Hype vs. natural tempo: a long-term study of dance music tempi

Dirk Moelants

IPEM-Dept. of Musicology, Ghent University, Belgium

`Dirk.Moelants@UGent.be`

ABSTRACT

Musical tempi found in dance music provide us with information on the relationship between music and movement. Large databases of (dance) music tempi are available as tools for DJs. In this paper, one specific database, the 'Scandinavian Dance Charts' is the main object of study. The database contains the tempi of the Top 40 in the dance charts which is updated weekly since 1998. Analysis of the tempo distributions thus provides us with details on the evolution in tempo over a period of 10 years. The long-term study of dance music tempi may allow us to distinguish between fashion trends in dance music (and dance movement) and the most preferred, natural tempo. It shows that he main peak stays very consistent at 128 bpm, with a small range around it (125-130) representing about half of the total entries. Looking for variation in the data throughout time has allowed us to identify the styles behind different tempo zones and to follow their evolution throughout time. Dance music found outside the preferred range can be associated with different types of movement related to different resonance phenomena.

INTRODUCTION

When studying the relation between music and movement, it seems necessary to examine the tempi of dance music. Contemporary (electronic) dance music has as its main purpose to accompany spontaneous, repetitive body movements in a social context. Dancers are not limited by a choreography, restricting them to specific dance patterns: they are able to express themselves freely in a natural way. This implies that the link between a 'natural body resonance' and the musical tempo should be more obvious than in e.g. ballet music or style-dances. In previous research on tempo preference (Moelants, 2002) we determined the existence of a preferable tempo ranging between 120 to 125 bpm, significantly faster than the 100 bpm found by Fraisse (1982). The preference for tempi around 120 bpm was found in both the distribution of tempi in different samples of music, as in the natural tempo of simple repetitive movements (tapping, clapping, walking).

As became apparent in several independent phenomena, this tempo was considered to be associated with the most natural speed of repetitive movements, or the 'natural frequency' of the human body. Van Noorden & Moelants (1999) developed the resonance theory of tempo perception, in which the human listener is considered as a resonator with a fixed resonance frequency who can start moving under the influence of an external force. In our case the beat of the music functions as a periodic external force and our body has the tendency to move to it. This movement can vary from a purely 'internal' movement, which we typically find with an audience attending a classical music concert. In this case the listeners 'feel' the movement, but don't externalize it. The lack of externalization can be related to the relative weakness of the external force, as most classical music lacks a prominent beat and the performance is not strictly periodic. Contemporary dance music, on the other hand, has a strictly periodic and dynamically articulated beat that, especially when played at a high sound level, almost forces the dancers to start moving. In terms of the resonance theory we could say that the power of the external force is very great. Since dance music is made to make people move and enjoy these movements, it is logical that they will use tempi that correspond to a natural repetitive movement of the body, allowing people to move freely and easily. Therefore studying the tempi of contemporary dance music can reveal interesting information about the relation between musical structure (tempo), music perception and embodiment.

The data used in the analyses are collected from so-called 'bpm-lists': lists containing tempi (in bpm) of large numbers of pieces. These lists, compiled and used by DJs to help them to create fluent transitions between two pieces ('beatmatching'), are made available to the community on the internet. Using these lists as study material has three major advantages. First there is the availability of huge data sets. Gathering information from different sources allows us to get a sample size that could never be collected by an individual researcher. Second, the use by DJs implies a focus on dance music, which forms an ideal subject for studying the relation between musical tempo and body movements. Third, the tempi in the lists are worthless if they do not correspond with the tempo as perceived by the crowd. Hence we could view the compilation of bpm-lists as a large-scale experiment on perceived tempo in music. This is important to solve the problem of metric ambiguity and personal differences in perception (McKinney & Moelants, 2006).

