Conveying Syncopation in Music Performance

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ABSTRACT

This paper investigates if and how musicians can convey syncopation without the presence of a fixed metric framework. In a first experiment 20 professional musicians played a series of simple melodies in both a metrically regular version and a syncopated version. These were analyzed using a series of audio parameters. This analysis shows a series of methods used by musicians to convey syncopation, using timing, dynamics as well as articulation. A selection of the melodies was then presented to 16 subjects in a second experiment, both audio-only and with video, asking them to identify them as syncopated or regular. The results of this experiment show that, although some expressive cues seem to help the recognition of syncopation, it remains hard to communicate this 'unnatural' rhythmic structure without a metric framework. Analysis of the videos shows that when musicians do provide such a framework using their body, it influences the results positively.

I. INTRODUCTION

Sloboda (1983, 1985) asked pianists to perform a short piece of music with the bar lines placed in different positions and looked how this affected timing and dynamics. He found that metrically important notes are played louder and more legato. Additionally he also asked listeners to identify the different versions. In most cases they recognized the patterns well above chance, but it was certainly not a trivial task and some performances turned out to be much easier to identify correctly than others. Here the distinction had to be made between patterns starting on the downbeat and the same melody but starting with an upbeat. In this paper we will adopt a similar methodology, but applied to the distinction between metrically regular and syncopated versions of short melodies.

Syncopation can be defined as "the regular shifting of each beat in a measured pattern by the same amount ahead of or behind its normal position in that pattern" (*Grove Music Online*) or "The displacement of the normal musical accent from a strong beat to a weak one" (*Oxford Companion to Music*). It is a widely used musical element, found in almost every musical style that is based on a regular beat. Often the syncopated patterns are combined with an articulation of the regular beat, or appear in a context in which a regular metric frame has been established (Temperley, 1999). This is for example the case in the typical syncopated melodies in jazz and popular music, where the rhythm section establishes a regular beat and the soloist/singer anticipates or delays the melody notes with respect to this metric grid. However, this is not always the case, sometimes syncopation is used without any reference to a regular metric framework. It occurs in different genres, but most notably in classical music of the romantic period (e.g. Beethoven, Brahms, Schumann; some examples are given in figure 1.)

Figure 1: Examples of syncopation without a fixed metric context: (a) the first bars of Robert Schumann's *Manfred* overture, op. 115; (b) A section (mm. 95-102) from *Faschingsschwank aus Wien*, op. 26 also by Robert Schumann; (c) the beginning of the ariette *Heureux petit berger* from *Mireille* by Charles Gounod (piano reduction); (d) the beginning of the song *La Danseuse* by Ludo Vandeau, arranged by Wouter Vandenabeele, first violin part (the other instruments play the same rhythm).

Theories of rhythm perception do not usually take this kind of patterns into account. Rather syncopation is seen as something that creates complexity and that our perception is guided towards a 'simple' and thus non-syncopated interpretation of rhythmic patterns (Longuet-Higgins & Lee 1982, 1984; Povel, 1981). Longuet-Higgins and Lee (1984) explicitly state that patterns as shown in figure 1 are, at least in isolation, most unlikely to be perceived. Nevertheless composers do write them and they probably wouldn't if they thought it would make no difference to either performer or audience. The goal of this paper is to investigate if this is the case or not. Two related experiments will be presented. The first experiment will focus on the performer, the second on the listener.

Since the 1980s interest in music performance research has increased considerably (for reviews see Palmer, 1997 and Gabrielsson, 2003). Yet, the phenomenon of syncopation in music performance has received little attention. This in contrast to the relatively large amount of studies dealing with performance of syncopated patterns in a non-musical context using tapping tasks (e.g. Mayville et al., 2001; Keller & Repp, 2004, 2005; Volman & Geuze, 2000; Weaver, 1939). The first experiment presented in this paper will investigate if musicians consistently change certain performance parameters (timing, dynamics, articulation) when they play a melodic sequence which is notated in a syncopated way, compared to a metrically regular version of the same sequence. As it is not 'natural' to interpret a melody as syncopated when a regular metric framework is not present, we expect that musicians will rather strong cues to convey their intention to the listener.

