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Chapter 3
Exploring music-related micromotion

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As living human beings we are constantly in motion. Even when we try to stand absolutely still, our breathing, pulse and postural adjustments lead to motion at the micro-level. Such micromotion is small, but it is still possible to experience it in the body and it is also visible to others. This chapter reflects on such (un)conscious and (in)voluntary micromotion observed and experienced when one attempts to stand physically still, and how musical sound influences such micromotion.

The theoretical starting point of this chapter is that of embodied music cognition (Leman, 2008; see Leman et al., this volume), and the acknowledgement of a close relationship between body motion and musical sound in both the performance and the perception of music (Godøy & Leman, 2010). The last decades have seen a growing interest in the study of what will be referred to as 'music-related body motion' – that is, any type of human motion carried out in a musical context. This term is used here to include the motion of both performers and perceivers, hence covering a broad range of functional motion categories, such as sound-producing, sound-modifying, sound-accompanying and communicative (see Jensenius et al., 2010, for an overview of different types of music-related body motion).

Most studies of music-related body motion, such as summarised in (Wanderley & Battier, 2000; Gritten & King, 2006, 2011; Godoy & Leman, 2010), have focused on fairly large-scale motion. Particularly, the many studies of different types of communicative 'gestures' in the performance and perception of music, focus on what could be referred to as *meso* level (at a centimetre-scale) or even *macro* level (at a metre-scale) actions. Such meso or macro level perspectives are prevalent also in the study of gestures in linguistics and psychology (Kendon, 2004; McNeill, 2005; Goldin-Meadow, 2003). This chapter, on the other hand, focuses on music-related micromotion, the smallest controllable and perceivable human actions, typically happening at a millimetre-scale (or smaller).

The empirical starting point of the chapter is data gathered during three phases of the artistic-scientific research project Sverm. The Norwegian word 'sverm' is quite similar to the English word 'swarm', and was chosen to symbolise the 'flocking' of markers observed in the motion capture recordings of the pilot study. In such recordings, the markers attached to the body of the people being studied move in a semi-random order, yet with a clear directionality as a group. Hence the 'swarm' may be seen as an abstraction of all the tiny actions happening in our bodies at all times. The Sverm project was a two-year-long exploration of physical standstill carried out with a group of professional artists, including composer-musicians, choreographer-dancers and a scenographer. The project culminated in a series of music/dance performances, entirely built up of micromotion and microsound. As it turned out, the Sverm project also forked into some smaller scientific sub-projects about human standstill, with the aim of answering the following questions:

1. How much do people move when standing still in silence?
2. Does the level of standstill change during the course of a standstill session?
3. Does the quantity and quality of standstill change with practice?
4. Does listening to music influence the level of standstill?

The chapter starts with a survey of related literature, followed by findings from the different phases of the Sverm project and a discussion of the elements of body, space and sound from a micromotion perspective.

The micromotion of standstill

The term 'standstill' will be used in this chapter to denote the act of not moving. This term is not so commonly used in the research literature on human body motion, so its usage deserves a brief explanation. In the medical literature, such as in Mulholland (1995), the word 'stillness' is often used to describe the act of standing still. Stillness, however, is clearly ambiguous in a musical context, since the word does not differentiate between the act of standing physically still and that of being silent – that is, making no sound. The same is the case for the term 'quiet standing', which is often used in the biomechanics and physiotherapy literature (Winter, 1995). Other terms commonly found in the research literature include 'immobile', 'inactive', 'motionless' and 'stationary'. These terms, however, suggest an inability to move, while we have focused on studying the motion of healthy people that are trying to stand still. As such, the term 'standstill' seems appropriate, even though it may give connotations to a traffic jam or a machine breakdown. It also effectively describes the methodological approach that is used in the project: people standing still.

Observing people standing still on the floor is a novel method in music research, but it is an approach commonly used in physiotherapy and biomechanics. In these fields the aim is to understand more about the physical and/or cognitive health of the patients, by observing the unconscious and/or involuntary micromotion of people's standstill. In the Sverm project, however, the focus was on using standstill as a method to uncover people's cognition of music, through their bodily behaviour.

