SOME BASIC OBSERVATIONS ON HOW PEOPLE MOVE ON MUSIC AND HOW THEY RELATE MUSIC TO MOVEMENT

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ABSTRACT

In this study we explore the relationship between music and body movements. The focus is on repetitive body movements made on music with a rather strong rhythmic character. An experiment was performed in which we asked people to move a joystick while listening to music. First some basic observations are being reported, secondly we analyze more in detail the movement data by making use of synchronization images and calculating the mean movement velocities. It turns out that people naturally synchronize the speed chunks of their movements with the pulse of the music. In a previous experiment people estimated the motional and emotional content of 160 musical excerpts. In the second part of this paper we link these estimations to the tempo of the music. The results do not conflict with the idea that the locomotion system is an intermediary between the music and the perceived emotion.

INTRODUCTION

The relation between music and movement is a fundamental one and has been exploited (e.g. in dance and march) probably since the beginning of music (Mc Neill, 1995). This has also been mentioned very often in discourses on the nature of music, however very little experimental work has been reported. In this article we start from the idea that the relation between music and movement is strongly connected to real body movements. In order to investigate the close relationship between music and our moving body we set up an experiment in which we asked people to move along with music. The musical stimuli had a strong rhythmic character. It was assumed that the subjects would make repetitive body movements along with the musical pulse.

From casual observations it is clear that some music is more appropriate to move your body on than other music. Some kinds of music seem to posses that specific kind of impulse that puts your body into motion. The most obvious way to move on music is by synchronizing your movements with the pulse of the music (e.g. tapping along with the music). However the specific form of the synchronization movements can vary a great deal. The movements can be fast or slow, curved or straight, extended or limited. Therefore we distinguish different levels of synchronizing with music. A first level refers simply to the act of synchronization (does one synchronizes with the musical pulse or not?). A second level refers to the qualitative aspects of the synchronization movements. In this second level the movements are extended with extra movement qualities which are related to other musical parameters than just the underlying grid of the musical pulse. This second level can be illustrated by examining a simple act like tapping along with the music. The act of tapping along with the musical pulse refers to the first level. However, one can tap gently without exercising much pressure on the top of the finger or one can tap in a very aggressive way using more than just one finger. These qualitative differences refer to the second level. A third level is referred to as the emotive level in which the movements are related to the expressive/emotive domain. The body movements have expressive and emotive connotations as a result of our musical experience and the way we connect the music to our own emotive and expressive contexts. Of course these different levels are not connected to each other in a one directional way. The different levels can work on their own or can be influenced by the others. For example, we can have an emotional experience while listening to our favourite musical piece and therefore be stimulated to produce repetitive or non-repetitive body movements. On the other hand we can be attracted by a musical fragment on a more bodily level. The music has a direct influence on our body movements and these body movements can then give rise to a certain emotional/expressive connotation/feeling. These three levels can thus be seen as a multidirectional system. In this explorative study we will focus on these three different levels by examining the movements that people made during our experiment, as well as by making reference to a previous experiment in which people were asked to give estimations of the motional and emotional content of music.

EXPERIMENT 1: MOVING ON MUSIC

The data presented here were obtained during a demonstration experiment that found place on a public trade fair (ACCENTA 2005, Ghent, Belgium) to which our research department participated (for PR reasons). This was an opportunity to have access to a wide variety of people. Visitors of this fair were invited to participate in a small experiment concerning the relationship between music and body movement. They were asked to move a joystick while listening to music.

Stimuli

In the context of a public trade fair it is not possible to get the attention of people for more than a few minutes. Therefore we decided to develop a stimulus that took no longer than 2 minutes. We restricted ourselves using music with a tempo of 120 BPM. The reason why we chose for this tempo is because Moelants and van Noorden (1999) have shown that many phenomena in rhythm perception/production can be explained by the fact that somewhere in the system for rhythm perception/production a resonance occurs with a peak close to 2 Hz (120 BPM). Macdougall and Moore (2005) have measured the

