The influence of loudness and synchrony on pleasure during listening to the drumming section of a Brazilian Samba School

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Abstract: Listening to the drumming section of a Brazilian samba school evokes positive emotions (happiness and power), physical sensations (goose bumps), and the desire to accompany the rhythms with movements and dance. This experience can be described as the feeling of being in "groove". In this behavioral study we investigated the effects of synchrony between instruments and loudness of the drumming section of a Brazilian samba school on experienced pleasure and the desire to move or dance. 12 volunteers (mean age 31±7 years) who had varying musical experience listened to sound excerpts of the drumming section of a Brazilian samba school. These excerpts were either loud (95dB) or softer (85dB) and varied in the degree of synchrony between instruments (realized by delaying the entrance of the snare drums by 0, 28, 55, or 83ms). Furthermore, volunteers participated in a test on rhythmic and time perception abilities. Results showed that drumming stimuli that had high synchrony between instruments and that were louder were perceived as more pleasurable and evoked more desire to move/dance with the drumming sounds than stimuli that had less synchrony between instruments. Participants who had better rhythmic abilities were more sensitive to asynchronies between instruments in the drumming section of a samba school, reflected in their ratings about felt pleasure and their desire to move/ dance with the drumming.
Keywords: rhythm perception, groove, musical emotions.

Título: *A influência do volume e da sincronia às emoções positivas enquanto se escuta uma bateria de escola de samba do Brasil.*

Resumo: *A bateria das escolas de samba tem o poder de elevar o humor e suscitar emoções positivas (alegria, vigor), sensações físicas (arrepios), e inclinação a acompanhar o ritmo com movimentos discretos ou de corpo inteiro (dança). A experiência é descrita como a percepção ou a sensação do "groove" na música. Neste estudo comportamental, investigamos como a sincronia entre os instrumentos e o volume da bateria influenciam a sensação de prazer e a vontade de dançar. Doze voluntários (idade 31±7 anos) com diferentes proficiências em instrumentos musicais ouviram trechos de uma bateria de escola de samba em volumes "alto" e "baixo". A sincronia entre os diferentes instrumentos foi variada atrasando-se em 0, 28, 55, e 83ms a entrada*

das caixas depois da chamada do repique nos trechos. Os voluntários foram também testados quanto às suas percepções temporal e de sequências rítmicas. Os principais resultados foram os seguintes: (i) quanto mais sincronizado e alto o volume da bateria, maior a evocação de prazer e de vontade de mover/dançar; e (ii) esse efeito foi relacionado às diferenças interindividuais de percepção de sequências rítmicas.
Palavras-chave: *percepção de ritmos, "groove", emoções musicais.*

Introduction

Music has the potential to induce strong emotional experience, although the description of such music-induced emotions is not trivial (Zentner, Grandjean, & Scherer, 2008). Nonetheless, several studies have attempted to disentangle their neural correlates (for review see Koelsch, 2010), finding that, for example, experiencing pleasurable music activates brain areas processing reward, such as the striatal dopaminergic system (Salimpoor, Benovoy, Larcher, Dagher, & Zatorre, 2011). A common phenomenon in experiencing music, in particular rhythmic music, is the urge to move in combination with a positive affect. This experience can be described as the feeling of being in the "groove" (Madison, 2006; Madison, Gouyon, Ullén, Hörnström, 2011; Janata et al. 2012) and can be found while listening to drumming sounds. Little is known, however, about the factors that modulate reward and appreciation during the perception of drumming.

In this study we investigated how (1) synchronization of instruments in the drumming section of a Brazilian samba school and (2) its loudness influence the pleasurable experience of a listener and the desire to move/dance with the drumming sounds. We hypothesized that listening to more synchronous stimuli would induce more pleasure and stronger desire to dance because: (a) experiencing synchrony (compared to experiencing asynchrony) between instruments during joint drumming triggers activity in brain areas processing reward (and this was related to the rhythmic abilities of drummers, Kokal, Engel, Kirschner, & Keysers, 2011); and (b) rhythm processing and beat perception is related to an activation of motor areas in the human brain (e.g., Chen, Penhune, & Zatorre, 2008, Grahn & Rowe, 2009). Furthermore, we assumed that louder stimuli would induce more pleasure and stronger desire to dance, but only when the instruments in the drumming section are played in time (synchronously). Todd and Cody (2000) have shown that samples of loud techno music (above 90dB sound pressure level) elicited a vestibular response and argued that such acoustically evoked sensations are comparable to self-motion and may account for the feelings of pleasurable sensation during listening to loud rock and dance music. Additionally, we examined (3) whether inter-individual differences in rhythm and time perception abilities have relations to the processing of asynchronies between instruments during listening to drumming sounds and felt pleasure.