Even though standstill may be new to music research, it is not new to music performance. Many musicians use physical standstill to build expectation before or after playing. A famous example is that of Michael Jackson's epic opening of the 1993 Super Bowl half-time show, during which he stood still in front of a cheering audience for 90 seconds. He brilliantly managed to build up a heightened expectation among the thousands of people in the stadium and millions watching through the TV screens, which was followed by a massive 'release' when the music began playing and he began dancing and singing. The 'lack' of performance was also used in a very different, yet related, concept in John Cage's *4'3"*. In performances of this piece the 'absence' of sound and motion of the performer leads to a heightened awareness of all types of other sounds in the performance space (Cage, 1961).

Standstill is also used in the visual arts, such as in the video works of Bill Viola (1995), who explore time-stretching his videos to such an extent that they feel like still images, albeit their slowly moving character. In dance performance, the Japanese Butoh tradition is famous for very slow motion sequences (Kurihara, 2000). The duo Eiko and Koma, for example, have been carrying out performances in which they have been standing, sitting or lying almost still for extended periods of time (Yamada et al., 2000). One example is their 1998 performance installation *Breathe* in which they lay naked still on the floor for several days. In the performance art project *Being on the beach* the participants stood still together while perceiving their surroundings (Refsum & Rimestad, 2013).

Watching others stand still, or performing standstill one your own, is not interesting because of what is not happening, but rather because of the micromotion that actually happens. As living organisms, our bodies are constantly in motion, even when trying to be still. Most such micromotion is produced unintentionally and is so small that it is barely visible at a distance. But the 'invisibility' of micromotion does not mean that it does not affect us. Rather, nuance and expressivity in music may to a great extent be conveyed and experienced through micromotion:

> As opposed to the external motor entrainment initiated by overt body motion, micro-movement might be a natural manifestation of the internal motor engagement (Su & Pöppel, 2012, p. 381).

While micromotion may have not received large-scale interest so far, there are several examples of its investigation over the years. This includes the seminal work on 'microexpressions' by Ekman and Friesen (1969), which focused on how facial micromotion reveal individuals' feelings, and how this can be used to determine when someone is lying. Similarly, research on micromotion of the eyes – such as microsaccades, drifts and tremors – has shown that our eyes are always in motion (Martinez-Conde & Macknik, 2007) and that microsaccades in particular are related to our mental visualisations (Laeng & Teodorescu, 2002).

In biomechanics, standstill has been studied as an example of the 'human pendulum', since we tend to sway in a semi-random pattern as adjustments take place throughout the body (Collins & De Luca, 1994). Many of these studies focus on explaining the biomechanical nature of the swaying by using force plates to examine feet and leg activity (Winter et al., 1998; Loram & Lakie, 2002). There are also examples of how chronobiologists study the temporal and rhythmic nature of human micromotion, with a focus on the various chronobiological cycles happening in the body (Klein, 2007).

In the world of rehabilitation, different types of slow-motion practice or standstill can be found in traditions like Feldenkrais (Feldenkrais, 1972), the Alexander Technique (Barlow, 1975), Release Technique (Johnson, 1995) and Kinetic Awareness (Saltonstall, 1988). These tools accommodate a deeper awareness or recovery from misalignments or injuries in the body, often through standstill and a focus on breathing. Similar approaches may be found in different versions of yoga and other physical meditation techniques.

Body – space

To understand the concept of standstill and micromotion better, I teamed up with dancer-choreographer Kari Anne Vadstensvik Bjerkestrand, who has extensive experience working with different types of slow motion practices. Together we carried out a small study in which we would explore micromotion through the act of standing still in silence for ten minutes at a time. This seemed like a good duration to work with, since ten minutes is a sufficient amount of time to get into the state of standing still, while at the same time being manageable from a practical point of view.

Together we carried out fifteen standstill sessions, each ten minutes long. The sessions were done in silence, since we wanted to explore the body and its motion in space before eventually moving to investigating the influence of sound on our motion. The data collection was done using a full-body motion capture set-up of the two of us using a high-quality system from Qualisys (Oqus 300) and also recording regular video as a reference track. Each of the sessions was followed by the recording of qualitative data in the form of notes of our subjective experience of standing still.