Figure 1: subject performing task H

energy spectrum of the movements of people wearing a 3D accelerometer at their baseball hat during a large part of the day during their daily activities. They found a sharp peak at 2 Hz and made a link between the human locomotion and the work of Moelants (2002) on the histogram of musical tempi. So there seems to exist a natural preference for a tempo of 120 BPM. This implies also that at this specific tempo people tend to agree most upon the tempo of the musical piece. The second consideration was to have two excerpts that differed clearly in "motion content". We took a march as the excerpt with strong motion content and a classical andante as the excerpt with intuitively less motion content. The third consideration was that we wanted to investigate the influence of loudness. The march was therefore included on two loudness levels. More specifically the three musical fragments were a passage from the march 'Under the double eagle' from Frans Joseph Wagner, the same passage but - 6 dB, and a passage from the Andante of the concerto in d minor from Johann Friedrich Fasch. Each musical fragment had a length of 30 seconds. Each fragment was preceded by a simple metronome sequence again at a tempo of 120 BPM. These metronome pieces were inserted before each musical fragment in order to bring the subject back to a 'basic movement level'. The first metronome sequence lasted 20 seconds, the second and the third 10 seconds. The metronome sequences cross faded into the musical fragments. To exclude the effect of order the order of the three musical fragments was randomized. Each subject got one of the six possible orders. In the experiment all orders occurred equally.

Procedure

Subjects were asked to move a stick that was attached to a joystick (Saitek S-90) while listening to music. A first group of subjects was asked to move the joystick (that was standing on the floor, see figure 1) with their left or right hand (Task H). A second group of subjects was asked to move the joystick with their left or right foot (Task F). Now the joystick hang horizontally to a stand. The stick attached to the joystick was attached to the ankle of the subject. A last group of subjects was asked to combine the two previous tasks by moving their hand and foot simultaneously while listening to the music (Task HF). After the experiment the subjects were asked to fill out a short form in order to get basic profiles of them. The questionnaire incorporated also some questions concerning the subjects' opinion on the relation between music and movement.

Subjects

211 subjects participated in the experiment. In task H, 86 subjects participated (50 men, 36 women). In task F, 51 subjects participated (19 men, 32 women). In task HF, 74 subjects participated (36 men, 38 women). The subjects' age ranged from 3 to 76, with an average of 27.48 years. Because many secondary schools visited the fair, 37 per cent of all participants were between 8 and 14 years old.

Data Capturing

The movement data were captured with the software Analog Box (http://www.andyware.com/abox2/index.html). The movement data were registered as stereo wave files. The left channel of the wave file contained the horizontal movements, whereas the right channel contained the vertical movements. The movements were registered with a sample frequency of 100 samples/sec.

SOME BASIC OBSERVATIONS

A first observation is that people found it very normal, if not amusing, to move on music. This is illustrated by the large amount of subjects that were willing to participate in the experiment, as well as by the fact that 73 per cent of all subjects said they moved their body quite often while listening to music and 96.5 per cent of all subjects agreed upon the fact that there exists a close relationship between music and movement. The subjects did not find the experimental task silly or funny. They understood quite immediately what was expected of them and what was the relevance of such an experiment. Everybody was able to make foot and/or hand/arm movements while listening to the music. However, during the experiment we noticed that people differed enormously in their amount of movement, in the variation of their movements and in their degree of synchronizing with the musical pulse. Some age categories seemed to be more sensitive for moving on music. Especially the age group between 10 and 14 years was a very enthusiastic one and moved very spontaneously in comparison with other (older) age categories.

By observing the subjects it seemed that the ones who performed task H were more spontaneous in their hand movements than the subjects who performed task HF. It seems thus that in the HF task the foot movements limit somehow the hand movements. A general observation is also that people tended to move more on the march fragments than on the andante piece and the metronome pieces. The sensitiveness of the movements in relation to the music differed considerably between subjects. Some subjects showed a

high sensitivity for changes in the musical fragments. These changes were directly reflected into their movements. Referring to the different levels put forward in the introduction we could say that these subjects not only situate themselves on the first level but also on the second level by bringing variation into their act of synchronization correspondingly to the varying musical content. Other subjects however did not show that sensibility and made straight back and forth movements without varying the movements according to the changing musical fragments. The movements of subjects acting on the first level are strongly related to just one pulse per time. Subjects who act on a higher synchronization level make more complex movements that often span over several pulses and sometimes reflect the metre of the piece. The speed chunks of the higher level synchronization movements are thus related to different rhythmic levels whereas the velocity chunks of the first level synchronization movements are mostly related to the rhythmic level of the pulse.