Methods

Participants: Twelve volunteers (mean ± standard deviation, SD: 30.6±6.9 years, range: 20-40 years, 8 female, 4 non-musicians, 10 Brazilians) participated in the study. Eight of the twelve participants played one ore more instrument(s) and their self-reported practicing hours comprised (years x hours per week x 52) 1700±2514 (range: 78-7800) hours alone on the instrument(s) and 1755±2010 (range: 234-5980) hours in musical ensembles. All participants liked hearing (4.1±.8) the drumming section of a samba school and were familiar with the sound (3.8±.8) and the rhythm (3.8±1.0) of it (values indicate mean and standard deviation for ratings on scale ranging from 1 'not at all' to 5 'very much').

Stimuli: For creation of the stimuli, a professional musician recorded all instruments while playing a typical sequence (2/4 bar) of a drumming section of a samba school (*bateria de escola de samba*) in Rio de Janeiro using an overdubbing procedure on multiple audio tracks. The beginning of that sequence (24s) was used in the present experiment and contained the call of the *repinique* (high pitch double-headed drum; 4 bars long), the entrance of the *surdos* (low pitched base drums) and *caixas* (snare drums), and finally, 14 bars after the start, the entrance of *chocalhos, cuícas* (a high-pitched Brazilian friction drum), *tamborins* (small frame drums), and *agogôs* (agogo bells). All instruments were played at 135 beats per minute (bpm). The timing manipulation concerning the synchrony between instruments (asynchrony steps) was achieved by either aligning the audio tracks of the single instruments "in time" (0ms asynchrony between instruments) or delaying the snare drums (*caixas*) by 28, 55, or 83ms ("out of time"). All obtained stimuli were presented in a louder (95 dB) or softer (85 dB) version, which was realized by the normalization of the mean root mean square (RMS) of the audio waveform.

Experimental design: The experimental procedure comprised (a) two perception tasks using the stimuli described above, (b) tests in order to measure participants' rhythmical and perceptual abilities and (c) questionnaires. The experimental design for the first perception task is based on a 2 (loudness) x 4 (asynchrony steps) factorial design. Participants judged in each trial after listening to a stimulus their felt pleasure and their desire to move/dance with the drumming sounds (both on a rating scale from 0 = 'not at all' to 10 = 'very much'). All stimuli were presented once in a randomized order. In the second perception task, participants listened only to the loud stimuli (95 dB) and judged in each trial to which degree the instruments were played in time (i.e., in synchrony) on a rating scale ranging from 0 = 'not at all synchronously' to 10 = 'perfectly synchronized'). This test was repeated, and all stimuli were presented in a randomized order.

In order to evaluate participants' rhythmic abilities, the rhythmical part of the Musical Ear Test (MET; Wallentin et al., 2010) was used, which measures general rhythmic abilities. Participants had to compare two rhythmical phrases by judging whether the phrases were same or different. Presentation of each of the pairs of rhythmical phrases started with 4 metronome clicks (100 bpm, 4/4 bar) followed by a sequence of 4-11 wood block beats (1 bar, first rhythmical phrase), further metronome clicks to complete the second bar, a sequence of 4-11 wood block beats (1 bar, second rhythmical phase) and further metronome clicks to complete the fourth bar. 52 pairs of rhythmical phrases were presented that varied in their difficulty and half of the pairs consisted of a rhythmic change in the second phrase.