Spatial distribution

As we presented in Jensenius and Bjerkestrand (2012) and has been reported also in other studies of the 'human pendulum' (Collins & De Luca, 1994), we easily experienced how our swaying, shifting of weight, breathing and heart beating influenced our micromotion when standing still. This micromotion was also easily picked up by the motion capture system. To give an impression of what the data looks like, Figure 3.1 shows a plot of the head marker of one person's motion capture data. The two-dimensional plot in the figure can be seen as displaying a person's motion pattern from above, with the nose pointing upwards in the image. This plot shows that there is more motion in the Y plane than in the X plane, which is to be expected since the feet stabilise the sideways motion better than the front-to-back motion. There is much less motion happening on the Z axis (up–down) than on the two other axes. This is also as expected, since a person standing still will not move very much up and down, although one may often find that a person will either tend to straighten up their back (increase height) or ‘fall’ together (decrease height) over time while standing still.

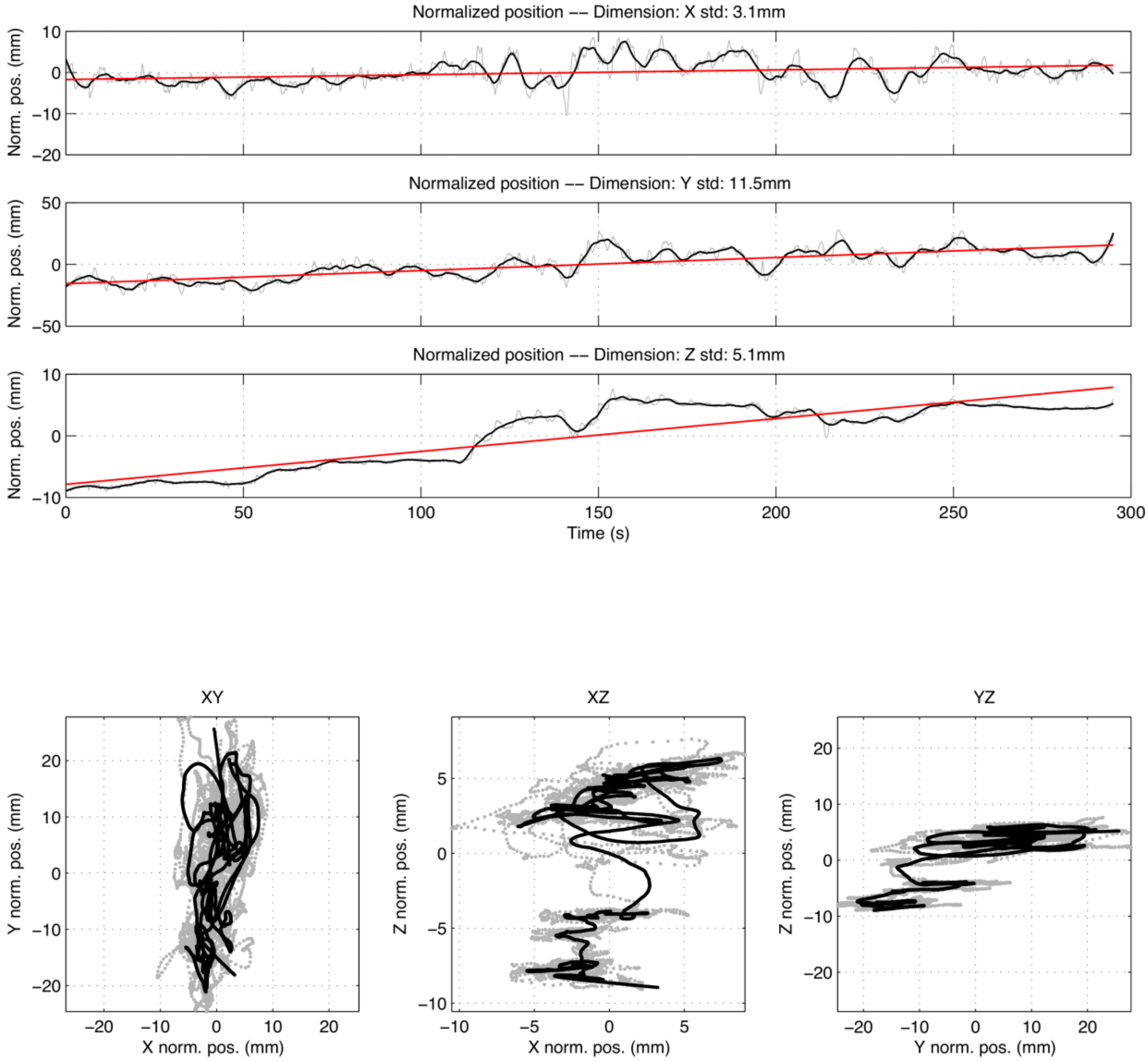

Figure 3.1: Example plots of the X (sideways), Y (front-back) and Z (up-down) axes of the normalised position of a head marker. The grey line is the raw data; the black line results from a ten-second smoothing filter; and the red line shows the linear regression (the trend) of the data set.