In the second experiment we will then investigate if listeners can distinguish between the metrically regular and the syncopated melodies. Also in a non-musical context, the study of the perception of syncopated patterns received much less attention than production (Fitch & Rosenfeld, 2007). Therefore we cannot predict if listeners will be able to hear these patterns as syncopated at all. But we assume that some patterns will be easier to identify than others (cf. Sloboda, 1983). If this is the case, it will allow us to determine which performance cues actually contribute to a successful transmission of the intended rhythmic character. In addition to this subjects will also be asked to make a similar judgment of the same musical phrases, but watching a video of the musicians performing. As we can expect that a purely aural transmission of syncopation can be hard, the musicians could have the tendency to use their body to help transmitting their intentions (Leman, 2007). In this case we would expect the results to be better in the video condition as compared to the audio-only condition.

II. Experiment 1: Performance

A Three simple 7-note melodies were used in three different rhythmic patterns (see figure 2): a simple series of quarter notes (rhythm 1), an eighth-quarter-eighth pattern (rhythm 2) and a series of eighth notes separated by eighth note rests (rhythm 3). Each of these combinations of melody and rhythm were presented in a regularly metric version and in a syncopated (shifted by half a beat) version (see figure 3). This gives a total of 18 different fragments, which were presented in a semi-random order (a series of different orders were made, taking care that the same rhythmic pattern was not given twice in a row and that there were no parallels between the different orders), and each performer played each fragment four times (each time in a different context).

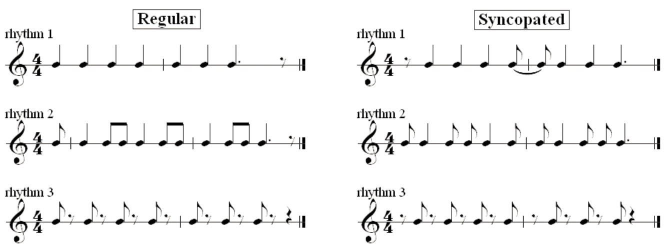

Figure 2: The three base rhythms used in the experiment, in a metrically regular (left) and syncopated (right) versions.

Figure 3: Fragment from the score given to the performers, showing the six possible rhythms and the three base melodies.

Subjects

Twenty professional musicians participated in the experiment: five guitarists, five clarinettists, five pianists and five violinists, aged between 27 and 46 (mean: 36), 8 of the participants were female. All of the musicians are active as performers at a professional level, 15 of them are also active as teachers, 4 as researchers, 5 as conductors and 4 as composers. All of them declared that they were familiar with playing this kind of rhythms and that they were able to perform everything without difficulty.

Procedure

The musicians were contacted by e-mail and an appointment was made to visit them at a place that was familiar for them (usually at home or in a classroom were they were used to teach). The experimenter briefly explained the goal of the research and handed over the four page score to the participant, who could briefly look at the score while the experimenter installed a video camera (Canon Legria) and a digital audio recorder (Zoom H2). When the installation was complete the musician had the opportunity to ask questions and they could start playing through the 72 melodies. The musicians could choose a tempo that was comfortable to them, but were asked not to change tempo too much. After finishing the recordings were stopped and saved and the participants received a small questionnaire about their personal background and their opinion about the task.

Analysis

A number of audio parameters were defined and computed for each individual note. First the timing was manually annotated by indicating the onset of every note using *Praat* (Boersma & Weenink, 2011). The total tempo of each melody was derived from the distance between the onset of the last and the onset of the first note of the pattern. The length of the individual note was coded as the percentage of time within the total length, this in order to correct for differences in base tempo.

The dynamics were processed using the *MIRtoolbox* (Lartillot & Toiviainen, 2007), based on the timeframes mentioned above, the average rms-value for each event as well as the peak value within each timeframe were determined. These values were normalized to the average value for each individual performer to account for the differences in amplitude between the different recordings.

From the dynamics two parameters representing articulation were derived: the distance between the onset and the time of the peak or the attack time; and the ratio between peak rms and mean rms, representing legato-staccato.

Results

The data can be analysed at different levels. First we will look if we can find some general differences between regular and syncopated patterns, then we will look within the three different rhythms, first at effects on the whole melody, then at the level of the individual notes in the pattern. Finally these analyses will be repeated for the four different instruments.

