purpose of measuring movement. See Appendix A for the two non-groove stimuli used in this study.

Visual Stimuli

To manipulate the participant’s perception of what was creating the sounds, we used MediaLab⁵ to alert the participants that they would be listening to either “Industrial Sounds” or “Industrial Music.” Images representing the stimuli were also shown when alerting the participants as to which type of stimulus they were ostensibly hearing. We chose a picture of a factory for the non-groove stimuli and a picture of musical notes for the groove stimulus. The factory picture was chosen to reinforce the non-groove stimuli to be factory sounds. The musical notes picture was chosen to reinforce the groove stimulus to be musical sounds. See Appendix B for the images administered to participants.⁶

Cover Story

Participants were told this study involves the investigation of individuals’ “reactions to sound.” This allows participants to have no knowledge that the study involved music or

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⁵ A program that can administer questionnaires, visuals and audio stimuli.
⁶ In the full experiment, the participants in the industrial condition will not be shown the picture of musical notes for the groove stimulus. They will be administered the same images used for the non-groove stimuli. This is to manipulate the participants into believing they are listening to a recording of an industrial worksite. Our goal with the visual stimuli is to let the participants know who or what created the sounds they will hear.
movement ensuring that the participants’ perspectives were manipulated only by the visual stimuli. This cover story protects movement measurements from being influenced by experimenter demand. That is, participants’ knowing that movement is being measured may lead to more or less movement. Furthermore, this cover story was needed for the later study in which one condition involves participants being led to believe that the groove stimulus reflects nothing more than ambient factory sounds. “Reactions to sounds” is a plausible research topic when listening to factory sounds. Participants in the future study may not realize the stimulus is music if they assume the experiment is simply investigating their reactions in this general way.

**Self-Report Questionnaires**

One question was administered after each stimulus to help protect the “reactions to sound” cover story. This question states, “How much pleasure did you experience listening to these sounds?” with a 1 (*not at all*) – 7 (*very much*) Likert-Type scale, similar to that used by Kowalewski et al. (2020), but changing the word “rhythm” to “sounds.” (Participants seeing the word “rhythm” might make them believe that movement is being measured, leading to the experimenter demand previously discussed.) Another reason to make this change was that we also plan to use this self-report measure in the Non-Musical condition of the full study, which would not allow for any mention of musical qualities. Furthermore, participants may become suspicious if no overt measurements are taken from them. Thus, this question measuring the pleasantness of the sounds helps resolve many concerns regarding potential confounds relating to the experiment’s design.

Another self-report measure administered was the Music Training subscale of the Gold-MSI scale. This subscale can measure participants’ expertise with music (Müllensiefen et al., 2014). This measurement was included to see if music expertise affects the participant’s
movement with the stimulus. Experience as a musician may allow individuals to better recognize rhythms. Thus this measurement will help us see if expertise enhanced the tendency for participants to move with the stimulus.

*Video Recording and Experiment Space*

We used a video camera behind a one-way window next to the room in which the participant was seated to record the participant’s movements without their knowledge. We chose not to tell the participant their movements will be video recorded because this knowledge could influence their responses to the stimuli. A 3.5mm auxiliary audio splitter was then used to have the headphones (Koss UR-20) and video camera linked to the same audio source. This was to help ensure we could synchronize the audio and visuals of the recording for data analysis. These videos were made to capture the participants’ movement with the stimuli.

Other elements of the experimental design were included to help protect our cover story that the experiment was not measuring movement. The lab space was organized in a way such that participants would not focus on the one-way window and connecting experiment room. There were stacked tables around the one-way window to make it seem that there was no focus on the view from the window. With the tables, it was checked that they would not block the video camera’s view of the participants. In addition, the linking audio cables between the video camera and the experiment computer were hidden within other cables, so they could not be seen. Finally, a computer desk to house the experiment computer was chosen based on its ability to give a clear view of participants’ legs in the video recordings. We also chose a chair without wheels to ensure the participant could not move out of the camera’s field of view. Refer to Appendix C for an image of the lab space. All these steps were made to help ensure that the participants did not realize that they were being video recorded during the experiment.
Procedure

Before the participants entered, the experimenter started the video camera. When the participant arrived, the experimenter provided the informed consent form to gain the participant’s approval for a procedure involving hearing sounds created by industrial equipment. After this, the experimenter asked the participant to be seated at a computer with MediaLab software, which was already loaded to start the experiment. Again, the experimenter did not tell the participant they were being video recorded because this could create demand characteristics, influencing participants’ movements.