Temporal levels

From the motion capture data we were also able to identify different temporal levels of motion. Adhering to the micro-meso-macro convention for the spatial levels mentioned in the introduction, we ended up with a similar three-level description of the observed motion in time:

- Micro: quasi-random motion happening on the scale of milliseconds. This may be caused by tiny adjustments happening throughout the joints to keep the body in balance.
- Meso: periodic motion at intervals of approximately five seconds, which most likely corresponds to respiratory patterns.
- Macro: ‘spikes’ or large-form changes every two to three minutes that can probably be explained by postural adjustments, or periodically larger inhalations.

Several studies have shown a 2 Hz resonance peak in human motion. For example, MacDougall and Moore (2005) found that the vertical acceleration of the head in everyday motion exhibits peaks at 2 Hz, independent of gender, age, height, weight or body mass index. A classic study on human locomotion showed that the preferred walking tempo is 120 steps per minute (2 Hz) (Murray, Drought & Kory, 1964), and other studies have shown that the sustained control of a person's position may be most efficient when carried out as a series of ballistic trajectories at a rate of 2 Hz (Loram et al., 2011). These findings correspond well with studies on the perception of musical rhythm, which suggest that there is a preference for musical tempi of 120–125 beats per minute (bpm) (Moelants, 2002), while the preferred tempo of dance music is a little faster (125–130 bpm) (Moelants, 2008). We were therefore curious as to whether we would find evidence of a similar 2 Hz resonance in our standstill data. As for now, however, we have not been able to find any particular resonance at this frequency.

Quantity of Motion

Starting out with the standstill study, we wondered about how it would feel to stand still for ten minutes at a time, and whether we would experience fatigue or boredom. It was interesting to find that it was in fact very easy to stand still for such a period of time. It most of the times felt relaxing and was at times even exciting. Furthermore, and contrary to our expectations, we did not find any difference in the level of standstill throughout the sessions. The plots of the cumulative distance travelled are virtually linear, and the calculated slopes of the first derivative are close to 0 for all recordings. Neither could we find any difference in the standstill level based on whether we stood still for 5, 10 or 15 minutes. The level and shape of motion was remarkably consistent throughout all of the recordings, which may indicate that each of us has a certain level of standstill in our bodies that it is difficult to alter.

Based on the positive, interesting and, partly, surprising findings from the pilot study, we did a follow-up study, Sverm 2, in which we were joined by violinist-researcher Victoria Johnson for a year-long study of standstill and micromotion. The methodological approach was the same as for the first project: ten-minute long standstill sessions, each being motion captured, video recorded and discussed in the group (see Jensenius et al., 2014, for details). The main difference from the first study was that we used only one, individual motion capture marker per person. In the Sverm 1 recordings we used a full-body motion capture set-up, with markers placed on all the main joints. For the analysis of the Sverm 1 data, however, we mainly focused on a marker placed on the neck, and this turned out to reveal quite a lot of the motion in the body. For Sverm 2 we therefore decided to use only one marker on the head of each person, the most extreme part of the 'swinging body'. Using only one marker per person simplified the set-up, both practically and conceptually, and still provided sufficient amounts of data for analysis.

One of the aims of Sverm 2 was to quantify the level of micromotion happening when standing still in silence, so that this base level could later be used to find how music influenced the standstill. Here we decided to calculate the 'quantity of motion' (QoM) of each motion capture marker by summing up all the differences of consecutive samples for the magnitude of its position vector – that is, the first derivative of the position:

$$QoM = \frac{1}{T}\sum_{n=2}^{N} ||\boldsymbol{p}(n) - \boldsymbol{p}(n-1)||$$

where p is the XYZ position vector of a marker, N is the total number of samples and T is the total duration of the recording. The resultant QoM is measured in millimetres per second (mm/s) and this is the feature and unit that will be used in the rest of this chapter.

