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RUNNING HEAD: Rhythm, affect, movement and syncopation

Syncopation levels, but not movement, are associated with pleasantness while listening to rhythmic music

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Abstract

The effect of moving along to music on induced affect was investigated by asking two groups of participants (N = 76) to listen to rhythmic patterns while either foot tapping along to the beat or staying still, respectively. Stimuli consisted of drum-breaks with three levels of syncopation (low, intermediate, high). Participants reported levels of induced pleasantness, relaxation, and wakefulness. It was hypothesized that participants who tapped along would experience greater pleasantness, less relaxation, and more wakefulness than those who remained still. Additionally, it was predicted that stimuli with intermediate syncopation would be associated with greater pleasantness, following an inverted U-shaped function, and that increasing levels of syncopation would be associated with decreased relaxation and increased wakefulness. Results showed no differences in affective state between participants who tapped along and participants who stayed still. While the predicted associations between syncopation, pleasantness and relaxation were only partially supported by the data, we did find an inverted U-shaped relationship between syncopation and difficulty to tap along, or stay still. The findings suggest that moving along to music does not automatically lead to more intense affective responses, potentially because any positive change associated with movement is outweighed by the difficulty of the synchronization task.

Keywords: Music-Induced Emotions, Music-Induced Movement, Syncopation, Affect.

Sometimes the urge to move in time with music is irresistibly pleasurable. This sensation has been psychologically defined as groove (Janata *et al.*, 2012). This phenomenon of synchronization with music is affected by rhythmic complexity. A common form of rhythmic complexity in music is syncopation. Syncopations occur when an event on a weak metric accent is followed by a rest on a strong metric accent (Longuet-Higgins & Lee, 1984), breaking with metric expectations (Huron & Ommen, 2006) and affecting sensorimotor synchronization (Fitch & Rosenfeld, 2007). There is no agreement on which aspect of music is most responsible for the urge to move in time with it (Senn *et al.*, 2019). However, several authors agree that syncopation is a crucial characteristic of music that induces groove (Witek *et al.*, 2014; Danielsen, 2006; Greenwald, 2002; Butler, 2006; Vander Elst *et al.*; 2021).

Although there is growing consensus that bodily movements facilitate rhythm perception (Manning & Schutz, 2013; e.g. Phillips-Silver & Trainor, 2008; Su & Pöppel, 2012), there is less agreement on the type of affective responses elicited by movement. Some have argued that moving along to the beat merely leads to *increased* arousal, due to the locking-in of listeners' physiological rhythms to the music, which propagates to other components of the emotional response (Juslin & Västfjäll, 2008; Scherer & Coutinho, 2013). Others have proposed that movement leads directly to positive affective responses ranging from pleasantness and liking, to discrete emotions such as power, calm, joyful activation (Trost *et al.*, 2017), and social bonding (Juslin, 2013, p. 241; McNeill, 1995; Molnar-Szakacs & Overy, 2006).

Several studies investigated the effects of music-induced urge to move on affective state. Labbé and Grandjean (2014) asked participants to listen to violin pieces and found that pleasurable experiences of rhythmic entrainment (i.e. synchronising body movements to the musical rhythm) could be categorised into two factors: visceral and motor entrainment, which each correlated with different emotional dimensions of the Geneva Emotional Music Scale (GEMS, Zentner *et al.*, 2008). They concluded that musical entrainment induces discrete, positive emotions, although paradoxically, they did not ask their participants to move along with the music. Witek and colleagues (Witek *et al.*, 2014) found that medium degrees of syncopation elicited the most desire to move and the most pleasure, indicating an inverted U-shaped relationship between syncopation and groove. While music with high syncopation prevents the generation of beat predictions, music with low syncopation offers few opportunities for their violation. Therefore, these two extremes hinder the process of pleasure induction via stimulation of prediction (Huron 2006; Vuust *et al.* 2018). In contrast, medium syncopation provides an optimal balance between violated and realised predictions, and invites the listener to "enact" the missing beats by moving their body in a beat-directed fashion (Witek, 2017). Finally, two recent studies compared the affective consequence of dancing to music associated with groove, as opposed to listening to it staying still. In their first study, Bernardi *et al.* (2017) found that participants reported higher ratings of induced pleasure when spontaneously dancing to high groove music, compared to listening to it staying still, and to dancing to low-groove music. In a follow up study, the same authors found that dancing to high groove music elicited stronger feelings of joy, power, and experiences of flow than staying still (Bernardi *et al.* 2018). However, in neither experiment did the authors analyse the relation between the music's rhythmic structure and the participants' affective responses. In summary, recent empirical research on groove suggests that there are associations between groove and pleasure, between syncopation and groove levels, and between pleasure and movement.