Yet, each of these advantages also has a possible flipside. Thanks to the extensive amount of data and the different structure of meta-data in each list, it is impossible to discover all the pieces that appear in two or more different lists. In some cases even multiple entries within one list occur (e.g. a dance mix and a radio edit of the same song). But this creates in fact a situation in which the most widely distributed pieces have multiple entries, which seems to enhance the validity of the data. The fact that we are dealing with dance music used by dj's, links it to a specific group of people. This music is mainly aimed at and consumed by 'healthy young adults'. Consequently it can not be guaranteed that the outcome of this research can account for the movement patterns of other demographics. Especially one must be cautious to extend the findings to groups with different body structures, such as children or elderly people. Finally there is also a lack of control. In most cases we do not exactly know who determined the bpms and what method was used. At worst one might assume that one might provide the wrong bmps on purpose. However, the analyses don't show any evidence to support this. On the contrary we can expect that a dj who publishes his bpms tries to be as reliable as possible and, moreover, that if there were some

mistakes, the availability of the bmps on the internet might evoke a response from users. We can almost say that we are working with 'peer-reviewed' data, and the 'noise-level' should be lower that what we normally expect in surveys.

EVOLUTION OF DANCE TEMPO OVER 10 YEARS

One list that is particularly interesting to investigate the relation between movement and music is the 'Scandinavian dance charts'. These charts are published weekly on the website http://www.deejaypromo.com, mentioning the tempo of most of the pieces. On their website they introduce the list as follows: "The various charts compiled by *Dee Jay Promotions* are recognized as the official dance charts in their respective countries. Many of these charts are featured on weekly national radio shows. All the club charts are compiled weekly from our 450 professional DJs, these charts reflect tomorrows commercial, leftfield and urban music trends." Within the charts offered by *Dee Jay Promotions*, the data analyzed here are collected from the 'commercial' dance charts, "contributing members are selected from the best commercial DJ's in Sweden, Finland & Norway. Music genres are more diverse." The website also presents two other charts, which have a more specific focus on house, techno, electro (prime cuts) or hip-hop RnB, reggae (urban cuts).

This list thus gives us a detailed view on the tempi heard in discos in Scandinavia on a weekly basis. The semi-official character of this database and use by a relatively broad, but highly specialized community, minimize the risk of mistakes. These data were collected from spring 1998 until now, and thus illustrate an evolution of the tempi people have been dancing to over a period of 10 years. The total number of entries is 19577. Due to the nature of this list, many pieces appear several times. Rather than thinking of a list of musical pieces with their perceived tempo, we could think of the list representing the chance that somebody danced at this tempo somewhere in a Scandinavian disco.

A global view on the tempo content of the 'Scandinavian dance charts' is given in *figure 1*. The mean tempo is 124.1 bpm, with a standard deviation of 13.8 bpm (11.1%). The median is found at 128 bpm, the slowest tempo in the list at 71, the fastest at 200 bpm. The distribution shows a sharp main peak around 128 bpm. With 2210 entries, the bpm number 128 on its own represents 11.3% of the total number of entries. If we include the neighboring tempi 127 and 129, this rises to 27.1% and the zone 125-130 bpm contains 44.2% of the total. Besides this main peak there are two secondary peaks. The first can be seen as an extension of the main peak at the fast side, around 137 bpm, beyond which the number of entries declines rapidly, with only 0.5% of the entries having a bpm of 145 or higher. The second 'peak', covers a broad range, roughly ranging between 90 and 110 bpm, which still contains 14.7% of the data. In view of the 'preferred tempo' around 120 bpm, it is quite remarkable that there is a 'dip' around 115 bpm, with only 4.7% of the data found between 110 and 120 bpm.
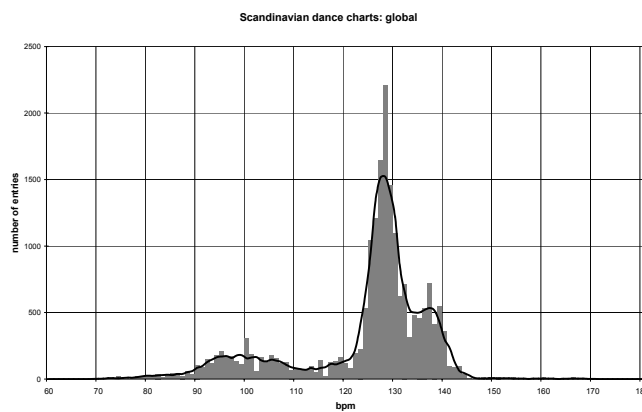

Figure 1. Global distribution of tempi in the 'Scandinavian Dance Charts' between 1998 and 2008, the line represents the average over five neighboring bpms.