Analysing 38 such ten-minute long standstill recordings showed that the individual average values for the three of us were 5.2 mm/s (SD = 1.1 mm/s), 6.4 mm/s (SD = 1.1 mm/s), and 7.3 mm/s (SD = 0.9 mm/s), respectively (Jensenius et al., 2014). The low standard deviations indicate that the results were very consistent over time, particularly considering that the recordings were done over several months, at different times of the day and with varying physical and mental tasks performed during the sessions. Also interesting was that we did not get any 'better' at standing still over time. One could have thought that we would improve our results with practice, but the findings indicate that each person may have a specific level of standstill that it is difficult to alter.

Physical and spatial factors influencing micromotion

During the sessions we experimented with different physical and mental strategies to see whether they would have an effect on both the measurable and perceivable level of standstill. The most influential factors turned out to be:

- Eyes. Keeping the eyes open stabilises the body more than closing the eyes. In fact, recordings with the eyes shut would usually lead to a 1 mm/s higher average QoM.
- Knees. Locking the knees leads to lower average QoM values, as it stabilises the legs more than if the knees are open.
- Arms. Letting the arms hang straight down is the most comfortable and efficient way of standing still. Closing the arms in front of the chest may work for some, but stabilises the body less than letting them hang and may also be uncomfortable over time.
- Feet. The most stable position is to stand with the feet facing forwards and at a shoulder-width's distance. We tried many different feet positions and some of them (particularly the asymmetrical ones) made it virtually impossible to stand still for an entire ten-minute session.

In addition to testing out various types of physical strategies, we also tried to employ different mental tasks while standing still, including employing various meditation techniques, playing mental number games, imagining motion within the body and so on. We also explored how standing in various part of the lab space would influence the experience, such as standing in the middle of the room, close to a wall, and close/far from each other. Interestingly, we have not been able to find any measurable differences in the quantity of motion from these tests. However, while the tasks and physical changes did not influence our level of standstill, these changes did have a major impact on each individual's experience of standing still, for better and for worse. Carrying out a mental exercise, for example, was a very different experience than just letting the thoughts wonder.

It was particularly interesting to find that the placement within the room had such an impact on the experience of standing still, even though it did not lead to any measurable differences. For example, the experience of standing next to a wall was clearly different from standing in the middle of the room, even when the eyes were closed. This may to a large part be based on aural differences; after all, it is easy to hear that you are standing next to a wall based on the perception of the room acoustics. But also the visual component might have had an effect, since standing closer to a wall felt like we were 'leaning' towards that wall. This knowledge about the importance of the position in space later turned out to be useful when developing the final performances of the Sverm project.

Sound – body

After having explored micromotion in a smaller group and over a longer period of time, we became interested in checking the validity of our findings with a larger group of people. This led to a study 'camouflaged' as the Norwegian Championship of Standstill. We had previously experienced that it was challenging to get volunteers for standing still in the lab, but adding a competitive element on a day with many visitors on campus turned out to be an efficient way of getting a fairly large group of people to participate. There are reports on other standstill competitions in which the aim is to stand still for a very long time (apparently up to 30 hours). We were more interested in studying the level and quality of the standstill and also the effect of music on people's micromotion.

Procedure

A little more than 100 participants were recruited to the study, and they took part in groups from 5-12 participants at a time. Not everyone completed the task and there were some missing/erroneous marker data, so the final dataset consisted of 77 participants, 42 male and 35 female, with an average age of 27 years (min=16, max=67). The participants filled out a questionnaire in which they indicated the number of hours per week spent on different music or motion-related activities:

- Listen to music: M = 19 hours per week (SD = 15 hours)
- Play/produce/compose music: M = 8 hours per week (SD = 8 hours)
- Dance: M = 2 hours per week (SD = 2 hours)
- Training/motion: M= 4 hours per week (SD = 4 hours)

The high standard deviations are due to the fact that about half of the participants were music students and professionals spending a lot of time on musical activities, while the other half had relatively little musical activity.