Regarding the two dimensional shapes of the hand movements it seems that we can distinguish a limited set of basic movements. A large group of subjects made simple straight movements with short stops at the end, after which the movement goes on in another direction. Others made more continuous round movements. It seems that the metronome fragments as well as the march fragments are more related to the straight category whereas the andante piece is more strongly related to the continuous, round movements. Although subjects were often arbitrary in their choice of motional direction, we observed that the speed chunks with which they moved were often synchronized with the music. Thus, we might conclude that the movement velocity is a more invariant parameter than the movement direction. Further detailed analyses will therefore focus on the movement velocity.

ANALYSES

In this more detailed analyses we distinguish two parts. We investigate to what extend subjects synchronized with the musical pulse and we have a look at the mean movement velocities.

Synchronization

The question to which extend the subjects synchronized with the pulse of the music is investigated by making abstraction of the movement directions and by calculating the velocity of the movements. In the velocity curves we then looked for repetitive patterns and whether these patterns were synchronized with the musical pulse. A first way to explore the synchronization of the movement patterns was by making 'buffer images' of the velocity curves. The buffer images are build out of vertical slices. Each slice is the movement velocity pattern made on 4 successive beats of the music. The vertical slices do overlay for 50 per cent i.e. the bottom half of a slice is repeated in the upper half of the slice next to it. The movement velocity is coded by colour. Blue stands for low velocity, red for high velocity and green and yellow for velocities in between. If the colours form horizontal lines the subject synchronized with the musical pulse. Figure 2 shows a buffer image. The image reflects the velocity pattern of the hand movements of a subject who performed task H. It is clear that the velocity pattern forms quasi-horizontal lines which means that the subject synchronized with the musical pulse. The fact that we see 4 lines means that the subject has 4 velocity peaks over a time span of 2 seconds. This corresponds with a back and forth movement with a velocity pattern at tempo 120 BPM. Furthermore we see that in piece 4 (the andante piece) the movement pattern shows more blue colours which means that the subject moved slower, however still at tempo 120 BPM. The march pieces show even some red colours which correspond with high velocities. The quasi horizontal lines are often jagged. This indicates that the synchronization is actually a detailed process in which the instantaneous synchronization is not perfect. It deviates from the strict tempo and is corrected each time the deviations become too big.