Despite the above-mentioned advances in research about groove, to the best of our knowledge, no study has yet tested whether syncopation influences affective responses to actual movement to music associated with groove, and whether simpler movements such as foot tapping may produce this affective effect. We tested this by asking participants to listen to rhythmic patterns varying in syncopation while staying still or tapping along to the beat with one foot. We chose to ask participants to do foot tapping instead of full bodily movement for several reasons: 1) this is commonly observed body response when listening to music (Janata et al., 2012); 2) we expected participants to feel less inhibited by the experimenter's presence, if they did small movements with their foot, rather than with their whole bodies; and 3) the size of the room where data was collected would have made it difficult for them to make larger movements. Participants reported experienced pleasure, and -following Schimmack and Grob's (2000) recommendation of distinguishing between tense and energetic arousal-, participants also reported how relaxed and awake they felt.

Since the urge to move to music is pleasurable, (Janata *et al.*, 2012; Witek *et al.,* 2014), satisfying that urge should feel more pleasurable than suppressing it. Consequently, we predicted that participants in the tapping conditions would experience overall greater pleasantness than participants in the stationary condition. It is also likely that moving in time with music affects experienced arousal (Juslin, 2013; Scherer & Coutinho, 2013; Bernardi *et al.*, 2017). On one hand, it may increase arousal due to the energy required to move to the music. On the other hand, since inhibiting unwanted movements is effortful (Chatham et al., 2012; Noorani & Carpenter, 2016; Jensenius et al., 2017), it is plausible that participants who are asked to stay still while listening to the music may experience more tension than participants who tap along to it. We addressed these two hypotheses by testing both degree of relaxation-tension (reflecting tense arousal), and degree of wakefulness-tiredness (reflecting energetic arousal) (Schimmack & Grob, 2000). Following Witek and colleagues (Witek *et al.*, 2014) we predicted that the relationship between syncopation and pleasantness would have an inverted U-shape such that medium syncopation would afford more pleasantness than low and high syncopation. This negative quadratic function was also predicted for ratings of "difficulty to stay still" in the stationary condition (Janata *et al.*, 2012). In the tapping condition, we predicted that ratings of "difficulty to tap along" would increase with each syncopation level, due to previous research showing linearly detrimental effects of syncopation on synchronisation ability (Fitch and Rosenfeld 2007).

The experiment used a mixed design, with 'listening condition' as the between-subjects independent variable (two levels: *Tapping*, *Stationary*); *Syncopation Level* as within-subjects independent variable (three levels: Low, Medium, High), and *Pleasantness*, *Relaxation, Wakefulness*, and *Easy-to-stay still/Difficult-to-tap* as dependent variables.

Method

Participants

Seventy-six individuals (age: 18-63 years, M = 29.75, SD = 10.87, 55 women) were randomly assigned to two conditions: tapping (n = 38) or stationary (n = 38). Using scales from the Goldsmiths Musical Sophistication Index (Müllensiefen *et al.*, 2013), we established that overall, participants had relatively high levels of musical training (M = 27.18, SD = 12.25; below the 85th percentile); but allocate intermediate levels of importance to musical activities in their everyday lives (M = 39.64, SD = 9.65; below the 41st percentile). Participants' enjoyment of dancing and familiarity with syncopated music was measured by using a 5-item ad-hoc questionnaire with items such as “"When I listen to music, I cannot help moving along with the sounds", answered on a 7-point Likert-type ranging from "strongly disagree" to "strongly agree". Their answers indicated that, in general terms, the participants enjoyed dancing activities (M = 4.64, SD = 1.79; more than 90% of participants scored above 17 points out of 35 possible points); and 80.3% reported frequently listening to and enjoying musical styles associated with groove (such as Funk, Soul, and Hip-hop).