General: To see if we can find some general differences between the regular and the syncopated versions of the melodies, we looked at the average of all the parameters

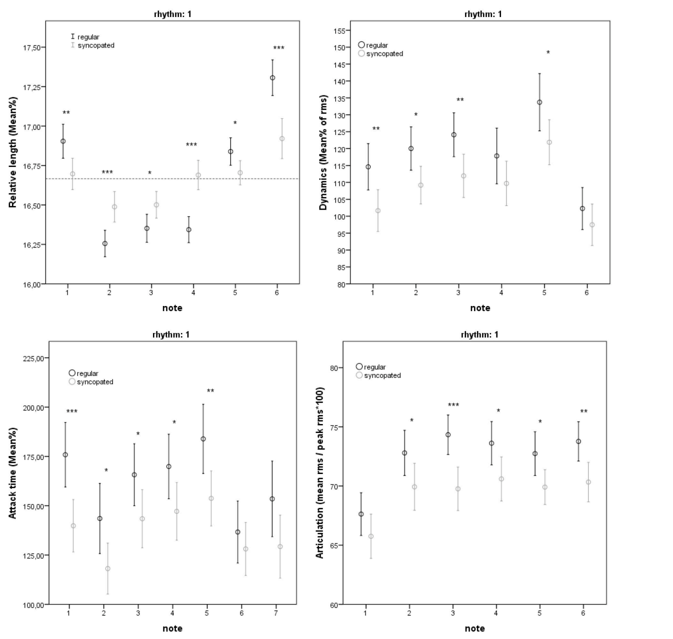

Figure 4: bar charts representing the results of the metrically regular (black) and syncopated (grey) patterns for rhythm 1: (a) relative duration, (b) dynamics, (c) attack length and (d) articulation.

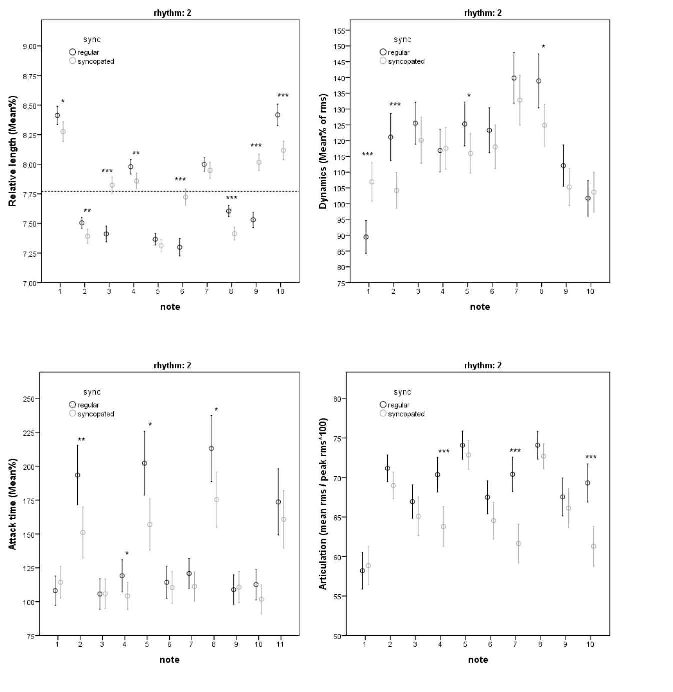

Figure 5: bar charts representing the results of the metrically regular (black) and syncopated (grey) patterns for rhythm 2: (a) relative duration, (b) dynamics, (c) attack length and (d) articulation.

mentioned above for every melody as well as to their variance within each fragment. No general effects were found for timing and articulation. A highly significant difference was found for average mean dynamics between regular (M = 103.58%, SD = 37.14%) and syncopated (M = 96.41%, SD = 35.95%) patterns; $t(720) = 3.72$, $p < .001$. A comparable effect was found for average peak dynamics between regular (M = 102.45%, SD = 19.98%) and syncopated (M = 97.55%, SD = 19.66%) patterns; $t(720) = 4.68$, $p < .001$. So we can conclude that syncopated melodies are played softer overall than their non-syncopated equivalents.

