TAPPING THE *TACTUS* A MEASURE OF RHYTHMIC ANTICIPATION

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ABSTRACT

Synchrony is defined as a group of events that coincide in time.

A particular form of synchrony is the rhythmic synchrony. It can be described as the ability to perform a chain of events (sounds movements, etc.) in phase with an external rhythmic pattern (chosen or imposed).

This kind of actions required temporal information that is conceptualized in terms of perceiving and processing groups into units (gestalten) and as internal clocks

Results obtained in a sample of musicians tapping the tactus (metronomic accuracy) will be presented. The test consisted of tapping the pulse in an informatics environment in according to the beats to a musical fragment (MM 110, 126 and 141).

The results shows i) delay is the most commonly observed tendency ii) anticipated responses are less frequent; iii) strict onset responses are infrequent. Subjects obtained in tempo 110 more onset accuracy and more negative synchronization than in tempi 141. The higher level of synchrony is in tempo 110

Temporal variability is a function of duration. Previous studies show that being greater in wide intervals than in brief ones. Our study shows the greatest variability when the tempo is faster, and it is also higher in the mean one: variation values are dependent on the tempo.

The highest synchrony point is observed at 7-8 seconds after the starting and later the lack of adjustment to the stimulus increases.

The study shows some cases that can be considered "clinic" with a) a high delayed mean in the three tempi (113 ms., 152ms and 164,5ms (in different tempi) b) a very high mean in the slowest tempo (148ms) c) a very high mean in the fastest tempo (231ms). This data suggest that sometimes practice is not enough, and probably indicates personal lack of adequacy to the tempo.

Anticipation seems to be a critical trait of rhythmic synchrony.

Synchronic performance represents the theoretical limit of anticipation.

1. BACKGROUND

Synchrony is defined as a group of events that coincide in time. A particular form of synchrony is the rhythmic synchrony (R.S.). It can be described as the ability to perform a chain of events (sounds movements, etc.) in phase with an external rhythmic pattern (chosen or imposed).

This kind of actions required temporal information that is conceptualized in terms of perceiving and processing groups into units (gestalten) and as internal clocks (Lerdahl and Jackendoff, 1983; Parncutt, 1994; Drake, 1993; Clarke, 1999, 2000).

According to Shaffer (1982) the rhythmic synchronization requires to build an internal model of the beat interval inter onsets and regulate the movement between each tap. The distributed timing implies the use of internal clocks from the music and the motor system that can reproduce a movement having a given period.

One of the most basic ways of R.S. is to fit with an isochronic rhythmic pattern. That is, the sequence of equals Inter Onset Interval (IOI) events that maintains a constant pace.

Tasks such as clapping along with our own singing or clapping along with Music are generally an example of R.S. with isochronic patterns. The lapse between clap and clap are determined by the music's pulse pattern period. In this case synchrony consists in assembling the clapping period with the music's period.

The pulse patterns have different salience levels; the most salient occurs at level of tactus distribution (Lerdahl and Jackendoff,1983, Parncutt,1994).

Tapping sequences with mechanical regularity is easier than following an expressive version (Drake, Penel, Bigand and Stefan,1997)

Which processes are activated in the synchronic performance of a musical piece? The activated processes are: prediction based on what is perceived and anticipation of what will follow.

Anticipation demands sending the signal to the mind just before the onset and to realize in advance the next onset (Fraisse, 1982). To be able to synchronise a tap and a sound demands to put an anticipatory system in action permitting to know the right moment in which the next onset will appear. The rhythmic anticipation is an inner process that builds a temporal scale based on the stimulus scale, adding minimal anticipation to the onset.

Synchronic music performances required essentially:

- To receive the musical stimuli (input);
- To register the metrical attributes;
- To process information over the time in real time, building a temporal scale abstracting the salient features

ISBN 3-931852-67-9
ISSN 1617-6847

- To put the required body segment in movement taking into account the available fraction of time according to the rhythmic pattern (anticipate the onset by motor gesture).
- To perform at the precise moment (or with minimal deviation);
- To recycle the whole circuit for the next onset.

Shaffer, Clarke and Todd (1985) consider that a skilled musician obtains rhythmic coherence by making reference to an internal representation of meter established not only as a formal sequence of markers but as a time scale or series of time scale. According to Ivry & Hazeltine (1995) variability on the tapping is a measure as a proof of the internal mechanism.

The study of perception and synchronic performance of pulse patterns, the representations that Music generates, the symbolic systems it uses, the processing modes that generates and the planning of sequences and other complex cognitive processes that it puts in action, justified the study of perception and synchronic performance.

Results obtained in a sample of musicians tapping the tactus (metronomic accuracy) will be presented.

2. AIMS

To measure the synchronic performance with the tactus in terms of the amount of displacement (deviation) from the zero point assuming that accuracy depends on the degree of anticipation.

3. METHOD

Musical fragment (metronomic accuracy) Tempi: 110, 126 and 141.

Presentation order: MM 126, MM 110, MM 141

Sample: musicians (N=40).

Software: Cakewalk 3.0. Settings: tick scale 480 ticks per quarter note.

4. RESULTS

Sixty onsets for each subject (N=40) and for each tempo were registered,2400 onsets were totalized.