Stimuli

The stimuli consisted of six, 32 seconds-long drum-breaks from a set of 50 developed for a previous experiment (Witek *et al.*, 2014) (See figure 1 in supplementary materials for notational transcriptions of the stimuli). Every drum-break consisted of a two-bar phrase looped eight times at 120 bpm. The syncopation level was calculated using an adjusted version of Longuet-Higgins and Lee's (1984) index. Briefly, the syncopation level of a pattern depended on the number of syncopations and their strength (see Witek *et al.,* 2015; and Witek *et al.*, 2014 for details). The strength of a syncopation depended on its position within the bar and thus its position within the metric hierarchy, e.g. a syncopation on the downbeat was scored as more salient than syncopations on 8th note and 16th note positions, in that order. Additionally, the index includes instrumental weights. Thus, even if the strong metric position following the syncopation is not silent, it can still be considered a syncopation if the instrumentation changes (Witek *et al.*, 2014). Specifically, syncopations (in either bass or snare) with only the hihat on the following strong metric position were the most salient, followed by syncopations in the snare-drum with the bass-drum on the beat, and syncopations in the bass-drum with the snare-drum, in that order. The total syncopation score is calculated by summing scores for all identified syncopations for a given pattern. However, the following parameters were not controlled for: the degree of half-measure organisation, event density, instrumentation order and repetition (self-similarity). Nonetheless, Witek and collaborators (Witek *et al.*, 2014) found that the index accounted for ~35% of the variance in ratings of pleasure and wanting to move.

The stimuli were chosen according to their degree of syncopation, and the mean ratings of induced pleasure and motivation to move in Witek's study. Thus, the *low syncopation stimuli* have syncopation degrees, ratings of motivation to move, and ratings of induced pleasure at least one standard deviation below the mean values in Witek's experiment (mean syncopation = 4); the *high syncopation stimuli* have ratings at least one standard deviation above the mean values (mean syncopation = 60); and the *medium syncopation stimuli* have ratings within 0.5 standard deviations above or below the mean values (mean syncopation = 38.5).

Measures

Induced affective state was measured with self-report. The pleasantness ratings reflect the valence dimension of the two-dimensional model of emotion (Russel 1980). The second dimension, arousal, was operationalized in two different ways; tense arousal, and energetic arousal (Schimmack & Grob, 2000), measured as relaxation and wakefulness, respectively. The questionnaires consisted of six items with 4-point Likert scales ("after listening to this piece of music…" 1 = I do not feel…, 4 = I feel very… *pleasant* (positive, good); *unpleasant* (negative, bad); *awake* (alert, wakeful); *sleepy* (tired, drowsy); *relaxed* (at rest, calm); *tense* (restless, jittery). All items were rated on unipolar scales, and later transformed into bipolar scales by subtracting ratings of the positive pole (pleasant, awake, relaxed) from ratings from the negative pole (unpleasant, sleepy, tense). Participants also rated the difficulty of the task they performed: participants in the Stationary condition rated *how difficult they found it to stay still* while listening to the stimuli, and participants in the Tapping condition rated *how easy they found it to tap along* to the beat.

Procedure

In individual sessions, participants sat at a desk with a computer that displayed the instructions and questionnaires and played the musical stimuli. Each stimulus was played once through headphones in counterbalanced fashion, and the participant could adjust the sound level for comfort. Additionally, participants in the Tapping condition received the following instruction: "*Please tap along to the beat, using your foot, in a regular and comfortable way. You can take a few moments to listen before starting tapping*". Participants in the Stationary condition received the instruction: "*When you listen to the music, all you have to do is to stay as still as possible. You don't need to tense your body, but please try not to move at all while the music is playing*". The instruction remained on the screen while the music played, and the experimenter reminded participants to stay still if he noticed that they had started moving.

Analysis

Using *lme4* (Bates *et al.*, 2007) and *lmerTest* (Kuznetsova *et al.*, 2015) in R, we applied linear mixed effects models with a random by-subject intercept. Separate models were applied for Pleasantness, Relaxation, Wakefulness and Task Difficulty ratings, with Syncopation and Condition as fixed within-subjects. We specified polynomial contrasts for the Syncopation condition, in order to test both linear and quadratic (U-shaped) effects; and performed post-hoc contrasts using the emmeans package (Lenth *et al.*, 2018), corrected for multiple comparisons using the Tukey method. Residuals of all models were normally distributed, except the Pleasantness model. A number of transformations were attempted to correct for non-normality (e.g. arcsine, log transforms), but none were successful. Therefore, the reported results for Pleasantness should be interpreted with caution.

Results

Likelihood ratio tests showed significant effects of syncopation on pleasantness (p = .030), but not Condition (p = .943), nor the Syncopation-by-Condition interaction (p =

.422). In the mixed model, there was a significant negative linear effect of Syncopation on pleasantness (t(378) = -2.22, *p* = .027), but no significant quadratic effect (t(378) = -1.46, *p* = .145). The results from the post-hoc comparisons showed that there was a significant increase in pleasantness ratings for medium versus high syncopation, but no difference between low and medium, nor between low and high (Table 1 and Figure 1).