The task given to the participants was to stand still on the floor for six minutes in total, three minutes in silence and three minutes with music. The experiment was presented as a 'championship' of standstill, with an iPod Nano as the first prize. The participants knew that they were part of a research project, but they did not know anything else about the content of the study. They were free to choose their standing position.

The musical stimuli were seven excerpts of 20–40 seconds duration, ranging from slow non-rhythmic music (electronic and acoustic) to dance music (electronic dance music and salsa). The motion capture data was recorded and pre-processed in Qualisys Track Manager and the analysis was carried out in Matlab using the MoCap Toolbox (Toiviainen & Burger, 2010).

The recordings were done with a sampling rate of 100 Hz. The motion capture system was calibrated before each recording session to ensure the highest possible accuracy and precision of the data. We have previously shown that the spatial noise level of the system is much lower than that of a person standing still (Jensenius et al., 2012), and this we also checked by recording the position of a marker placed on a pole standing in the middle of the capture space throughout all the recordings.

Results

In the Sverm project we had found QoM values in the range of 5–7 mm/s for the participants, but this was for only a few people. We were therefore eager to see if we would find a similar QoM level for a larger group of people.

As summarised in Table 3.1, we found an average QoM of 6.5 mm/s (SD = 1.6 mm/s) for the entire data set. The best result was 3.9 mm/s (the winner) and the poorest 13.7 mm/s. These values, however, included both the no-music and music conditions, so Table 3.1 also shows a breakdown of the values in these two conditions, as well as for each of the individual music tracks (parts 2–8).

Table 3.1: Average QoM values for the entire session, no-music and music conditions, and for each of the individual parts.

	No music (3 min)	Music excerpts (3 min)						
Part	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Mean values (mm/s)			6.5					
Mean values (mm/s)	6.3				6.6			
Mean values (mm/s)	6.3	6.2	6.5	6.7	6.5	6.6	6.9	6.7
Standard deviation (mm/s)	1.4	1.8	1.9	1.9	1.7	1.8	3.8	2.3

On average, participants moved slightly more to the 3-minute part with music (M = 6.6 mm/s, SD = 1.9 mm/s) than to the 3-minute part without music (M = 6.3 mm/s, SD = 1.4 mm/s, t(76) = -2.61, two-tailed t-test, $p < 0.01$). This is not a very large difference, but still shows a tendency that the musical stimuli influenced the level of standstill. The results are even clearer when looking at results for the individual stimuli, with relatively high QoM values for the electronic dance music excerpt (part 7, M = 6.9 mm/s, SD = 3,8 mm/s) and for the salsa excerpt (part 8, M = 6.7 mm/s, SD = 2,3 mm/s). As such, the results confirm the idea that 'music makes you move'. This may not be very surprising, but it is still interesting to see that even in a competitive setting during which the participants actively tried to stand still, the music had an influence on their micromotion. In future studies we will also be interested in looking at the influence of the participants' height, age, gender and music/motion background on their QoM results.

Self-reports

From the Sverm studies, we knew that two of the most important factors when it comes to influencing the level of standstill, is whether one is standing with eyes open or closed and with open or locked knees. Hence the most stable position should theoretically be to stand with the eyes open and with locked knees. We did not record any data that would allow for quantifying these two conditions, but the participants did self-report on their strategies for eyes and knees, as summarized in Table 3.2.

Table 3.2: Self-reported standstill conditions of the participants

	Yes	Both	No
Eyes open?	64	8	5
Locked knees?	35	32	10

The participants were not instructed to keep their eyes open or close, but most people decided to keep them open during the experiment. Some participants also reflected on how they used their sight, such as:

I tried to watch a particular point all the time […]

The material does not allow for evaluating what people meant when they indicated that they had both open and locked knees. Presumably they varied during the course of the experiment, but one person also wrote in the free-text field of the questionnaire that:

I locked the left knee all the time, while the right was bent […]

There were also some that reported other types of physical strategies, such as:

I sucked my belly in […]

The participants were asked to self-report on how much they felt that they moved and how tiresome it was. The values, summarised in Table 3.3, indicate that they felt it was not particularly tiresome.