Two types of evolution throughout time can be investigated: periodic and linear evolutions. First we can investigate a link between the time of the year and the tempo preference. One could for example imagine that music played in summer is more lively than music played in winter. To investigate this, the data were labeled per month and season. Despite the large number of data, ANOVA shows no effect. The tempi heard in different seasons are intriguingly similar with means of 124.2, 123.9, 123.8 and 124.4 for spring, summer, autumn and winter respectively ($F(3,19573) = 2.05$, $p = .11$). Also the division in months shows no effect of tempo, with means varying between 123.5 (October) and 124.6 (May) ($F(11,19565) = 1.54$, $p = .11$).
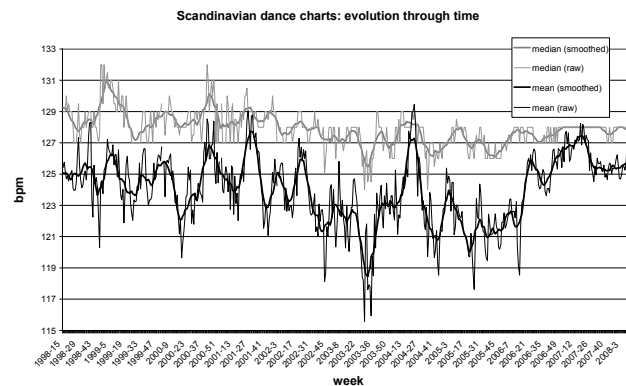

Figure 2. Evolution of mean and median tempo in the 'Scandinavian Dance Charts' between 1998 and 2008, the bold lines represent the averages over five neighboring bpms, the thin lines the raw data.

The linear evolution in tempo is shown in figure 2. Plots of means and medians on a weekly basis show a fluctuating pattern, but no regularity can be seen. To investigate the evolution over a period of time, the data were categorized according to years and seasons. It must be noted that the first data were collected in week 15 of 1998. Therefore the years do not entirely coincide with calendar years but rather with the period of time ranging from week 15 of the main year to week 14 of the next year, thus the division is made somewhere in April rather than with New Year. The distributions found for each of the 10 years is shown in *figure 3*. In *figure 4*, the

relative weight of the different tempo zones is illustrated and *figure 5* shows the mean, median and mode for 4 x 10 = 40 seasons from spring 1998 to winter 2007 (weeks 13 and 14 of 2008, normally associated with the spring season, were linked to winter 2007 as they did not contain enough data to establish an independent category).
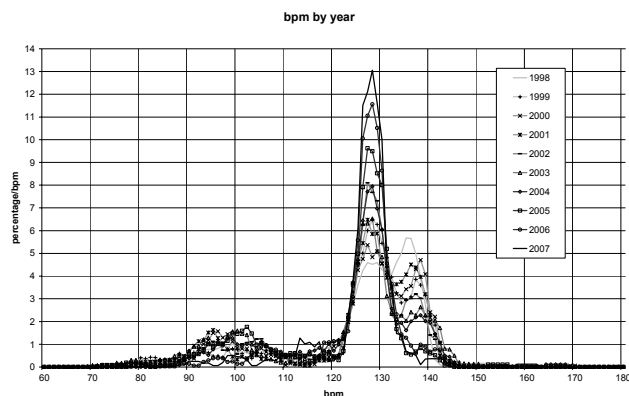

Figure 3. Distribution of tempi for each of the 10 years contained in the 'Scandinavian Dance Charts'.
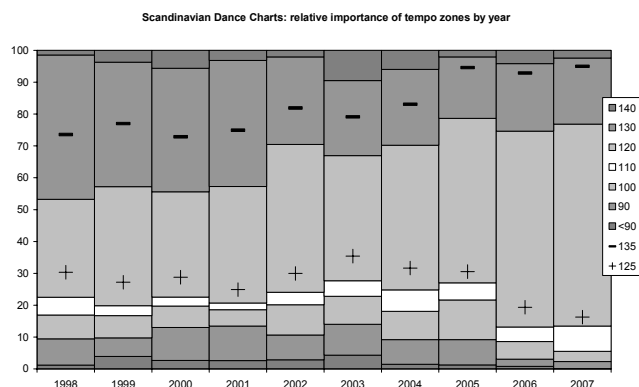