Figure 2: buffer image of a subject performing task H

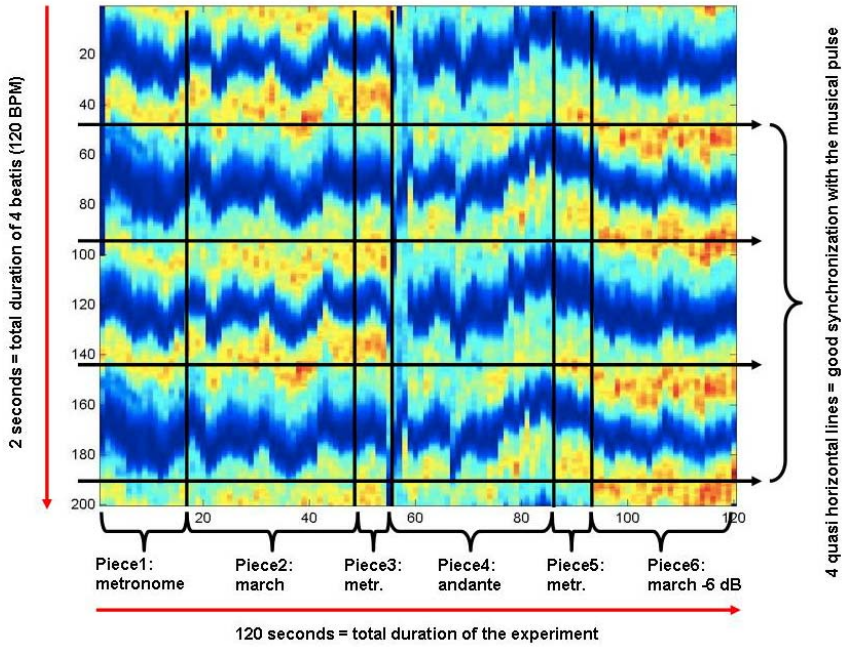


Figure 3 shows again the buffer image of a subject performing task H. When we look at this figure we can make some very interesting observations. First of all we see in the metronome pieces eight blue horizontal lines in stead of four. This means that the movement pattern has eight velocity peaks over a time span of 2 seconds. This pattern corresponds with movements at the double tempo (240 BPM). When we look at the march pieces we see a situation similar to figure 2. However, interesting to see here is that in the second part of piece 2 the subject makes movements with a higher velocity (see the dashed line). This corresponds with bigger movements. If we listen carefully to the march piece we here indeed at this point a reprise of the first part which is played louder and with more bravura. The velocity patterns illustrate that this subject is very sensitive for musical changes and reflects these changes directly into body movements. In the andante we don't see clear horizontal lines which means that the subject did not synchronize with the musical pulse. Figure 4 shows the velocity pattern of the hand movements of a subject who performed task HF. At the beginning of the first metronome piece the subject hardly moved, only at the end of the piece we see four horizontal light blue coloured lines (120 BPM). In the andante we only see two horizontal lines. This means that the subject's velocity pattern corresponds with a tempo of 60 BPM. In stead of the blue colour of the velocity pattern of the andante piece we see yellow and red colours in the march pieces. Again we see some kind of differentiation between the velocity pattern in the first and the second half of the march pieces. Just like the previous subject, this subject follows the musical changes in a very profound way. It is odd however to see that in piece 6 the subject moved less in the second part of the march whereas this second part is louder and more intense than the first. All the buffer images can be found on www.ipem.ugent.be.

Figure 3: buffer image of a subject performing task H

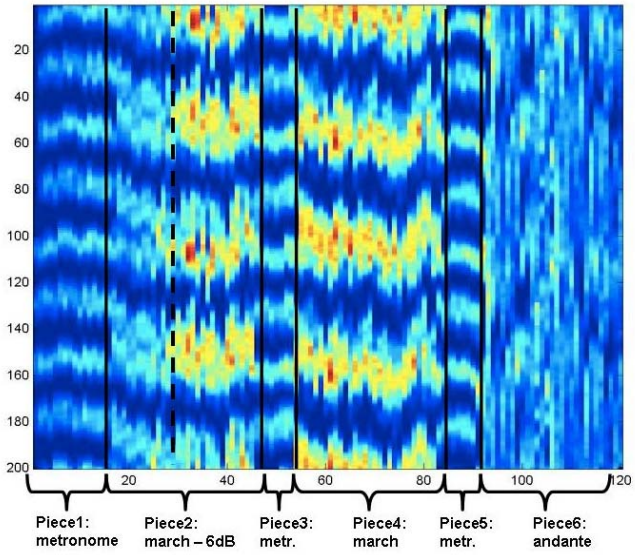
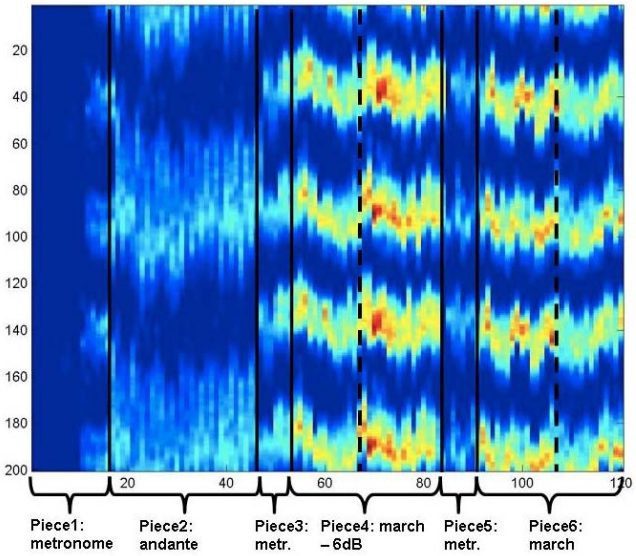


