# Beaten by the chord to nail the melody:
## Influence of metric and irregular submerged dissonance accents on auditory sequence learning

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**ABSTRACT**
Dynamic attending theory (Jones, 1976; Large & Jones, 1999) suggests that isochronously repeating salient points in time are predictable and facilitate processing by synchronizing attentional oscillations in the brain. By manipulating amount and spacing of such salience, this design attempts to enhance accuracy of reproduced melodies. Salience was introduced by dissonant harmonies. All subjects seemed to get distracted by the harsh sound of dissonance. However, non-musicians seemed to benefit from a regular ¾ meter. More research with larger non-musician samples is needed to investigate how dissonance raises cognitive load but may also function as attentional refresher when predictable.

**Keywords**
Auditory sequence learning, motor learning, salience, dissonance, dynamic attending.

**INTRODUCTION**
Dynamic attending theory (Jones, 1976; Large & Jones, 1999) states that peaks of internal oscillations of increasing and decreasing attention align with external regularly recurring salient events. An example of such events, also known as accents, would be the first beat in a waltz. Neurons periodically become more sensitive for input at expected points of significance, increasing their ability to learn. If an accent occurs in the moment it was predicted, meaning that external and internal oscillations peak in phase, then attention to the external source increases. This implies that a melody with a strong metric pulse should be easier to grasp than one with a complex rhythm.
Hauge (1931) investigated the so called “beating complex”, which appears if the original frequencies are almost identical. The frequencies interfere in such a way that their amplitudes periodically cancel each other out and maximally add on each other, appearing as jittering noise. Musicians refer to this pulsating beat or roughness as dissonance. Dissonant chords create perceived tension and need for resolvement (Arthur & Timmers, 2016) and should therefore stand out from their meek adjacencies.



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This study combines the theory of dynamic attending (Jones, 1976; Large & Jones, 1999) with the idea of the beating complex (Hauge, 1931), trying to demonstrate that cognition aiding salience can be introduced by means of dissonance. Thereby, dissonance chords were added to target melodies at different points in time. A regular manipulation consisted of placing accents in a regular, predictable manner, versus an irregular, unpredicting one. The salience amount manipulation included either four or three accents, which, in the regular context, formed a 3-4 and 4-4 meter respectively. Two hypotheses are introduced:

1) Evenly spaced accents, as opposed to irregularly spaced ones, create better reproduction of the melody. This regularity manipulation predicted that accuracy of 3-4 regular and 4-4 regular melody would be superior to the irregular versions. This would be a main effect of regularity.
2) In metric context, more salience leads to more accurate performance than less salience. This salience amount manipulation predicted that the 3-4 regular manipulation would be the best learnt melody, because it has predictable accents and more accents than the 4-4 regular condition. This would technically be a simple effect of salience amount, as it should only be present in the regular condition.

**METHODS**
Thirty-two participants (5 male, 21 with training for any musical instrument) learned to play four different melodies on a button box with four buttons, producing four pitches. In each of fifteen learning trials, subjects first listened to the target melody, then played along and lastly reproduced it from memory. When playing along, subjects only heard the target melody including dissonances, whereas they received feedback of solely their own play when they were asked to reproduce. Dissonances consisted of an added pitch in a semitone distance to the target melody, producing a beating complex (Hauge, 1931) predicted to act as accent. Chords where not resolved but simply changed into the consonant tonic of the key the melody was composed in. Participants were instructed to play back the highest melody line on the button box, as harmonies were added at lower pitches. The melodies were all isochronous, excluding rhythmic accents. Pitch leaps did not induce accents, as tested by Thomassen’s model of melodic accent salience (1982).

Each participant was exposed to four different accent patterns, counterbalanced over the four melodies:

- 3-4 irregular
- 3-4 regular
- 4-4 irregular
- 4-4 regular

3-4 and 4-4 refer to the amount of salience; regular and irregular refer to their distribution. For illustrative purposes the patterns are displayed in table 1 below.