Table 3.3: Self-report on experience (1=low, 5=high)

	Mean	SD
How tiresome?	2.6	1.0
How much motion during silence?	3.1	0.9
How much motion during music?	2.7	1.2

It is interesting to see that several of the participants wrote that they moved less during the sections with music than during the part in silence. This clearly contradicts the idea that 'music makes you move', it contradicts our QoM findings and it contradicts some of the free-text comments, such as:

> *I noticed how I automatically started moving when the music started […] particularly the hip-hop.*

Another had a similar observation:

> *It was difficult to stand still to the 'funky music'…*

The participants were also asked to submit free-text replies on the overall experience. These were generally positive and some people even wrote that the experience had been so pleasant that they would start standing still for a few minutes every day.

Body – sound

The scientific outcomes and the experiential knowledge gained from the first parts of the Sverm project led to the final part, Sverm 3, which was devoted to the development of a music/dance performance based on and around the concept of micromotion and microsound. After having worked analytically for several months, the group was at this stage eager to use the experiential and theoretical knowledge in artistic practice, and particularly in a truly combined music and dance constellation.

Spatiotemporal categories

Throughout the rehearsals it quickly became clear that we needed a common vocabulary to systematically work with relationships between actions and sounds together in the group. Here we ended up combining the three spatial and temporal levels mentioned earlier into a set of spatiotemporal categories, as summarised in Table 3.4. The system is simple and is based on separating both space and time into three levels: micro, meso, macro, as presented above. Even though Table 3.4 refers to some specific number ranges for both space and time, these should be thought of only as indicative. The main point of the system is that the meso level is used to describe what would be considered 'normal' actions and sounds, while the micro and macro levels are used to describe smaller/shorter or larger/longer actions and sounds, respectively. Of course, the interpretation of these levels is highly subjective and also context-dependent. Still the descriptions worked very well within the group, and it was also easy to introduce the system to other musicians and dancers that we occasionally worked with.

Table 3.4: Overview of the spatiotemporal categories developed in the Sverm project (approximate values).

	Space	Time
Micro	< 1cm	< 0.5s
Meso	1–100cm	0.5–10s
Macro	> 100cm	> 10s

From the spatiotemporal categories we were able to create a 'matrix' from which we could also come up with combinations of the different levels. For example, a 'micro-micro action' would designate an action small in both space and time, while a 'micro-macro action' would be an action small in space but long in time. In rehearsals we systematically explored all such possible combinations of small and large, short and long actions, and everyone would easily be able to perform any type of combination spontaneously.

Microsound

While sound had been produced also for the exploration of actions, we next turned our attention to working specifically with sound-producing actions. Here we used the same type of matrix solution to explore different types of sounds. For example, a 'micro-micro sound' would be soft in loudness and short in time, while a ‘macro-micro sound’ would be very loud but short. Again, these categories are highly subjective and context-dependent, but the system still worked very well in a rehearsal context in which it was necessary to try out a number of things in rapid succession.

We found it particularly rewarding to systematically explore combinations of sounds and actions. From nature we are used to a clear causality between actions and sounds, in which the nature and quality of a sound is directly related to its sound-producing action (cf. Windsor, this volume). Since we were working between dance and music, we wanted to explore the two by ‘splitting up’ a sound-producing action into two parts: the action and the following sound. In that way a dancer could perform a ‘sound-producing action’, such as hitting in the air, which was then ‘sonified’ by a musician, for example through a vocal expression from the singer or violin sound from the violinist (see picture from a rehearsal in Figure 3.2). This we did using the above-mentioned matrix, testing connections between short/long and small/large actions followed by short/long and low/loud sounds. At first it appeared mainly as a miming game between the dancers and musicians, with some funny ‘mickey mousing’ effects in between. After getting used to this type of sonic interplay, however, we reached a level at which lots of interesting perceptual ‘conflicts’ were exposed, for example combinations of large/short actions followed by low/long sounds. Such combinations in some ways feel ‘wrong’, but many of them turned out to be aesthetically interesting, and some of them we also developed into parts of the final performance.

Figure 3.2: Two dancers and two musicians rehearsing relationships between actions and sounds at different levels.

Microinteraction

The above-mentioned exploration of 'unnatural' couplings between actions and sounds were performed acoustically by the dancers and musicians. Following from this we also developed a live electronics parts, through what we have called 'microinteraction' (Jensenius, 2017). Here we used the motion capture system (Qualisys Oqus 300) in realtime mode, tracking each of the performers in space. The data was sent to an OSC-controlled sound synthesis system and a DMX-controlled lighting system, for further electronic exploration.