We also see a significant effect on the variance within the dynamics, but as the conditions of normality and equality of variances cannot be assumed, an additional Mann-Whitney U-test is performed. This test confirms that we see less variance in dynamics in syncopated patterns compared to the regular patterns for both the average dynamics ($Z = -2.12$, $p < .05$) and the peak dynamics ($Z = -2.26$, $p < .05$).

As we are actually dealing with three different rhythms we have to see if these effects can be found in every rhythm or not and weather or not other effects occur in specific rhythms.

Rhythm 1: The highly significant effect of syncopation on (mean and peak) dynamics holds for rhythm 1, the effect on the variance is not significant and other effects do not reach significance.

Rhythm 2: The effect of syncopation on (mean and peak) dynamics holds for rhythm 2, but only at a $p < .05$ level of significance, while the effect on the variance of the dynamics is not significant. But some other effects, specific for this particular rhythmic pattern occur: There is a significant effect on syncopation on the normalized tempo with regular melodies (M = 100.41%, SD = 4.07%) played faster than syncopated (M = 99.45%, SD = 4.70%) patterns; $t(240) = 2.39$, $p < .05$. Also the variance of the timing is larger in the regular (M = 12.42, SD = 2.41) than in the syncopated (M = 11.24, SD = 2.87) patterns; $t(240) = 4.87$, $p < .001$. We also find a significant effect on the articulation in rhythm 2, with regular melodies (M = 118.35%, SD = 8.93%) played more staccato than syncopated (M = 114.05%, SD = 9.31%) patterns; $t(240) = 5.17$, $p < .001$.

Rhythm 3: The highly significant effect of syncopation on (mean and peak) dynamics holds for rhythm 3 and here also the effect on the variance is significant, other effects do not reach significance.

Next we can take a look at the individual notes within each of the three rhythms, for the whole group of performers together and for the four instruments separately:

Rhythm 1: The results for this section are summarized in in figures 4a-d. We see a large number of significant effects of syncopation on timing, dynamics and articulation. For the timing we see that the syncopated version is much 'flatter', in the metrically regular versions the first (strong) note is elongated and there is a stronger final retard. Therefore we find that the first, fifth and sixth note are played shorter and the second to forth notes are made relatively longer in the syncopated versions. The syncopated versions are in general played softer (cf. supra) and this is particularly the case for the notes on metrically strong beats (1, 3 & 5). For the articulation we see that the notes of the syncopated pattern are in general played with a shorter attack time and more staccato

Rhythm 2: The results for this section are summarized in figures 5a-d. Also for rhythm 2 we see a large number of significant differences between the metrically regular and the syncopated patterns. As this pattern is in fact a repeated three-note rhythm, we see that similar effects occur repeatedly.

In the timing we see that the first 8th note and the quarter note are shortened in the syncopated versions, and that especially the second 8th note is always played relatively longer. The quarter note gets a shorter attack time and the first 8th note is played more staccato in the syncopated versions. The latter effect is not found on the first note, but this is compensated by a strong dynamic accent, with the note on the downbeat played much stronger: the first note in the syncopated, the second in the regular versions.

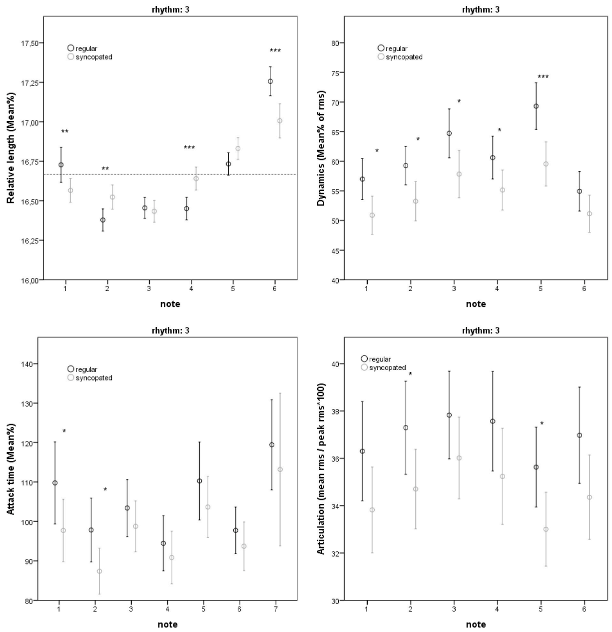

Figure 6: bar charts representing the results of the metrically regular (black) and syncopated (grey) patterns for rhythm 3: (a) relative duration, (b) dynamics, (c) attack length and (d) articulation.