An adaptation of an auditory flutter fusion task (Rammsayer & Altenmüller, 2006) was created in order to determine participants' perceptual thresholds for perceiving two sounds as being simultaneous or not. Stimuli consisted of sound pairs created by two bongo sounds (one of them with a higher pitch, the other one with a lower pitch) that were separated by a gap ranging from 0-200ms. In each experimental trial two synchronous (0ms gap) and one sound pair (deviant stimulus) that contained a gap were presented. Participants indicated which of the three sound pairs had a gap. Stimuli presentation followed an adaptive staircase procedure (see Janata & Paroo, 2006): in case of a correct answer the gap of the deviant stimulus decreased in the following trial, while the gap increased for the next trial in case of an incorrect answer. The adaptive testing procedure required participants to have 10 turnovers (incorrect answers) and the thresholds of the correct answers before the incorrect answers were averaged for the last 6 turnovers in order to determine the perceptual threshold.

Finally, participants responded to questionnaires that assessed (1) their musical background by self-developed questions specific to samba drumming, practicing hours and playing in musical ensembles; (2) emotional experience (Geneva Emotional Music Scale, GEMS-9, Zentner et al. 2008; Fig. 1A) and (3) physical sensations (Becker 2004; Fig. 1B) when listening to the drumming section of a samba school.

The data analyses were performed with SPSS 20.0 (IBM Corp, Somers, NY) using multivariate tests of repeated measure Analysis of Variance (ANOVA), paired *t*-tests for comparisons of loud and softer stimuli, and the Pearson correlation coefficient *r*. According to our hypotheses, one-tailed significance testing was applied.

Results

Participants indicated (results for ratings on 5 point scales, see Fig.1) that they normally experience emotions such as joyful activation (4.5±0.5) and power (4.2±1.3) when listening to the drumming section of a samba school (Fig.1A). Furthermore they reported to have physical sensations (Fig.1B) such as of goose bumps (3.8±1.0) or a racing heart (3.1±1.1).

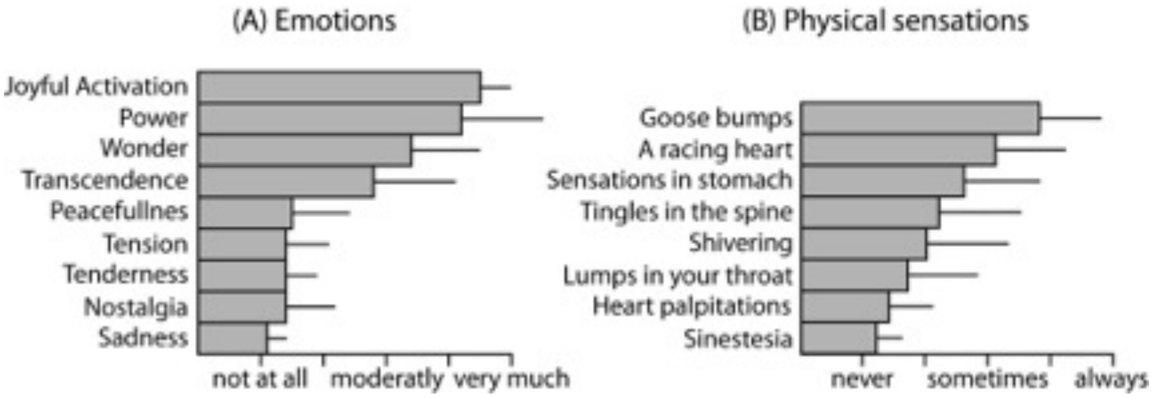

Figure 1. Means (N=12) and standard deviations displayed for (A) the intensity of emotions and (B) occurrence of physical sensations normally experienced when listening to the drumming section of a samba school.

We analyzed participants' responses on their felt pleasure and their desire to move/ dance with the drumming stimuli (Fig. 2) using a 2 (task: pleasure /move) x 2 (loudness: loud/ softer) x 4 (asynchronies between instruments) ANOVA. We found a main effect of task ($F_{(1,11)}$=4.9; p<.05, η^2=.31) indicating that participants generally felt more pleasure with the stimuli than a desire to move/dance with the drumming stimuli. The significant main effect asynchrony ($F_{(3,9)}$=10.5; p<.01, η^2=.78) confirms our hypothesis that the felt pleasure and the desire to move/dance with the drumming sounds decreased with increasing asynchronies in the drumming stimuli. In addition there was an interaction of loudness x asynchrony ($F_{(3,9)}$=4.1; p<.05, η^2=.58) showing that more synchronous stimuli (0ms and 28ms) were liked more and evoked more desire to dance when they were loud compared to softer versions. When the drumming sounds had more asynchronies between instruments (55ms and 83ms), softer stimuli tended to be more pleasant and evoked more desire to move than louder drumming sounds. There was neither a main effect of loudness ($F_{(1,11)}$<1, η^2=.05) nor other significant interactions (task x loudness, $F_{(1,11)}$=2.6; p=.14, η^2=.19; task x asynchrony, $F_{(3,9)}$<1, η^2=.17; task x loudness x asynchrony, $F_{(3,9)}$<1, η^2=.11).