With this possibility in mind, measures were taken to deceive the participants that the experimenter was leaving the lab space. When the participant was seated and ready to start, the experimenter would give instructions to ensure the participants could go through the procedure without the experimenter in the room. Participants were told “that all the instructions will be on screen and to read them through because there is no way to go back” and to “keep the headphones on throughout the experiment, with the left side on the left ear, and right side on the right ear”. The experimenter then provided the cover story, “I need to go check on another experiment, but you are able to go through with the experiment without me.” Afterwards, the experimenter left the room and closed the door behind them. All of these steps would ensure that the participant thought nobody was watching them throughout the experiment.

While the participants went through the experiment, the experimenter also took steps to ensure that the experiment was functioning correctly. To ensure the video camera was recording, the experimenter checked it after leaving the participant alone. After this, the experimenter waited outside the room until around 10 minutes past the time the participants spent on the experiment or until they went looking for the experimenter.
After the experiment, the experimenter returned to the participants to check if they figured out the deceptive procedures in the experiment. Participants were administered a suspicion check to see if we successfully deceived them into believing that we were not collecting data on their movements. This procedure is similar to that of Kowalewski et al. (2020), who also conducted a suspicion check to ensure participants were deceived. Questions asked were: “How do you feel about the study as a whole?”, “How do you feel about the industrial sounds played in the study?”, “What do you think the purpose of the study is?”, “What do you think the study was trying to measure?” Each question aimed to see if the participant believed they were video recorded to collect data on their movement.

After the suspicion checks, the participants were fully debriefed about the study’s purpose, the deception, and the video recording. Within this debriefing, we also provided participants with the contact information of the University at Albany, SUNY Counseling and Psychological Services (CAPS) to ensure that the participants had care if they felt embarrassed or stressed from their experience with the study. The debriefing was administered after the suspicion checks to accurately measure participants’ suspicions regarding being alone during the experiment. After this debriefing, participants were asked for verbal consent to use their video recordings in this study. Participants were also reminded that they could remove their data recorded from the questionnaire and video recording without consequence. In the absence of consent, the video recording would then be destroyed. Questionnaire data would also be destroyed if requested by the participant. If the participants were not fully deceived, their data would have been removed; however, no participant need to be removed because of this.

At the conclusion of the experiment, the experimenter ended the video recording and wrote the participant’s number and the video’s time/date information onto the suspicion check
form. This information was used to help pair the videos with the data recorded in MediaLab and suspicion check. No participants failed the suspicion check; thus, no data was removed due to concerns with successful deception.\(^7\)

**Data Analysis**

**Video Coding**

Initially, all the videos were reviewed to see if there were any technical issues during the experiment. The removal of videos due to technical issues follows the precedent of Hove et al. (2020). After this review, only one video was excluded from the analysis.

Videos were then edited to include only the second non-groove stimulus as well as the groove stimulus. The second non-groove stimulus was included to see if the participants moved before the groove stimulus, providing a baseline. Then, the videos were analyzed without sound to see if the participants made any movements. Sound was removed for the first coding round to ensure the audio did not influence ratings. The operational definition, “Movement that is done three times in repetition”, guided the rater to see if the stimuli caused the movement. Due to the possibility of participants moving for non-related things such as head scratching, repetitive motions were the focus of analysis. Videos found to have repetitive movement were included in a more detailed analysis, and videos found not to have repetitive movement during either stimulus were removed from later analysis. This first round of analysis was meant to see if the

\(^7\) A difference between our plan for the full study and this pilot study is when the demographic questionnaire is administered. The music training questionnaire may allow the industrial condition participants to believe the experiment is about music, creating an inaccurate suspicion check. After the suspicion checks and debrief for the industrial condition, this questionnaire must be administered. However, MediaLab is still planned to be the tool to collect demographic data. After issuing the suspicion check and debriefing, the experimenter would open the demographic questionnaire in MediaLab. This change in procedure for the full experiment can help gather accurate suspicion data for the industrial condition.
non-groove stimulus and groove stimulus led to any repetitive movements by the participants, allowing for the rating of repetitive movements in response to the stimulus’ rhythm.

After excluding the single participant who failed to show repetitive movement, the remaining videos were analyzed to see if the stimulus’ rhythm caused the movement. The same definition for repetitive movements was used in this round of analysis. Still, there was a stipulation that the repetitive movements needed to be “close to the rhythm in the stimuli” to establish that the stimuli were associated with the movements shown. Videos were coded in terms of how many instances of movement were present, how long the movement lasted, and what body part was moving. One movement sequence caused by the stimulus’ rhythm was recorded as a single instance. For example, if the participant moved their hand for five seconds and stopped, then restarted a repetitive movement with the stimulus, this would be recorded as two instances. Along with measuring instances of movement, the duration of movement was measured between each body part. The body parts focused on for both instances of movement and duration of movement were head, hands, torso, and feet, similarly to Janata et al. (2012). This measurement was recorded in a mm:ss format. (For the full study, the same video coding methods are planned to be used.)