Figure 4. Relative distribution of the different tempo area's: < 90, 90-109, 110-119, 120-129, 130-139, 140 < and the position of 125 and 135 bpm for each of the 10 years contained in the 'Scandinavian Dance Charts'.
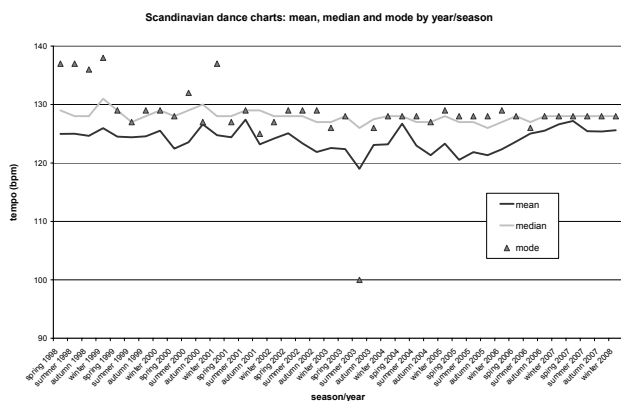

Figure 5. Position of mean, median and mode for each of the seasons (4 x 10 years) in the 'Scandinavian Dance Charts'.

When we analyze these figures we can make a series of observations. First it is clear that the range between 120 and 140 is very dominant, containing between 62.5% (2003) and 84.1 % (2007) of the entries. Within this range we see a gradual shift from tempi above 130 to tempi below 130. The main peak around 128 gradually becomes sharper, but its location is extremely stable. This is less the case with the secondary peak around 137, while the main peak in 1998 is located at 135, it gradually moves to a somewhat faster tempo, reaching 138 in 2003, and at the same time declines, until there is nothing left of a peak since 2005. So within the 130-139 category, the entries near 130 gain relatively more importance during the 10 year evolution. Also in the 'slow' secondary peak in the area 90-110 we see a lack of consistency. The activity in this tempo area in the period 1998-2005 varies between 12.8 (1999) and 20.4% (2005), but rapidly declines after 2005. However the spread of the entries within the zone varies from year to year. The mean and especially the median values are very stable. The mode is usually located near the median, except at the start of the measurement proceedings where is found at the secondary peak and once again in the summer of 2003 where it shifts to 100 bpm. In order to get more insight into the nature of these evolutions, we will compare this to a survey of tempi found in a series of different bpm-lists. This is an extension of the study presented in Moelants (2003).

TEMPO AND MUSICAL STYLE

Besides the Scandinavian Dance Charts, a total of 50 independent bpm-lists were analyzed. The lists contained between 184 and 21734 entries with an average of 2487.6, giving a total number of 124.379 entries. There is a fairly large variety within the collection of lists. The collections are geographically spread (including lists from 10 European countries and from North-America, Japan and Australia) and they focus on different styles and time-periods. Again, we can not avoid overlap between lists, a number of pieces feature in more than one list and is thus counted multiple times in the global analysis. But anyway, the differences in style and origin still guarantee a large variety in content.
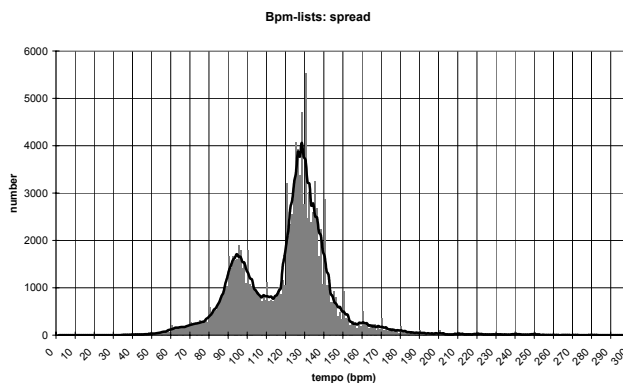

Figure 6. Global distribution of tempi in the combined bpm lists.