Figure 4: buffer image of a subject performing task HF



The buffer images can give us a good first view on how the subjects synchronized with the music. By performing a spectrum analysis on the velocity patterns per musical piece per subject we can say more in detail how many subjects synchronized with the musical pulse. The highest peak of the spectrum analysis was detected and considered as the tempo at which the subjects moved. Table 1 shows a detailed overview of the tempi of the velocity patterns of the hand movements of task H, table 2 shows the tempi of the velocity patterns of the hand movements of task HF (N. S. = Not Synchronized). The results reflect clearly the ambiguity of the tempo of the andante. The march fragments reflect most clearly a tempo of 120 BPM, even more than the metronome fragments! It is interesting to note that the addition of the foot movements in task HF concentrated the hand movements more on the 120 BPM execution. In most cases there are much less 60 and 240 BPM executions (see table 2).

Table 1: tempi of the velocity patterns of the hand movements of task H

BPM	Metr. 1 per cent	andante per cent	Metr. 2 per cent	march per cent	Metr. 3 per cent	March -6dB per cent
N. S.	27,7	61,6	41,9	29,1	30,2	23,5
30	1,2				1,2	
60		16,3		4,7	2,3	2,4
120	47,0	22,1	45,3	61,6	50,0	69,4
240	24,1		12,8	4,7	16,3	4,7

Table 2: tempi of the velocity patterns of the hand movements of task HF

BPM	Metr. 1 per cent	andante per cent	Metr. 2 per cent	march per cent	Metr. 3 per cent	March -6dB per cent
N. S.	35,1	51,4	41,9	21,6	39,2	31,1
30	1,4				1,4	
60		24,3	1,4	1,4	1,4	2,7
120	62,2	24,3	56,8	75,7	58,1	66,2
240	1,4			1,4		

Because we only measured the movements of one foot and people often synchronized with both feet we could not differentiate the tempi of the foot movements as clearly as the hand movements. We could not conclude from the analysis whether, for example, 60 BPM should be interpreted as 120 BPM (because the subject might have use both feet in stead of one). However we can say how

many subjects synchronized and how many did not. Table 3 and table 4 illustrate this for task F and task HF respectively. Again most people managed to synchronize with the march pieces, more than with the metronome pieces! Most subjects did not synchronize with the andante.

Table 3: tempi of the velocity patterns of the **foot** movements of task F

synchr	Metr. 1 per cent	andante per cent	Metr. 2 per cent	march per cent	Metr. 3 per cent	March -6dB per cent
No	58,1	66,2	67,6	24,3	67,6	23,0
Yes	41,9	33,8	32,4	75,7	32,4	77,0

Table 4: tempi of the velocity patterns of the **foot** movements of task HF

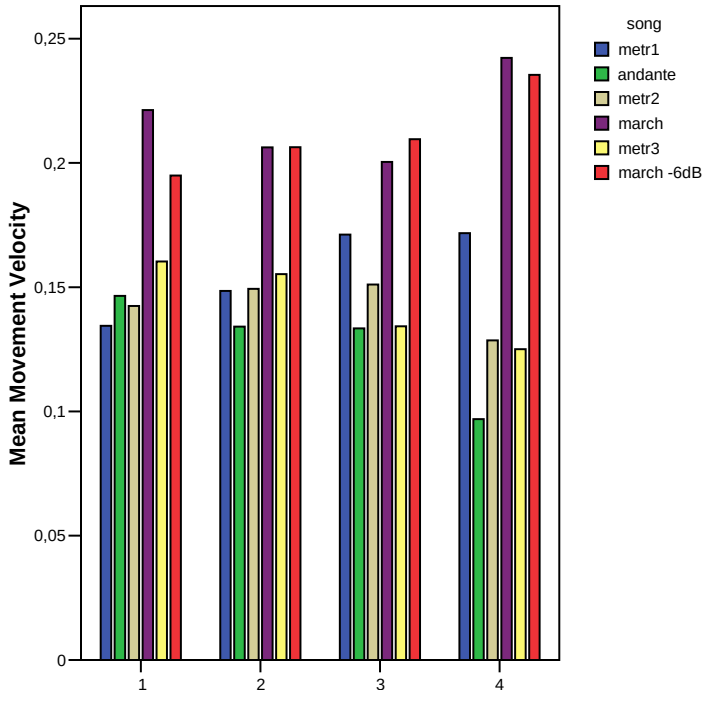
synchr	Metr. 1 per cent	andante per cent	Metr. 2 per cent	march per cent	Metr. 3 per cent	March -6dB per cent
No	52,9	56,9	56,9	15,7	66,7	15,7
Yes	47,1	43,1	43,1	84,3	33,3	84,3