## RESULTS

A two (amount: 3-4 versus 4-4) by two (regularity: regular versus irregular) by two (play trial: play versus play along) within subjects analysis of covariance (ANCOVA) with years of musical training as covariate was conducted. Figure 1 illustrates the average independent play learning curves of the sample per accent pattern, showing that on average accuracy increased over the 15 learning trials.

No main effect of salience amount ($F(1,30) = .663$, $p = .422$) was found. Equally, salience regularity did not cause meaningful differences in the sample ($F(1,30) < .01$).

However, there was a main effect of play trial ($F(1,30) = 16.457$, $p < .001$) with superior accuracy when subjects played the melody from memory as compared to playing along the target melody.

Furthermore, comparing musically trained and untrained individuals yielded a main effect of musical training ($F(1,30) = 15.587$, $p < .001$). Subjects that had learnt to play a musical instrument were better at the task.

Lastly, and importantly, for subjects that had not learnt to play a musical instrument, the three-way interaction between play trial by meter by regularity showed a trend ($F(1,10) = 4.037$, $p = .072$). Simple effects were not meaningful. However, visual inspection of the estimated marginal means (table 2) suggest that a 3-4 regular meter accent pattern seemed to increase accuracy.

## DISCUSSION

This study attempted to show that dissonant harmonies are a viable means of introducing salience, and that amount and spacing thereof influences the accuracy of reproduced melodies. A first glance at the non-existing main effects of salience amount and regularity did not support this notion. However, the meticulous inspection of the data suggested that the hypotheses cannot be discarded as easily either.

Firstly, subjects were better at playing independently as compared to playing along. The auditory feedback of playing from memory solely consists of the notes produced from pressing the buttons. When subjects played along, they only heard the target melody, including dissonances. This led to the conclusion that the dissonant harmonies hampered their attention to the target melodies, because their harshness distracted from the melodies. Alternatively, the increased accuracy could be a result of learning effects: the play trial always followed the play along trial.

Secondly, non-musicians were best at playing melodies from memory that had previously been heard in a 3-4 meter accent pattern. This suggestion need to be voiced cautiously, as the underrepresentation of musically untrained subjects reduces power and is based on an interaction trend and visual inspection of estimated marginal means. However, the effect would be in line of resent research that suggests that the regular meter in the play along trial could have acted as attentional refresher (Plancher, Lévêque, Fanuel, Piquandet, & Tillmann, 2017) which would have helped keeping the just heard melody in working memory (Burunat, Tsatsishvili, Brattico & Toivainen, 2017). This would be in line with dynamic attending theory (Jones, 1976; Large & Jones, 1999) and would support the prediction that both higher salience amount and regularity together aid processing. Nonetheless, empirical research should explore this further in a larger sample of non-musicians.

Lastly, a recent study by Burunat, Tsatsishvili, Brattico and Toivainen (2017) offers an explanation why only the musically un-apt seemed to react to experimental manipulations. They suggest that non-musicians construct meter based on external cues, whereas musicians utilize self-generated beats as temporal framework. Thus, the untrained subjects seemed to have used the dissonant harmonies as temporal framework to construct a regular 3-4 meter which increased accuracy in this condition.

## CONCLUSION

The hypothesis could not fully be confirmed. Dissonance seems to be a successful method for implementing salience, leading to superior results in non-musicians when asked to reproduce the melody from memory. It I possible that (dissonance) accents act as attentional refresher in those who rely on external cues for construction of meter (non-musicians). However, while audible, dissonance may even be too salient and therefore distract from the actual stimulus, explaining the more accurate results of dissonance free independent play trials.

## ROLE OF THE STUDENT

The research described was conducted as Bachelor Thesis of the student Anna Sophie Wagner. Supervised by Dr. Rachel Brown, the student developed the idea of introducing salient events by means of dissonant harmonies. The design of an already existing project of salience motor learning was used. Harmony composition, data collection, analysis, conclusion and documentation in form of a thesis were done by the student.