The global distribution of tempi is shown in *figure 6*. The mean tempo is 121.9 bpm, with a standard deviation of 24 bpm (19.7%). The median is found at 124 bpm, the slowest tempo in the list at 23, the fastest at 300 bpm. The mode is found at 130 bpm (N = 5521; 4.4%), while 128 bpm, the peak found in the

Scandinavian Dance Charts, ranks second (N = 4709; 3.8%). The main peak covers a range from 120 to 140 bpm, which contains half (49.85%) of the data. There is a clear secondary peak at 95 bpm, with the range 85-105 bpm featuring 21.64% of the data. Also here there is a clear 'dip' around 110 bpm.
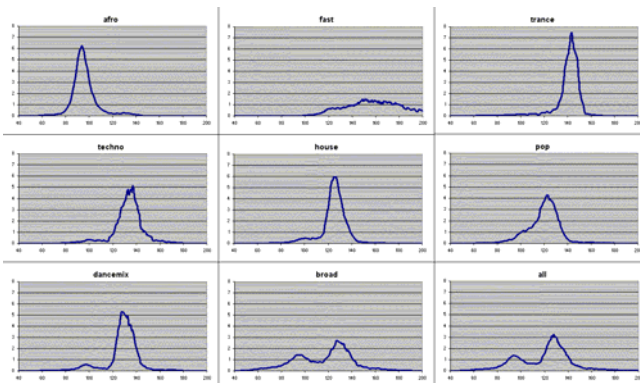

Figure 7. Distributions of tempi in the 8 clusters of bpm-lists, compared with the global distribution.

Differences between the lists are obvious, with means ranging from 92.1 to 203.9 bpm and standard deviations ranging between 5.5 and 38.6 bpm. Thus both the peak and the spread of the tempi in the different lists are highly variable. In order to find similarities between certain lists, we applied a cluster analysis. First the profiles of the individual lists were normalized to percentages, and then the data were smoothed, taking averages over 5 bpms. Looking at the average linkage between groups using Euclidian distance measure reveals 8 different clusters. In *figure 7* we see the distributions of these clusters, while details about the groups are given in *table 1*.

Table 1. Characterization of the 8 clusters of bpm-lists.

	Mean	Median	Peak	%SD	N
1.afro-american	95.1	93.2	93	11.5	8923 (8)
2. fast	171.8	165.0	152	22.5	4929 (2)
3. trance	139.7	142.0	144	8.9	2687 (4)
4. techno	133.0	134.0	134	9.8	3848 (4)
5. house	124.4	125.3	126	9.1	20055 (3)
6. pop	119.8	121.0	122	11.6	5463 (6)
7. dancemix	125.4	128.0	128	11.9	9378 (4)
8. broad	117.4	123.8	128	20.8	69096 (19)
All	121.9	124.0	128	18.7	124379 (50)

The first group unites eight lists (8782 entries), the mean tempo (95.1 bpm) is much slower than the general mean and coincides with the secondary peak in the general distribution. At first sight the lists are not a homogenous group, they include different styles: rap, hip-hop, R&B and soul. Apparently, these styles are linked by a similar distribution of tempi. In fact they also have a similar background that we can describe as

'Afro-American'. The second group contains only two lists (4929 entries), with a high standard deviation and a high mean tempo (171.8 bpm). This group is the least homogenous of the four. Within the lists there is a large spread of tempi and the two lists concentrate on styles that seem dissimilar from each other: boogie-woogie (dance music based on old-style rock & roll) and hardcore-techno (the fastest style in electronic dance music, characterized by a loud repetitive, often distorted, bass and beat). The only thing both styles of music have in common is that they are generally characterized as 'fast'. The third group consists of four lists (2687 entries), it is characterized by a relatively high average tempo (139.7 bpm) and a small standard deviation. Lists in this group concentrate on 'trance' music, an uplifting type of dance music that combines a high tempo with accessible melodies, developed in Europe (Germany, Belgium, Netherlands) during the early 1990s.