Mean Movement Velocities

In order to get a more profound idea of the velocity of the movements we calculated for each subject the mean velocity for the six musical fragments. Before calculation the data were screened visually. Subjects who had barely moved were excluded for further analysis (14 subjects in total). In order to make abstraction of the big differences in the amount of movement between subjects we normalized the data by dividing all six subject's velocities by the sum of the subject's six velocities. The velocity calculation was done in Matlab, the normalization in excel.

The statistical analysis (one-way ANOVA, alfa level 0.05) shows that for task H there are some significant differences between the mean movement velocities for the different songs ($F(5,510) = 26.077$, $p < 0.01$). The velocity of the movements that the subjects made on the march fragments were significantly higher than the ones they made on the metronome pieces and the andante. The same holds true for the hand movements in task HF ($F(5,438) = 24.664$, $p < 0.01$). There are no statistical differences between the metronome pieces and the andante. These statistical findings confirm the intuition we got about the movement velocities by just looking at the buffer images. In these images the andante piece as well as the metronome pieces had clearly more blue colours (which refer to lower velocities) than the march fragments. By just looking at the buffer images we also thought that people moved less fast on the march – 6dB than on the unmodified march. However, the statistics do not give prove of this intuitive finding. For the foot movements of task F ($F(5,300) = 28.955$, $p < 0.01$) and task HF ($F(5,438) = 14.567$, $p < 0.01$) there are also statistical significant differences between the mean velocities for the different musical stimuli. In both cases the velocity of the andante is again lower than the velocities of the march stimuli. But strangely enough the first metronome piece has now a significantly higher mean velocity than the andante and the third metronome piece. The basic observation that subjects performing task H seemed to make bigger hand movements than people performing task HF is not confirmed by statistical analyses. An Independent-Samples T test did not reveal any significant difference between the mean velocities of the hand movements in task H and the hand movements in task HF. Figure 5 shows the mean velocities per task per song.

Figure 5: mean movement velocity (in arbitrary units) of all subjects per task per song. The x axis stands for the task, where 1 = hand movements of task H, 2= hand movements of task HF, 3 = foot movements of task HF, 4 = foot movements of task F.



SUMMARY

Our intuitive findings are partly being confirmed by the more detailed analyses (buffer images, calculation of the mean movement velocities). By looking at the buffer images we found that some subjects moved in the same way regardless of the musical piece. Other subjects were very sensitive to musical changes and differentiated their way of moving according to the musical piece they heard. We could say that a first group of subjects situated themselves on the first synchronization level. They just paid attention to the act of synchronization, they just focused on keeping in time with the music. A second group however was more sensitive for the music in that they differentiated their act of synchronization along with the different musical pieces. A second observation, namely that people moved more on the march pieces than on the metronome pieces as well as on the andante piece, was confirmed by the statistics concerning the movement velocities. The calculation of the mean movement velocities confirmed that the subjects moved with a higher mean velocity on the march fragments. There was no evidence for a statistical significant difference between the mean velocity of the movements on the unmodified march and the ones on the march -6dB. Not only did the subjects move the most on the march fragments, the march fragments were also the fragments with which most subjects synchronized in a proper way. In contradiction with our basic observation we did not find a statistical difference between the mean velocities of the hand movements performed in task H and the ones performed in task HF.

This explorative study situated itself so far on the first two synchronization levels. Namely, how many subjects synchronized with the music, and were the synchronization movements differentiated according to the different musical pieces? The third level, the emotive/expressive level, cannot be entered by just referring to the data of this experiment, because we did not ask the subjects for their emotive connotations while listening to the music or how they thought about the relationship between their movements and the emotional content of the music. However, by referring to a previous experiment we can get some preliminary insights into this relationship.