In the model testing effects on relaxation, there was a significant effect of syncopation (*p* = .032) but not Condition (*p* = .478) nor Syncopation-by-Condition (*p* = .271). The model showed a significant negative quadratic effect of Syncopation on relaxation (t(378) = -2.372, *p* = .018), but post-hoc comparisons showed that only medium syncopation was associated with significantly higher levels of relaxation than high syncopation, with no significant differences between low and medium, and low and high (Table 1, Figure 1).

For wakefulness, we found no significant effects; Syncopation (*p* = .878), Condition (*p* = .334) and Syncopation-by-Condition (*p* = .755) (Table 1, Figure 1).

For perceived task difficulty, there were significant effects of Syncopation (p < .001), the Syncopation-by-Condition interaction (p < .001), but not Condition on its own (*p* = .090). Both the negative linear (β = -0.305, t(286) = -2.31, *p* = .021) and negative quadratic effects (β = -0.659, t(286) = -4.98, p < .001) were significant for Syncopation. Condition significantly interacted with the linear effect of Syncopation (β = -0.667, t(286) = -3.98, p < .001), but not the quadratic effect (β = -0.141, t(286) = -0.84, *p* = .402). Post-hoc comparisons of the two Conditions at each level of Syncopation showed increased ratings of task difficulty in the Tapping Condition compared to the Stationary Condition at high, but not low or medium Syncopation. When comparing levels of Syncopation within each Condition, there were significant differences in ratings of “difficulty to stay still” between low and medium, and medium and high, but not between low and high for the Stationary Condition. In ratings of “difficulty to tap along” in the Tapping Condition, there were significant differences between low and high, and medium and high, but not between low and medium (Table 1, Figure 2).

Table 1 Post-hoc comparisons of effects of Syncopation and Condition on Pleasantness, Relaxation, Wakefulness and Difficulty Staying Still/Ease Tapping Along.

Figure 1 Adjusted means for effect of Syncopation on Pleasantness, Relaxation, Wakefulness

Figure 2 Adjusted means for effect of Syncopation and Condition on Difficulty Staying Still/Ease Tapping Along.

Discussion

This experiment investigated the effect of rhythmic syncopation and movement on induced affective state during listening to music with different levels of syncopation, while either staying still or tapping along to the beat.

We found no significant differences in affective responses between moving to the beat and still listening in our study. Previous studies have found that performing overt movements affects beat perception (Su & Pöppel, 2012), but this effect seems to depend on whether the vestibular system is involved in the movements (Phillips-Silver & Trainor, 2008). The fact that movements in our study were confined to small foot-movements could have prevented large-enough effects on arousal, and therefore also the spreading of activation from the motor system to the physiological and experienced arousal predicted by Juslin and Västfjäll (2008) and Scherer and Coutinho (2013). Unfortunately, it is not possible to empirically examine this conjecture, because no objective measures of physiological arousal or synchrony were taken.

Another possible explanation is that participants might have felt that the tapping instruction was too restrictive, and had they been able to make free movements, the effect on their affective state may have been stronger. This suggests that the pleasure induced by moving along to music associated with groove is only noticeable when listeners engage in unrestricted, whole-body movements (Bernardi *et al.*, 2017, 2018). However, it should be noted that there was no indication of this restrictive feeling in the participants' comments. Moreover, in another experiment that compared participants who stayed still with participants who tapped along or moved freely while listening to music associated with groove, participants preferred listening to the music without moving (Janata *et al.*, 2012).

An alternative interpretation is that, as predicted by Maes and colleagues (2014), synchronisation and affective reactions to music are driven primarily by the music's implied expression. In contrast to stimuli used in Bernardi and colleagues' experiments (2017, 2018) which consisted in commercially available songs, our stimuli consisted of drum-breaks with no melodic or harmonic elements; they contained little, if any, expressiveness. Indeed, several participants commented that they found the stimuli not "musical enough". It may therefore be that in order to test the effect of rhythmic movement on affect, more naturalistic stimuli are needed.

Finally, it may be that our between-subjects design introduced some inter-individual differences that masked any true effect of movement. Future studies may consider manipulating movement within subjects, for better control.