## ACKNOWLEDGMENT

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Table 1

*Accent patterns for play trial and play along trial per accent condition*

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 3-4 irregular | X | _ | X | _ | _ | X | _ | _ | _ | X | _ | _ |
| 3-4 regular | X | _ | _ | X | _ | _ | X | _ | _ | X | _ | _ |
| 4-4 irregular | X | _ | _ | _ | _ | X | _ | X | _ | _ | _ | _ |
| 4-4 regular | X | _ | _ | _ | X | _ | _ | _ | X | _ | _ | _ |

*Note:* X as accent; _ as normal note

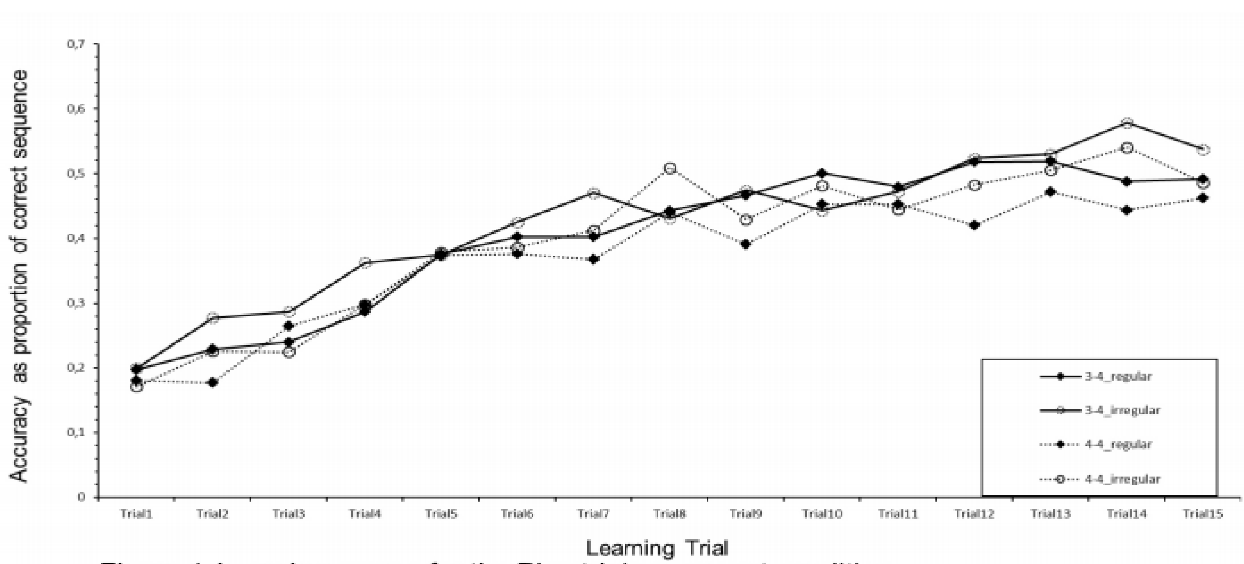


*Figure 1.* Learning curves for the Play trial per accent condition

Table 2

*Estimated marginal means of non-musicians per condition*

| Play trail | Accent Condition | Mean | Std. Error | 95 % Confidence Interval | |
|---|---|---|---|---|---|
| | | | | Lower Bound | Upper Bound |
| Play Along | 3-4 irregular | 1.925 | .687 | .394 | 3.455 |
| | 3-4 regular | 2.292 | .657 | .829 | 3.756 |
| | 4-4 irregular | 1.599 | .565 | .339 | 2.859 |
| | 4-4 regular | 1.644 | .455 | .630 | 2.658 |
| Play | 3-4 irregular | 3.347 | .510 | 2.211 | 4.484 |
| | 3-4 regular | 4.158 | .567 | 2.894 | 5.422 |
| | 4-4 irregular | 3.459 | .841 | 1.586 | 5.332 |
| | 4-4 regular | 2.775 | .252 | 2.213 | 3.337 |