EXPERIMENT 2: ESTIMATING (E)MOTIONAL CONTENT

In a previous experiment performed by Lesaffre (2005) 92 subjects were asked to make semantic descriptions of 160 musical fragments. The experiment consisted of seven forms gathering ratings of adjectives representing expressive and structural qualities of music. Respondents were also asked to give more information on the music excerpts with regard to familiarity, appreciation, degree of difficulty and physical response. For the annotation of the expressive affective qualities of the music subjects of the previous experiment had to make ratings on a 5-point scale (ranking from “not” to “very”) for a set of eight adjectives (cheerful, sad, carefree, anxious, tender, aggressive, passionate, restrained) that appeared in random order on a list. For the description related to physical response in terms of movement subjects had to rate again on a 5-point scale (from “not” to “very”) the question “to this music I start moving spontaneously”.

Figure 6: relation between movement ratings and musical tempo

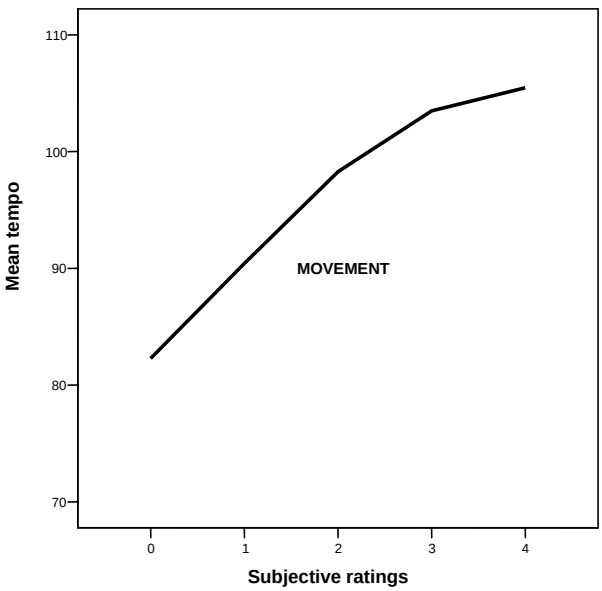
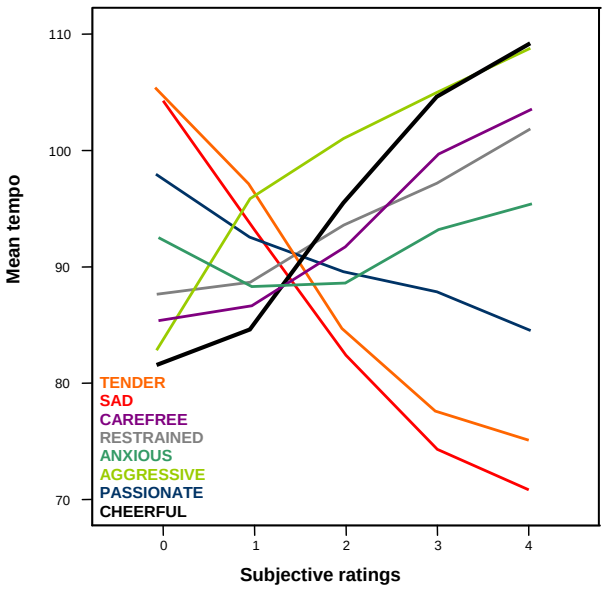


Figure 7: relations between expressive affective qualities and musical tempo



In the context of the current explorative study we are in the first place interested in the degree subjects judged that a certain excerpt would make them “start moving spontaneously”. In order to link this to an aspect - that in our opinion is strongly related to the locomotion system (see our comments in the paragraph “Stimulus” above) - of the musical excerpts we added to the database an estimation of the tempo of the excerpts. Our hypothesis is that the closer the tempo is to 120 BPM the stronger the motion content of the piece will be. Once we had this tempo estimation added to the database it was also easy to see how the emotion related estimations relate to the tempo. Given earlier experiments, e.g. Clynes (1977), there are reasons to assume that there indeed exists a

strong relation between musical emotion and tempo. Such a relation would fit very much in the recent thinking about music as an embodied communication channel for emotions.