For this pilot study, there was only one rater (who understood the hypothesis) that conducted the video coding procedures. For the full study it is planned to have two raters that are blind from the hypothesis. This can ensure the measurements have no bias and reinforce the findings from this study.
Data Analyses

We calculated the percentage of participants who had evidence of synchronized movement with the groove stimulus. To have a reference point to see if the stimulus caused the majority of participants to move, 50% was chosen as this target threshold. If more than half of the participants move with the stimulus, this pilot study will be successful in verifying that the industrial stimulus induces participants to move when it is described as music. Duration of movement was also compared to previous research with high groove stimuli by Janata et al. (2012) to establish reliability that the stimulus can evoke movement in other individuals. Also, linear regression analysis was conducted with the Gold-MSI scores and the presence of movement by participants. This was included to analyze the association between music training and movement ratings with the groove stimulus.

Results

Instances of Movement

Participants showed multiple instances of movement in response to the groove stimulus. No participants showed repetitive movements following the second non-groove stimulus; thus, this stimulus was not further analyzed. 65.2% of participants showed repetitive movements following the rhythm of the groove stimulus. This exceeds the 50% threshold set to decide if the groove stimulus evokes individuals to move. Among participants who moved to the groove stimulus, most showed only a single instance of movement, but some participants showed more than one instance. There was a range of 0 to 4 instances of continuous movement between participants with the groove stimulus ($M=1.74$, $SD=1.28$). With all the data taken together,
participants who listened to the groove stimulus showed substantial movement. See Appendix D for a table showing the frequencies of instances of movement to the groove stimulus.

Furthermore, no correlation was found between music training and presence of synchronized movement, $r(23)= .17, p = .45$, conflicting with the evidence presented by Senn et al. (2019).

**Duration of Movement**

Participants showed a long duration of movement to the groove stimulus. The mean duration of head movement lasted for 6.81% of the groove stimulus ($M= 4.22$ s, $SD=10.6$ s). The mean duration of hand movement was 15.15% of the groove stimulus ($M= 9.39$ s, $SD= 15.2$ s). The mean duration of movement for the torso lasted for 2.31% of the groove stimulus ($M= 1.43$ s, $SD= 6.46$ s). Finally, the mean duration of foot movement was 9.44% of the groove stimulus duration ($M= 5.85$ s, $SD= 17.4$ s). For the overall duration of movement shown, this pilot test found that participants’ mean amount of movement ranged from 0 to 55 seconds ($M= 12.5$ s, $SD= 16.6$ s). This was 20.16% of the groove stimulus duration, comparable to the data presented by Janata et al. (2012). This finding was not normally distributed; however, participants’ movements were present for a considerable duration of the groove stimulus. See Appendix D for a table showing the mean movement duration to the groove stimulus, indexed by body parts.

**Discussion**

This pilot study found that the novel groove stimulus created with industrial sounds evoked movement in individuals. With this confirmation, the stimulus can now be used in subsequent research in which participants will be told that they are merely listening to industrial sounds. As discussed earlier, we plan to use this stimulus in a more extensive study that involves
deceiving a group of participants that this is not music. The next step will be to conduct a second pilot study testing whether the stimulus will be perceived as ambient sounds from a factory that involved no musical intent on the part of a human composer.

The fact that our groove stimulus elicited movement using a moderate amount of syncopation supports previous research conducted by Witek et al. (2014). The fact that it included a relatively fast tempo also reinforces the conclusions presented by Janata et al. (2012). Even further, its use of bass presence reinforces the importance of this auditory feature to groove, as shown by Hove et al. (2020). Additionally, our industrial stimulus showed a longer movement duration than the stimuli used in the second study by Janata et al. (2012). These four pieces of evidence support that the tested stimulus can elicit individuals to move, suggesting that it can be used for the planned complete study.

Supporting previous groove research, our results using this stimulus also found that music training did not influence participants’ movement to the rhythm (Janata et al., 2012; Witek et al., 2014). However, our data does conflict with Senn et al.’s (2019) findings, further reinforcing the conflicting conclusions with music training’s effect on groove. To move in synchrony with a rhythm, individuals may simply need to recognize the beats. It is possible that this skill is so simple that music training did not affect it, allowing those with low and high music training to respond similarly. On the other hand, in the case of more complex rhythms, it may be necessary for individuals to have music training in order for them to appreciate the complexity of the rhythms and receive pleasure from listening to them. In contrast, non-musically trained individuals may not understand the complexity and thereby fail to receive any pleasure from listening to them. Further research focusing on music training and groove, from a
diverse music style and cultural background, will enable development of a clearer understanding of music training’s effect on groove.