Rhythm 3: The results for this section are summarized in figures 6a-d. The results for rhythm 3 closely resemble those of rhythm 1. The timing curves are similar, but the differences between the regular and the syncopated patterns are somewhat less pronounced. We also find shorter attack times and a more staccato articulation in the syncopated versions, but also here the differences with the regular patterns are smaller. On the other hand, the dynamic stress on the 5th note on the downbeat in the regular patterns is more pronounced here compared to rhythm 1.

A detailed decription of the differences between the different instrument groups goes beyond the scope of this paper, but we can make a few general observations. We see that the use of rhythmic cues is widely used in all four instrument groups and that the effects go in the same direction. For the guitarists and the pianists the rhythmic cues are by far the most important source of variation. In this context their possibilities to vary the articulation are of course very limited, but they also hardly use any dynamic cues. Clarinetists use dynamics a bit more, but it is mainly the violinists who vary their dynamics to make a distinction between the metrically regular and the syncopated patterns. Both groups also use articulation, varying the attack time and playing more staccato in the syncopated versions. The use of staccato is primarily found with the clarinetists and is especially prominent in their interpretations of rhythm 1.

Discussion

We see that musicians use a wide range of techniques to differentiate between regularly metric and syncopated versions of the same basic material. Some more general tendencies can be derived from the detailed overview of the results. A first element is the importance of the metric structure, where we see that metrically important notes are stressed by playing them relatively longer, louder or with a longer attack time. It is also striking that the variance between the different notes is almost always smaller in the syncopated patterns, this effect is significant for the dynamics, but the same tendency is also found in the timing and to some extend also in the articulation. Minimizing the variance seems a part of conveying syncopation, in rhythms 1 and 3, this goes hand in hand with the metrical aspect, as they do not contain any onsets on metrically strong beats, avoiding metric articulation inevitably results in a lower variance. But we also see that the metrically regular patterns have a stronger u-shape phrasing than the syncopated patterns, especially for the timing. Even though the melodies are short, we can see a phrasing where the first note is elongated and which ends with a final retard. In the syncopated melodies also this overall phrasing seems to be limited. Finally it is also striking that syncopated patterns are played softer, with a shorter attack time and more staccato overall. All together this gives the impression that the syncopated patterns sound more mechanical, less natural than the metrically regular patterns.

III. Experiment 2: recognition

Stimuli

From each player one example of each of the 18 patterns played in experiment 1 was selected. More specifically the examples were taken from the third series played by each musician. Two versions of each melody were made: one in 48 kHz 32-bit stereo .aiff format, containing only the audio and one with the video recording in .mov format. In the latter version, the original sound recording from the video had been replaced by the audio recording to ensure there were no qualitative differences between both.

Participants

16 subjects participated in the experiment, 5 of them were male, average age was 29.5 (SD 6.4). They had an average of 11.89 years of musical training with a minimum of 5. All participants declared to be familiar with the concept of syncopation and could imagine performing syncopated and metrically regular versions of the same rhythmic pattern in a different way.

Procedure

The experiment took place in a quiet room, where the participants were seated behind a computer screen. The 180 audio and the 360 video fragments were both divided in two groups of 180. Each participant listened to 180 audio-only fragments and to the other set of 180 fragments with video. Half of the participants started with the audio, the other half with the video excerpts. After each fragment they were asked if they thought the melody was syncopated or metrically regular and how confident they were of their answer. The confidence could be indicated on a scale from 1 to 5 where 1 was 'not confident at all' and 5 'very confident'. One session took about half an hour after which the participants could take a break before starting the second part.

Analysis

For each of the 360 excerpts we calculated the percentage of correct answers over the 16 subjects and the average confidence number. Additionally we did the same for the audio-only and the examples with video separately. Besides this quantitative analysis we performed a qualitative analysis, comparing highly ranked and lowly ranked examples auditively and visually.