The profile of these three clusters is clearly different from the overall distribution (cf. *figure 7*). The profiles of the other clusters are much closer to the general distribution of tempi. However they consist of lists that don't cover popular (dance) music in general, but focus on specific styles. Their peaks are situated closely to the main peak of the overall distribution, but their distribution has different characteristics, usually being less broad (see *figure 7* and *table 1*). Two of these clusters have a focus on particular styles of electronic dance music: the faster, more atonal 'techno' on one hand and 'house', the simpler, melodic 'successor of disco' on the other hand. The other two clusters don't focus as much on a specific style, but rather consist of different 'applications' of dance music, a different social context. One cluster ('pop') includes a broader range of popular music, also containing non-electronic genres (e.g. disco, rock, new wave…). Most typically is a higher representation of tempi in the local minimum around 100 bpm. The other ('dancemix') aims at club dj's, including only dance music, but mixing different styles. We find a certain bi-modality, but the secondary peak is much weaker than in the global profile. This cluster could contain also the 'Scandinavian dance charts' if this list is added to the cluster analysis. Finally we retained an 8th group, containing those lists that do include a general selection of contemporary popular dance music. The profile of this group closely resembles the overall distribution discussed in the previous section. The main difference is a smaller share of 'extreme' tempi.

We can now compare the clusters to the evolutions seen in the analysis of the 'Scandinavian dance charts'. First we see that the clusters 7 & 8, which are style-independent, but still focus on dance music, as well as the global profile, bear a strong similarity to the distribution presented in the previous chapter. Especially the clear peak at 128 bpm and the existence of a secondary peak around 95 bpm share striking similarities. If we then compare the position of the two secondary peaks found in the analysis of the 'Scandinavian dance charts' with the distributions of the remaining clusters, we see the slow 'peak' around 95 bpm, which exactly coincides with the 'afro-american'-cluster . The secondary peak at 137 bpm is situated near to the 'techno' and 'trance'-clusters. The changes found in this 'fast' peak could thus be related to a shift in popularity from techno to trance or other substyles which typically have tempi within this range. While it seems that

techno was the dominant music style in 1998, we then see a gradual decrease, mainly in favor of more 'conventional tempi', possibly related to the 'house'-cluster. Then in the period 2003-2005 we see a relatively strong presence of the 'slow' peak. This coincides that in this period afro-american styles (R&B in particular) achieved great popularity in Europe, an effect that was clearly also felt in the Scandinavian discos! The variability found here can be due to the presence of a large mix of substyles (from hip-hop to soul) and a weaker link to a specific dance movement (cf. infra). Since 2006 it seems that both the secondary peaks have largely disappeared. This can only be explained by a conformation of today's trends in dance music to the 'natural resonance' around 128 bpm. Probably we should just wait a while until a new secondary peak appears which can be linked to a new 'hype' in dance and dance music.

DISCUSSION & CONCLUSIONS

The long-term study and comparison to a diversity of data, obtained from different sources with a different stylistic background, allows us to distinguish between fixed factors and fluctuations related to the emergence of musical styles connected with specific body movements. The analysis of the 'Scandinavian dance charts' over a period of 10 years shows that the main peak remains very consistently located at 128 bpm, this is supported by the data from other bpm-lists, which also illustrate a main peak at 128 bpm. The result of an analysis in which we simply retain the minimum value for each bpm over the 10 years studied is shown in figure 8.
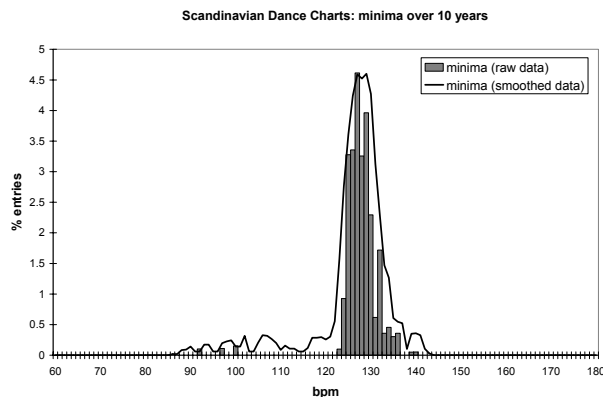

Figure 8. Minima taken from the 10 yearly distributions, column representing the raw data, the line the smoothed data.