Interestingly, the fact that our groove stimulus elicited comparable duration of movement to traditional Western-style music in the research of Janata et al. (2012) raises some questions. This study’s sample was small and showed a large variance between participants. It is possible that the high-scoring outliers influenced the means to be higher than they would be in a representative sample from the general population. Furthermore, it is possible that the two non-groove stimuli administered allowed for a response bias to the groove stimulus. Participants could have compared the stimuli and felt they should move to the third one because it showed more musical qualities. Further testing with this stimulus can help investigate these possibilities, reinforcing the need to conduct a second pilot study with the groove stimuli.

Limitations

One of the primary limitations of this pilot study is that we were unable to secure a second rater for the time-intensive task of assisting with video coding. The rater also served as the experimenter who administered the MediaLab procedure to the participants and designed full the study. This experimenter may have given higher movement ratings with their knowledge about the research question and methods.

There was also no video coding program, which has been used in previous groove research studies (Hove et al., 2020). The use of programs like OpenPose can help find more accurate movement ratings. It is worth noting that these video analysis programs are imperfect and may have errors, but comparing ratings between a computational program and a human rater can help gather accurate ratings.
Even further, we had a poor angle for recording the participants due to the constraints of deception. We could only have one side of the participant’s body video recorded. This limits our visibility of the participants’ entire body and might have allowed us to miss some subtle movements created by the stimuli. As shown earlier, there were situations in which we were unable to see movement by the legs. Ideally, having multiple hidden cameras may be a solution for capturing the participants’ complete body movements.

Another limitation is the difficulty for participants to conceptualize that they are listening to music. Sampling sounds in a factory setting have been rare in most popular music. Since we planned on deceiving participants into believing they were not listening to music, we could not make the stimulus musical. This could have been a new experience for participants, leading to less movement than they would have done to this rhythm in a different sound texture environment. Measurements with participants’ familiarity with the stimuli might be valuable in exploring this possibility.

**Future Plans**

In this study, we tested whether our groove stimulus could cause movement and whether our procedure involving deception and surreptitious video recording was successful. Given the evidence consistent with this, we now need to test if the stimulus we devised is capable of being used to deceive participants into believing that they are not listening to music in the Non-Musical condition. Modifying the current procedure, instructions will state to participants that they will be listening to recordings from a factory instead of music. Furthermore, the visual stimulus presented with the groove stimulus will also be modified to alert the participants that the sounds are from a factory. If participants are successfully deceived into believing that the stimulus was only ambient factory noise rather than music, we can conduct our comprehensive study.
examining whether the knowledge that a rhythm is *music* causes more movement than when it is not construed as such.
References


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https://doi.org/10.1037/a0024208


https://doi.org/10.1371/journal.pone.0089642


https://doi.org/10.1177/1029864919839172


https://doi.org/10.1371/journal.pone.0094446
Appendices

Appendix A

Syncopated Rhythm Example: https://livealbany-my.sharepoint.com/:u:/g/personal/esmith21_albany_edu/ER02QE-_pLtKkVvq5Rt2akYBRY9-ILbBnWfZdOV-RDJGHA?e=omMmWh

Industrial Groove Stimulus: https://livealbany-my.sharepoint.com/:u:/g/personal/esmith21_albany_edu/EYS6ATIVl9GmULPos68u6sBA6_AkZh_51siRpsM0smSjg

Non-Groove Stimulus 1: https://livealbany-my.sharepoint.com/:u:/g/personal/esmith21_albany_edu/EaS8y1bOKIBPq-wMnE1LmI8BUyiRVWqwd0tREgvzyZQwA

Non-Groove Stimulus 2: https://livealbany-my.sharepoint.com/:u:/g/personal/esmith21_albany_edu/ET3EDgC-QTNOpdGDjGER7kkB19j67Q6P0D3CzPhOyVzvXw
Appendix B

MediaLab Visuals: https://livealbany-my.sharepoint.com:/p/g/personal/esmith21_albany_edu/EVnKmubXw-NJgjS9iOL-Fn4BDo9qW640tsR0lCYE1D4dQQ?e=dJk1xw

Appendix C

*The Experiment Space*
Appendix D

Participant's Movement Data

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<th>Torso</th>
<th>Feet</th>
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Participants with * were removed from video coding.

N/A refers to data points that could not be collected due to problems with visibility in the video.