Results

Overall only 55.43% of the examples were correctly identified. The number was slightly higher for the excerpts with video (57.40%) than for the audio-only examples (53.47%). Remarkably, the confidence was on average quite high (3.34), and oddly enough the confidence for the audio-only examples (3.48) was higher than for the videos (3.31). No differences were found between the three melodic types and for the number of correct identifications there is no significant difference between the three rhythms. Yet, there is some effect on the mean confidence. The confidence is higher for rhythm 1 than for rhythms 2 and 3; this effect is significant for the video examples ($F(2,357) = 3.12$, $p < .05$), but a similar tendency is found for the audio-only examples. Table 1 shows the distribution of confidence levels, comparing right and wrong answers. We see that the relative share of wrong answers is larger at the lower confidence levels, but still it is striking that in more than a third of the cases where the subjects are 'very confident' about their answer, the answer was actually wrong.

Table 1: Results of the perception test, giving the percentage of the answers distinguishing the right and the wrong answers in each of the confidence levels.

	right	wrong
5	11.58	6.41
4	16.32	12.50
3	14.64	13.49
2	9.83	9.03
1	3.07	3.14
total:	55.43	44.57

Comparison between syncopated and regular sequences shows that regular patterns (60.97%) are more often identified correctly than syncopated patterns (49.90 %), $t(180) = 6.19$, $p < .001$. This effect holds for both the audio-only and the video examples, but the difference in correct identification is smaller with the video examples (61.53% vs. 53.26%) than with the audio-only examples (60.42% vs. 46.53%). If we look at the general distribution of the answers we also find that 'regular' is more often (55.54%) reported than 'syncopated' (44.46%). Yet, there is no difference in confidence judging syncopated or regular patterns.

Looking at the difference between instruments we see a strong effect of instrument on the number of correct answers $F(3,356) = 4.912$, $p < .01$, post-hoc tests show that the excerpts played on guitar (M = 61.39%) are better recognized than those played on other instruments. The effect is even stronger for the examples with video $F(3,356) = 7.81$, $p < .001$, while it is not significant for the audio-only examples. This point will be further elaborated in the qualitative analysis below. A strong effect of instrument is also found on the mean confidence. As the conditions of normality and homogeneity of variance were not satisfied, an additional Kruskal-Wallis test was performed. This confirmed the effect of instrument on the confidence overall ($\chi^2(3) = 34.62$, $p < .001$), as well as for the audio-only ($\chi^2(3) = 32.37$, $p < .001$) and the video versions ($\chi^2(3) = 37.71$, $p < .001$) separately. Also here the guitarists rank higher, while the confidence is clearly lower for the pianists.

We can now investigate if the recognition ratio and the confidence can be related to any of the performance parameters extracted for the analysis of experiment 1. For this analysis we combined correctness and confidence level into one parameter. For each individual answer the two parameters were combined into a score from -5 to 5, where -5 represents a wrong answer given with the highest confidence. Also here the average of all the scores over all 16 subjects was taken for all 360 sound examples. Additionally, the sign of the metrically regular patterns was changed. The result is one number between -5 and 5, for each sound example, indicating how well it is perceived as syncopated. This parameter was then correlated with the performance variables used in experiment 1 using a Spearman correlation within each of the three rhythms. This should give us a list of expressive means that are successful in conveying syncopation to the listener.

Rhythm 1: Syncopation seems to be better recognized when the performer plays slow (absolute tempo: $r(120) = -.310$, $p < .001$) and relatively soft (mean rms: $r(120) = -.277$, $p < .01$), with a more staccato articulation ($r(120) = -.247$, $p < .01$). More specifically when the notes that fall on metrically important points in the metrically regular patterns like the first ($r(120) = -.222$, $p < .05$), third ($r(120) = -.304$, $p < .001$) and fifth ($r(120) = -.207$, $p < .05$) should not be stressed dynamically. Finally playing more staccato in the middle of the pattern seems a good cue, with significant correlations between articulation and the recognition results for the second ($r(120) = -.247$, $p < .01$), third ($r(120) = -.208$, $p < .05$), forth ($r(120) = -.189$, $p < .05$) and fifth ($r(120) = -.204$, $p < .05$) note.