For the sonic interaction we played with a number of different mapping modes, ranging from the direct mapping of marker data to sine tones to granular synthesis playback of pre-recorded sounds. The lighting was also explored fully, from motorised control of light sources based on positioning on the floor to colour transformations based on motion patterns. The perhaps most interesting finding from these explorations was how the microinteraction worked as a 'microscope', expanding the micromotion of the performers into large-scale sound and light effects in the performance space. This was also something that would have a major impact on the final performance.

Putting it all together in performance

The Sverm project and its various forked sub-projects culminated in a series of 45-minute long evening performances focused on 'a micro universe of dance and music'. The performance was built up of seven 'pieces' that in various ways explored the concept of standstill, micromotion and microsound. Being a minimalist project in nature, each of the 'pieces' explored only one or a few key concepts, and each of them also used the live electronic sound and lighting sparsely.

The perhaps most important challenge of the entire process was to develop a performance setting in which an audience could have a meaningful experience of watching the standstill of others. After all, to fully be able to explore the richness of such a 'micro-performance' requires some attentiveness and concentration. Through various workshop presentations and small-scale testing we found that it was necessary to start each performance with the audience members standing still themselves for a few minutes. That way they would 'calm' down, get to experience their own breathing and micromotion, and relax into a state from which they could enjoy the micromotion of the performers. So each of the performances started with the audience members coming into the space and being instructed to stand still and listen to ambient music for five minutes before sitting down. This was a very easy and efficient way of preparing the audiences for what would come.

From the performers' point of view, the main challenge was to learn how to turn the inwards-facing focus of a regular standstill session into a performance context. Here it became important to differentiate between the 'state' of standing still and the 'action' of carrying out motion at a micro-level, such as moving the finger one centimetre over the course of ten minutes (Jensenius, 2016). At first, it was not immediately clear whether an observer could actually spot the difference between a state and such a microaction. From the performer's perspective, however, it is quite different to walk on stage with the intention of standing still for ten minutes as compared to carrying out a 10-minute long microaction. In the end it also turned out that the focus of the performer's intention and attention was clearly visible to the audience.

The use of interactive lighting and sound was very subtle throughout the performances, but the electronics still played a crucial role. The slowly moving light and colour changes helped create transitions between the various parts of the performance, and the lighting was also the most important visual element next to the performers' bodies. Since the performers stood still most of the time, the different lighting conditions helped create very different atmospheres of the performance space itself, but it also helped in emphasising different parts of the micromotion of the performers. The interactive sound played a similar role in creating a sonic environment ranging from the silence of the room to fully spatialised ambient sounds. Two of the pieces also contained direct mappings from micromotion to sound synthesis, during which the sound worked as the 'motion microscope' mentioned above.

We performed a total of eight 45-minute evening shows, which received both positive reviews and interesting feedback from some of the audience members that were interviewed right after the shows. One participant commented:

> *I didn't know what to expect, but was curious […] at the end it felt like I had been given a massage.*

Many of the audience members commented that they had enjoyed being transformed into 'another time and space'. As such, we succeeded in what we aimed for with the performances.

Conclusions

Summing up, this chapter has presented results from a nearly two-year long exploration of human micromotion in the project Sverm. Combining scientific and artistic aims and methods, I worked together with a group of musicians and dancers to gain both experiential knowledge of the phenomenon of micromotion in music and dance but also to develop a conceptual model for using this knowledge in artistic practice.

We found that most people move their head at around 6.5 mm/s when standing still for sustained periods of time, and that this level is consistent over individual standstill sessions but also across different sessions. Results from the 'Norwegian Championship of Standstill' confirmed that music can affect our micromotion, even though the differences are small. This was only a pilot study, however, so more systematic studies are needed to investigate more closely how (much) music influences micromotion. Here it will also be interesting to more closely study bow people's background influence their results, and also how different musical features (rhythm, melody, loudness, spatialisation etc.) come into play.

In addition to learning more about the effects of music-induced micromotion, it will be interesting to continue exploring the field of musical microinteraction in artistic practice. We have already seen that this level of interaction may open up for entirely new performance techniques, many of which give us a quite different way of exploring body, space and sound in music and dance performances.

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