The 2 (loudness: loud/softer) x 4 (asynchronies between instruments) ANOVA for responses on felt pleasure confirmed a significant main effect of asynchrony ($F_{(3,9)}$=7.4; p<.01, η^2=.71) and a marginal interaction of asynchrony x loudness $F_{(3,9)}$=2.9; p=.09, η^2=.49) while there was no significant main effects of loudness ($F_{(1,11)}$<1, η^2=.00; c.f. Fig.2A). Comparing loud and softer versions of the stimuli revealed that the loud synchronous stimulus induced more pleasure than the softer version ($t_{(11)}$=2.2, p<.05), while there were no significant differences between loud and softer versions of the asynchronous drumming stimuli (ts<1). The 2 (loudness: loud/softer) x 4 (asynchronies between instruments) ANOVA for responses on the desire to move/dance with the drumming sounds revealed a significant main effect of asynchrony ($F_{(3,9)}$=11.9; p<.01, η^2=.80) and a significant interaction of loudness x asynchrony ($F_{(3,9)}$=4.5; p<.05, η^2=.60) while there was no significant main effect of loudness ($F_{(1,11)}$=1.5; p=.26, η^2=.11; c.f. Fig.2B). Comparing loud and softer versions of the stimuli revealed that the loud synchronous drumming stimulus ($t_{(11)}$=4.5, p<.001), and the loud drumming stimulus with 28ms asynchrony ($t_{(11)}$=2.1, p<.05), induced more desire to move/dance than their softer versions. The same comparisons of loud and softer versions of the stimuli with 55ms (t<1) and 83ms ($t_{(11)}$ = -1.1, p=.14) asynchrony between instruments showed no significant differences.