Rhythm 2: To efficiently communicate syncopation it seems that musicians should increase the variance in the dynamics ($r(120) = .191$, $p < .05$), but minimize the variance in the rhythm ($r(120) = -.185$, $p < .05$) and the articulation ($r(120) = -.202$, $p < .05$). Besides this the quarter notes should be played relatively short and soft, for the timing this effect is significant for the second ($r(120) = -.199$, $p < .05$) and fifth ($r(120) = -.242$, $p < .01$) note of the pattern, for the dynamics only for the second ($r(120) = .185$, $p < .05$)

Rhythm 3: As for rhythm 1, melodies which are played slow are more often identified as syncopated (absolute tempo: $r(120) = -.531$, $p < .001$). Next to this, it seems good to increase the variance in the attack time ($r(120) = .264$, $p < .01$) and articulation ($r(120) = .192$, $p < .05$), but to minimize the variance in the rhythm ($r(120) = -.245$, $p < .01$). More specifically one should not elongate the first ($r(120) = -.205$, $p < .05$) and especially the sixth ($r(120) = -.392$, $p < .001$) note of the pattern.

These results give us some indication about the importance of the different parameters in conveying syncopation, but do not give an explanation for the difference between the audio-only examples and the examples with video. To investigate this we looked at the difference between the two conditions in the results of the perception task, using the -5 to 5 scale for the audio-only and video excerpts separately. The scores are higher in the video condition for 200 of the excerpts, 151 have a lower score and 9 the same score, on average there is an increase with 0.36 points. From the set of 360 we took the 10 examples that showed the highest increase (between 3.75 and 5.75, M. 4.46) and the 10 examples with the biggest decrease (between -2.88 and -5.00, M. -3.44). In the first group it is striking that 7 out of 10 are played by guitarists (next to 1 piano and 2 clarinet examples), the second group there is only one guitar example next to 4 piano, 3 clarinet and 2 violin fragments. In nine of the examples in the second group rhythm 3 is played (next to one example of rhythm 1), also in the 'positive' group rhythm 3 is overrepresented with 5 examples, next to 4 times rhythm 1 and only one of rhythm 2. When we look at the videos it is clear that in all of the examples of the selection, the articulation of the basic beat in the body of the player plays a role. The guitarists are the only musicians who actually had a 'free' foot which was visible (the violinists and clarinettists were standing, while the feet of the pianists were hidden) and in the examples where the addition of the video positively influenced the recognition, they clearly beat the tempo with their feet, while the pianist and clarinettists do the same with their hand or arms. This also explains why rhythm 3 is overrepresented in the examples where the recognition rate decreases: the rests invite the performer to make a movement and the viewer interprets this as an articulation of the main beat, thus reporting the sequence as syncopated

IV. CONCLUSIONS

The results of experiment 2 show that it is indeed hard to correctly identify syncopated patterns when a metric framework is absent. The excerpts are more often reported to be metrically regular and for the audio-only fragments, the recognition rate of syncopation is even below chance. When video is added the recognition rate rises, but a qualitative examination of the fragments which show a large increase in recognition rate shows that this is mainly due to the articulation of the beat in the body of the performers. Interestingly, the confidence rating is not a very good predictor of correctness, in quite many cases the listeners are very convinced of the 'wrong' answer. This underlines the difficulty of communicating an 'unnatural' rhythm effectively.

Despite this, comparison between the results of the listening test and the audio parameters used in the analysis of experiment 1 allowed us to find some parameters which positively influence the perception results. A somewhat puzzling result is that for both rhythm 1 and rhythm 3 syncopation is associated with a slower absolute tempo. The effect is very strong, especially for rhythm 3, but further analysis is necessary to provide an explanation for this effect. Other factors such as the avoidance of temporal contrast, to reduced stress on metrically important notes, and playing softer and more staccato were also found in experiment 1.

We can conclude that musicians have developed a whole set of expressive means, using timing, dynamics and articulation to distinguish syncopated rhythms from their metrically regular versions. Especially timing cues seem to be important as they are largely shared by all four of the instrument groups. On the other hand it seems that communicating the syncopation to the listeners remains very difficult without providing any metrical grid against which the syncopation becomes audible.

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