Again we see the range from 125 to 130 bpm stand out, with an extension towards 136 bpm. The slower tempi almost completely disappear from the raw data analysis, while some inconsistent noise remains apparent in the smoothed data analysis. This indicates that tempi across the peak range are not permanently played, but belong to certain trends that gain popularity over a limited time-span and are afterwards replaced by new hypes. Looking for variation in the data throughout time has allowed to identify the styles behind different tempo zones and to trace their evolution throughout time (e.g. the decline of 'trance' and fast techno 1998-2004 or the importance of R&B in the period 2002-2005).

The constancy of the 125-130 bpm range suggests that this corresponds to a natural frequency that stimulates people to dance. This fundamental relation to movement and perception fixes the position of the main peak, while the secondary peaks that appear, depend more on trends and the popularity of certain substyles. Dance music not situated within the preferred range can be associated with different types of movement. And can be related to other resonance phenomena. Thus the slower tempi around 95 bpm can be related to more circular movements, such as hip swings, which are often associated with afro-american music and have some sexual connotations. In this case the typical up-and-down, locomotion related resonance is replaced by a fundamentally different type of behavior with a slower natural frequency. When dealing with higher frequencies, an opposite effect could be expected: people will probably make specific smaller movements. However, if we look at the music styles discussed here, notably trance, we might keep in mind the influence of drug-use, especially party-drugs like XTC or amphetamines. It is still possible to move freely to tempi around 140 bpm, but, according to the resonance model, it will take more energy to attain a similar level of movement. Thus the use of stimulating drugs, and behavior imitating this, will make it possible to deal with this higher frequency dancing. If we increase the tempo scale we see that the basic movements become smaller and are combined with larger movement coinciding with lower metric levels. This is the case both in boogie-woogie dancing, where small foot-steps at the fast speed are combined with large swinging movement, as well as in hardcore techno dancing where short kicks ('hakkuh') are combined with slower arm movements.

The natural tempo for dancing within a social context can be fixed around 128 bpm. This is only slightly above the assumed natural resonance at 2 Hz (120 bpm), associated with natural movement in music and repetitive movements like tapping, clapping and waving (Moelants, 2002). The same 2 Hz was found in the long-term energy spectrum of motor activity, measuring different people during their normal daily activities (MacDougall & Moore, 2005). Both the 120 bpm 'spontaneous movement'-tempo and the 128 bpm 'dance movement'-tempo both seem to be quite precisely located. This is shown in the above analysis for the dance tempo and by MacDougall & Moore (2005) for the normal human locomotion. They concluded that the location of the peaks is very fixed among different test subjects, regardless of the mechanical properties of their bodies. The 2 Hz phenomenon is also found in distributions of other samples of music (Van Noorden & Moelants, 1999; Moelants 2002 Interestingly the 'pop'-cluster from our bpm analysis also has a peak closer to 120 bpm. Apparently, typical dance music occupies a special position if you compare it to a more general view on tempo distribution in music. So how can these two frequencies be related? When looking at the differences in speed when walking to music of different tempi, Styns, Van Noorden, Moelants and Leman (2007) found the highest averages in the area 126-138 bpm with a peak at 130 bpm, thus exactly coinciding with the data from the dance music analysis. Bertram (2005) found that at a constrained step frequency of 2.1 steps/s, subjects walked at a speed exceeding preferable walking speed and not chosing the most 'economical' way of walking. He concluded that in this area, the 'cost' of moving faster than the natural, most

economical, speed, is so low that people easily tend to accelerate. We can conclude that tempi around 128 bpm are perfect for a somewhat 'excited' movement and that music provides a good driving force to stimulate rhythmic behavior in this tempo zone. Thus we see a close relation between the characteristics of our body and the structural aspects of music that is designed to make the body move.

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