The second set of hypotheses concerned the effect of syncopation on affective experience. The prediction of a negative quadratic relationship between syncopation and pleasantness was only partly supported by the data. Specifically, the slope of the observed quadratic function was not steep enough to produce differences across all syncopation levels: there were significant differences between medium and high, but not between the medium and low syncopation nor between low and high.

For ratings of relaxation, we found effects of syncopation, with the same pattern of significant differences as for pleasantness. However, there were no effects of syncopation for wakefulness ratings. These results confirm the importance of distinguishing between these two dimensions of arousal because they may not be experienced equivalently (Schimmack & Rainer, 2002). Future studies should complement these subjective measures of arousal with objective ones.

Our predictions concerning the relation between syncopation and task difficulty were partially supported: as predicted, participants in the stationary condition found it more difficult to stay still with medium syncopation than with low and high syncopation. In contrast, our prediction that tapping participants would find it increasingly difficult to tap along with every syncopation level was not supported; the results showed a similar inverted U-shaped pattern to the "difficulty-to-stay-still" ratings.

Taken together, our results offer partial support to Witek's theory that music with intermediate syncopation provides an ideal level of rhythmic complexity, which in turn induces a pleasurable urge to move (Witek *et al.*, 2014). However, in our results, there were no pleasantness or relaxation differences between medium and low syncopation. The small number of stimuli tested for each syncopation category (two) may have prevented us from showing full-blown U-shaped functions. A recent study suggests that three items per level are sufficient to produce the inverted U-shaped effect (Stupacher *et al.* 2021). Alternatively, there may be other, non-prediction related factors affecting the pleasure derived from listening to music associated with groove, such as degree of dissonance (Matthews *et al.* 2019). Future studies should present a larger number of stimuli and study the effects of other characteristics of groove, such as low-frequency instrumentation and the repetition of melodic phrases. Additionally, future research could also record the participants' movements to examine the extent to which the effects of entrainment on pleasure are associated with the production of regular or accurate movements by listeners.

In conclusion, the results suggest that realizing the urge to move to the musical rhythm does not automatically lead to increased subjective feelings of pleasure, tension, or wakefulness, possibly because any positive change in affect associated with syncopation is outweighed by the perceived difficulty of the synchronization task, and because the pleasure-inducing effects of moving along to music associated with groove only become noticeable when listeners use widespread, whole-body movements. At the same time, the results add to previous research by showing that music with intermediate levels of syncopation are more difficult to resist moving along to.

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Table 1 P values from comparisons of Syncopation, Condition and Syncopation-by-Condition interaction for Pleasantness, Relaxation, Wakefulness and Difficulty Staying Still/Ease Tapping Along. The table only displays post-hoc comparisons for variables where significant main effects or interactions were initially found.

	Pleasant-ness	Tension arousal (Relaxation)	Energy arousal (Wake fulness)	Difficulty to stay still / Easiness to tap along
Condition: Stationary > Tapping	.943	.478	.344	.090
Syncopation: Medium > Low	.987	.298	-	-
Syncopation: Low > High	.069	.494	-	-
Syncopation: Medium > High	.047*	.024*	-	-
Interaction: Syncopation Low: Condition Stationary > Tapping	-	-	-	.922
Interaction: Syncopation Medium: Condition Stationary > Tapping	-	-	-	.271
Interaction: Syncopation High: Condition Stationary > Tapping	-	-	-	.001*
Interaction: Condition Stationary: Syncopation Low > Med	-	-	-	.005*
Interaction: Condition Stationary: Syncopation Low > High	-	-	-	0.056
Interaction: Condition Stationary: Syncopation Medium > High	-	-	-	< .001***
Interaction: Condition Tapping: Syncopation Low > Medium	-	-	-	.115
Interaction: Condition Tapping: Syncopation Low > High	-	-	-	< .001***
Interaction: Condition Tapping: Syncopation Medium > High	-	-	-	< .001***

$^{*}p < .05$, $^{**}p < .01$, $^{***}p < 0.001$

Figure 1 Adjusted means for low, medium and high syncopation for ratings of Pleasantness, Relaxation and Wakefulness. Error bars represent standard errors.