In order to relate these semantic descriptions to the musical tempo of the 160 musical pieces three experts (musicologists) determined the tempo of the 160 musical fragments. All three experts used the software Jackson (http://www.jacksondj.com). This software makes it possible to determine the tempo of a musical piece both in a visual and an auditory way. After completing this task we took the tempo where at least two of the three experts agreed upon as the 'right' tempo. These tempi were then correlated with the semantic descriptions of the subjects making use of the gamma correlation coefficient. In the figure 6 and 7 we see the relation between the movement ratings and the mean musical tempo as well as the relations between the ratings of the expressive affective qualities and the mean tempo. All eight adjectives concerning the expressive affective qualities of the music as well as the ratings concerning the physical response show significant correlations with the musical tempi as determined by the musical experts (movement ($r=0.244$, $p<0.01$), tender ($r=-0.312$, $p<0.01$), sad ($r=-0.339$, $p<0.01$), carefree ($r=0.174$, $p<0.01$), restrained ($r=0.089$, $p<0.01$), anxious ($r=-0.037$, $p<0.01$), aggressive ($r=0.290$, $p<0.01$), passionate ($r=-0.102$, $p<0.01$), cheerful ($r=0.272$, $p<0.01$)). In particular it seems clear from these data that our hypothesis, the closer to 120 BPM the stronger the perceived motion content of the music, cannot be rejected. However, a set of musical stimuli with a larger range of tempi is needed to see whether there is really a maximum at 120 BPM.

GENERAL DISCUSSION

In the past different authors have tried to connect music to body movement. In the context of the present study the two most interesting authors are Becking and Clynes. Both authors understood that body movements in synchrony with the musical pulse are part of a multi-layered system. Beckings main idea is that there exists a dynamic rhythmic flow beyond the musical surface. This flow, a continuous up-down movement, connects points of metrical gravity that vary in relative weight. Beckings most original idea is that these metrical weights vary from composer to composer. The analytical method Becking worked out in order to determine these weights was his method of accompanying movements, conducted with a light baton. By studying these conducting-like movements he determined some basic movements. These basic movements form the basic vocabulary that allowed him to classify the personal constants of different composers in different eras (Becking, 1958). Manfred Clynes was one of the first scholars who – making use of his sentograph - really measured body movements while listening to music. Clynes asked subjects to press the button of his sentograph in a repetitive way while listening to the music. Depending on the musical fragment, Clynes was able to distinguish different pressure patterns. Thus, both Becking and Clynes confirmed that synchronizing along with the musical pulse can vary a great deal according to the musical stimuli. Next to moving along with the pulse different qualitative movement aspects can be distinguished depending on the musical content. Becking tried to connect his findings to personal constants of different composers. Clynes explained his pressure patterns in the context of his theory that different emotions are related to different temporal forms (Clynes, 1977). By doing this, he made a very interesting connection between music, motion and emotion.

Similar to the findings of Becking and Clynes we showed in this explorative study that even at the basic level of synchronizing with the musical pulse we can distinguish different levels. We distinguished three levels. With the first level we referred to the act of synchronizing with the musical pulse (does one synchronizes with the musical pulse, or not?). With the second level we referred to the qualitative aspects of the synchronization movements. The third level was defined as the expressive/emotive level in which the synchronization movements are being connected to emotive/expressive contexts.

These three synchronization levels are reflected in the basic conclusions of our study: Most people were able to synchronize with the music in a very accurate way. Next to just synchronizing they were also able to give extra meaning to their movements by varying their movements according to the musical content of the stimuli. This is being reflected in the movement velocities. Although most subjects took a large degree of freedom on behalf of the motional direction, the speed chunks of their movements were in synchrony with the musical pulse. From the second experiment it is clear that people are able to give a good opinion on the fact whether they would move spontaneously on music. Their opinion is clearly related to the musical tempo. It seems that also the emotions expressed by the music depend to a large degree on the tempo of the music. This is not strange as Clynes showed that emotions are coupled to certain movement patterns (gestures) with a specific speed (at a specific tempo?) and form.

We have shown that we can measure quite easily motion related to music and that these movements are musically relevant. We will continue to study this relationship as we have not presented all information that can be obtained from this rich data set.

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