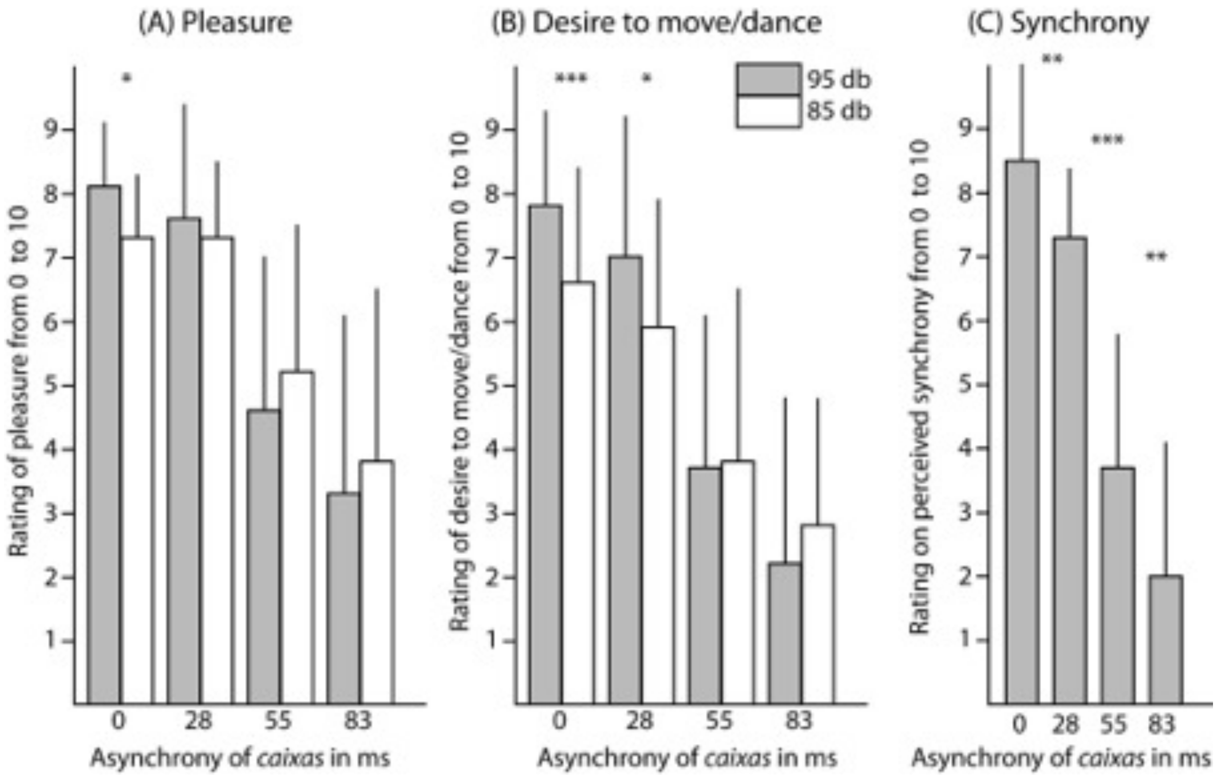

Figure 2. Means and standard deviations for ratings of (A) felt pleasure, (B) the desire to move/dance and (C) perceived synchrony between instruments for the different drumming stimuli that varied in their asynchrony and their loudness (A, B). Stars indicate significance levels (p<.05/.01/.001) for comparisons between conditions.

Participants evaluated in a second perception task the synchrony between instruments explicitly (using only loud stimuli; Fig. 2C). An ANOVA analyzing the asynchrony steps confirmed a significant main effect ($F_{(3,9)}$=13.4, p<.001, η^2=.82; with significant differences between the asynchrony steps, *p*s<.01).

In order to calculate an index for the sensitivity to the asynchrony in the drumming sounds we correlated the (objective) asynchrony values (0, 28, 55, 83) with participants (subjective) ratings (ranging from 0-10) for (A) felt pleasantness and (B) desire to move/dance. The correlation coefficients varied between *r*=.23 to -.96 (mean *r*=-.62±.39) for the pleasure ratings (A), and *r*=.06 to -.92 (mean *r*=-.70±.31) for the ratings on the desire to move/dance (B), while more negative values mean a higher sensitivity to the asynchrony manipulation. These indices for the sensitivity to asynchronies in the drumming sounds were correlated with (1) the performance obtained from the test on rhythmic abilities (MET: 79.6±7.8% correct answers, range 61.5-88.5%); and (2) perceptual thresholds for perceiving two sounds as being simultaneous (8.0±5.7ms, range 2.7-21.8ms). Rhythmic abilities were related to the sensitivity to asynchronies in pleasure ratings (*r*=-.57, *p*<.05) and the ratings on the desire to move/dance (*r*=-.55, *p*<.05), i.e. participants who achieved a better performance in the test on rhythmic abilities rated more synchronous stimuli as being more pleasurable and expressed a stronger desire to move/dance. No such correlations were found for perceptual thresholds on perceiving two sounds as being simultaneous.

Conclusions

In this study we showed that synchrony between instruments in the drumming section of a samba school had an effect on experienced pleasure in listeners and on their desire to move/dance with the drumming sounds. Thus, synchrony between instruments, or in other words "playing in time", constitutes a further important factor for the sensation of "groove" (Madison et al. 2011). Confirming our hypothesis, loud drumming sounds were perceived as more pleasurable (c.f., Todd & Cody, 2011) and evoked more desire to dance but only when the drumming sounds were well synchronized. Furthermore, we found some indications that participants who had better rhythmic abilities were more sensitive to asynchronies between instruments in the drumming section of a samba school reflected in their ratings about felt pleasure and their desire to move/dance with the drumming.

In a follow-up study we used neuroimaging in order to study effects of synchrony in drumming sounds on experienced pleasure and it's processing in the human brain (Engel et al., 2014). We found that listening to more synchronous drumming (in absence of overt movements) is related to stronger activation of motor areas in the brain (e.g., premotor areas, basal ganglia and cerebellum) that were shown previously to be involved in rhythm processing and beat perception (Chen et al. 2008; Grahn & Rowe, 2009). Such a motor-related brain activity might explain the desire to move or dance with the drumming sounds that are pleasant (Madison, 2006; Madison et al. 2009; Janata et al. 2012, Stupacher et al. 2013).

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