Statistical test shows:

One sample statistics				
	N	Mean	Std. Dev	Std Error mean
Tempo110	2400	24,4	53,76	1,1
Tempo126	2400	30,46	44,85	0,92
Tempo141	2400	53,28	57,17	1,17

Table 1.

One Sample Test						
Test value = 0						
	t	df	Sig (2 tailled)	Mean difference	Lower	Upper
Tempo110	22,233	2399	0,000	24,4	22,25	26,55
Tempo126	33,278	2399	0,000	30,46	28,67	32,26
Tempo141	45,7%	2399	0,000	53,28	50,99	55,56

Table 2: 95 % Confidence Interval of the Difference

Accuracy degree is rated as

- advanced, negative synchronization, before zero point;
- delayed, positive synchronization, after zero point
- coinciding with the zero point (strict).

Strict onsets (zero point), tolerance window onset (-60 to -1 and 1 to +60), the slightly delayed onset (61-180), the delayed ones (181-300) and extremely delayed onsets (301-420) were analyzed.

Results are shown as following:

Total Results (2400 tactus)						
TEMPO	STRICT	-60 to -1	1 to +60	61 to 180	181 to 300	301 to 420
Tempo110	34	539	1656	114	29	28
	1,4%	22,4%	69 %	4,8%	1,2%	1,1%
Tempo126	22	373	1734	229	25	17
	0,9%	15,54%	72,25 %	9,55%	1%	0,7%
Tempo141	16	146	1557,00	593	51	37
	0,7%	6%	65 %	25%	2,1%	1,5%

Table 3

The results show:

Delay is the most commonly observed tendency. In MM110, 1827 onsets = 76,12%; in MM 126 ,1927 onsets = 80,29 % and in MM 141, 2238 onsets = 93,25 %. .

Anticipated responses are less frequent. In MM110, 539 onsets = 22,4%; in MM 126 ,373 onsets = 15,54 % and in MM 141, 146 onsets = 6%

Strict onset responses are infrequent. In MM110, 34 onsets = 1,4%; in MM 126 ,22 onsets = 0,9 % and in MM 141, 16 onsets = 0,7 %

ISBN 3-931852-67-9
ISSN 1617-6847

5. CONCLUSIONS

Subjects obtained in tempo 110 more onset accuracy and more negative synchronization than in tempi 141. The higher level of synchrony is in tempo 110

In speedy tempo the time in disposition to send the target affects the synchrony. The percent of delayed onset is wider than advanced The standard deviation is higher than the mean in tempo 110 and 126 and next to the mean in 141.

The results show: a) synchrony as a tempo's function S-f (T) b) an observed tendency of delaying the onset; c) strict synchrony as an unusual trait d) high variability of performances.

According to Ivry & Hazeltine (1995), temporal variability is a function of duration, being greater in wide intervals than in brief ones. Our study shows the greatest variability when the tempo is faster, and it is also higher in the mean one. Performance variability is estimated by the standard deviation. According to Rash (1979) the SD is about 30-50 msec. In our study, the mean was 27,45ms (in tempo 110), in 126 29,82 msec. and in 141 59,94 msec. This tends to indicate that variation values are dependent on the tempo.

There is considerable discrepancy between our findings and these of Aschereleben & Prince (cfr Fraisse 1982) as they report a steep tendency to delayed performance on the first onset, being synchronized in subsequent performances. In our study the highest synchrony point is observed at 7-8 seconds after the starting and later the lack of adjustment to the stimulus increases.

Gerard & Auxiete,1992; Radil et al 1993 (cfr Fraisse, 1982) and Prinz (cfr Parncutt, 1994) consider negative asynchrony as the most frequent tendency. In our study, positive asynchrony is dominant in the three tempi.

Positive asynchrony has also being shown in previous work such as Nagasaki 1987; Peters 1989 (cfr Wittman & Poppel 1999). They point out as delayed a mean range between 50-100 ms. In our study, the positive asynchrony mean is 111,87ms for tempo 141. So, the difference between understood and active response (Wing, 1973 in Vorberg & Hambuch, 1978) and the incidence of the tempo have to be taken into account.

There is common agreement when considering that musicians master anticipation and in this way their performances are highly synchronic. However, in our study we have observed some cases that can be considered "clinic" with a) a high delayed mean in the three tempi; 103 tics=113 ms (tempo: 110); 155 tics=152ms (tempo:126) and 188 tics=164,5ms (tempo: 141). b) a very high mean in the slowest tempo (132 tics=148ms) c) a very high mean in the fastest tempo (264 tics= 231ms).

This data suggest that sometimes practice is not enough, and probably indicates personal lack of adequacy to the tempo. There is general agreement that peripheral transmission is around 30ms. However, three subjects did not obtain any onset below 35 tics (30ms in tempo141). These probably show that in this tempo they were not able to anticipate.

The construct of anticipation may be inferred from the performance mediated by motor gesture. Although it is possible to anticipate the action, it does not necessarily derive from playing on time. Acute anticipation requires advancing the exact estimation of time.

Consistency of action may be taken as an indicator of synchronic performance. Estimating the time over the time allows considering rhythmic accuracy as a measure of anticipation. Anticipation seems to be a critical trait of rhythmic synchrony. Synchronic performance represents the theoretical limit of anticipation.

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ISBN 3-931852-67-9
ISSN 1617-6847