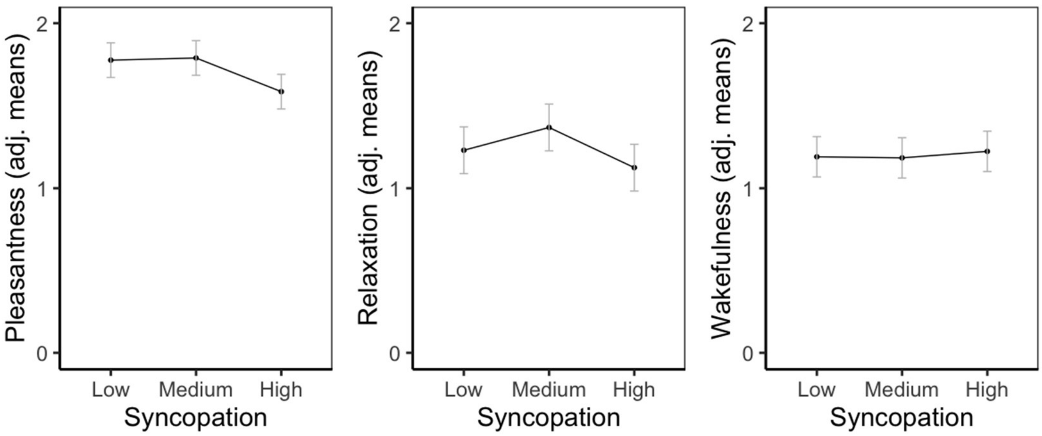
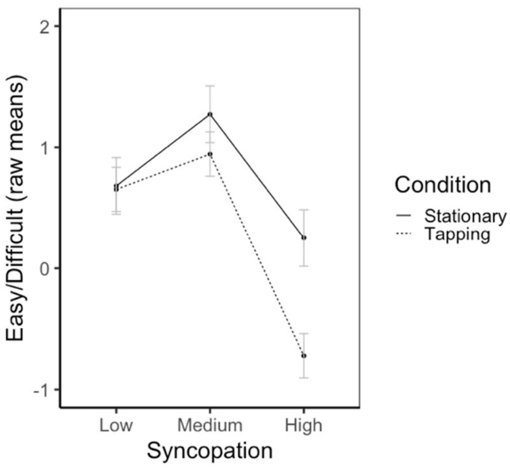
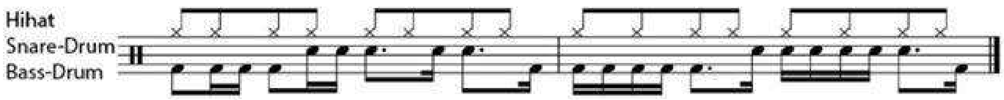


Figure 2 Adjusted means for low, medium and high syncopation in tapping and stationary conditions for ratings of Difficulty Staying Still/Ease of Tapping Along. Higher ratings indicate more difficulty staying still in the stationary condition, and more ease tapping along to the beat in the tapping condition.

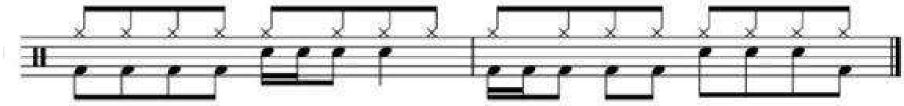


Supplementary Materials: Notational transcription of stimuli

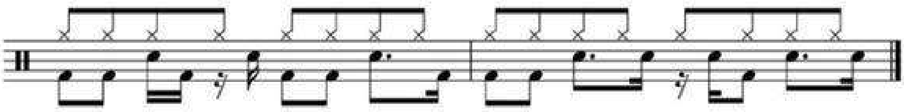
Stimulus 1: Low syncopation. Syncopation value = 0



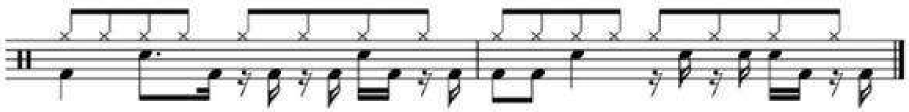
Stimulus 2: Low syncopation. Syncopation value = 8



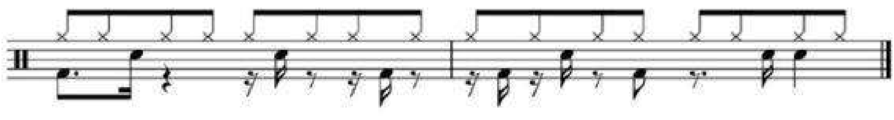
Stimulus 3: Medium syncopation. Syncopation value = 34



Stimulus 4: Medium syncopation. Syncopation value = 43



Stimulus 5: High Syncopation. Syncopation value = 58



Stimulus 6: High Syncopation. Syncopation value = 62