# Final Report

## 2002 — 2005

## About the psycho-physiological effects of music

## Physiological measurements and clinical studies about the impact of music on the fundamental life processes

## First approach towards a new educational concept

Forschungsnetz Mensch und Musik
Science Network Men and Music

Salzburg, May 12th, 2005

# Content

# Preliminary Report Summary:

# Tomatis Hearing Treatment Study

**(21.01.2002 – 29.04.2002)**

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Salzburg, November 29th, 2002
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# 1 Goal of the Study and the Executing Institution

The goal of the pilot study in question, carried out by a collaboration between the Science Network Man and Music („SNMM“), Mozarteum University Salzburg, and Tomatis International (Germany) GmbH („TID“) was to document the effects of the Tomatis method on musicians. Using specially modified music (Mozart, Gregorian Chants) the treatment is intended to increase hearing ability, and, consequently, vocal ability of persons undergoing the treatment. The goal was therefore to show a correlation between improved hearing and vocal capability using different analysis methodologies (measurement of psycho-physiological parameters, subjective impressions, audiometry, voice analysis) on students studying voice, and thus to verify whether – and wherever possible provide proof of how - music affected with the Tomatis method actually causes such improvements. Additionally, the study was intended to ascertain optimal measurement methods and evaluate the most practical study conditions.

# 2 Methodology

## 2.1 Study Execution

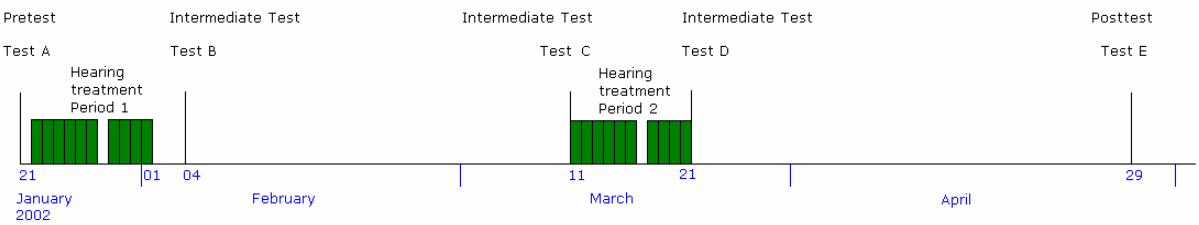
### 2.1.1 Selection of Testsubjects, Exclusion Criteria and Research Specifications

A total of seven male subjects took part in the study (six test subjects with a seventh reserve subject). Their selection was based upon consideration of in- and exclusion criteria (singers, male, aged 20 – 30, non-smoking, moderate alcohol consumption, no ear, nose and throat disfunction, no long term use of medicinal substances, nor any requirement of logopaedic or phonetic therapies).

The research and testing were carrried out at the center of the Science Network Man and Music (ZIB – Zentrum im Berg) of the Mozarteum University Salzburg. During the treatments all subjects were seated in special reclinable chairs in which they could select an optimal seating (or lying) position. They were allowed to rest, close their eyes or carry out other creative activities, such as drawing, painting or puzzle solving. Only reading, writing, eating and talking were not allowed.

### 2.1.2 Sequence of Execution

Two listening treatment phases were spread over ten days each (with a one day break on Sunday). The two treatment phases were separated from each other by a five week break.

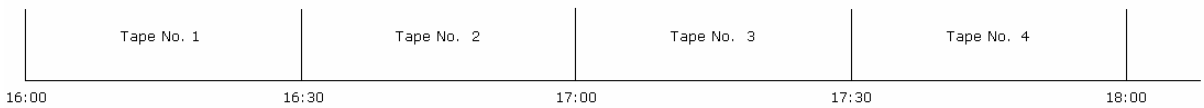



Study Time Schedule

After completing two intermediary monitoring phases – Test B and Test D – analysis of the collected data could begin.

Each listening-session was based upon a similar principle: 4 sequentially executed half-hour non-stop segments, during which various compositions of Mozart (or Gregorian Chants) were played to the subjects. The music played was affected in the way that frequencies were slightly altered by filtering. The selection of the four musical pieces to which seven subjects were exposed was determined by criteria set by the Tomatis Institute. (Selection and filtering can be viewed in the complete study report).

Commencement of the listening sessions always took place at 4:00 p.m, followed by a ten minute break upon completion of the listening sessions.




Time schedule of each listening session.

### 2.1.3 Testing Methodology

On the test days A to E the following methodologies were used (note that not all tests performed were carried out on each day of testing):

- SNMM Questionnaire (Science Network Man & Music) to ascertain subjective states and personality profiles of the subjects
- Tomatis Questionnaires (provided by the Tomatis Institute) to ascertain subjective existential orientation
- Blood pressure relaxation test (ISR – Institute for Stress Research, Berlin) to determine the blood pressure type (normotonic, hypertonic, hypotonic), cardiac type (tachycardial, normocardial, bradycardial), and relaxation level and ability
- Brain hemisphere dominance test (SNMM) to determine the hemisphere dominance
- Equilibrium test (SNMM) as a measure of the subjects' point of equilibrium in the body (to check vestibular behaviour)
- Tomatis Listening Curves (Tomatis Institute) to compensate ~~for~~ deviations from the Tomatis norms for auditory threshold in air and bone conduction, adjusted for both left and right ears
- Ear, nose and throat (ENT) audiometry (ENT clinic of Dr. Schlömicher-Thier) and examination used as a comparison to the Tomatis Listening Curves
- Voice analysis (recordings: Medialab of the Mozarteum University Salzburg; analysis: Institute for Speech Science in the Paris-Lodron University, Salzburg) to determine the changes in vowels, high tonal range, periodicity (vibrato), and proportion of harmonics present

During the listening sessions the following was also done:

- registration of psycho-physiological parameters at the underarm of each subject to record changes in vegetative-nervous and vegetative-emotional conditions as well as the activity of the motor function (SNMM). Every 10 seconds measurements of skin potential, skin resistance, skin and convection temperatures, pulse and heart frequency readings (EMG) were taken.
- on some days blood pressure readings were also taken during listening (blood relaxation test).

- during the two-hour listening sessions detailed notes were made as to which activities and influences were taking place

## 2.2 Methodology of the Analysis

### 2.2.1 General Remarks to the Analysis and Statistics

*The number of executed examinations and tests (10) and relative to the small number of test subjects (6) prevents us from coming to statistically firm conclusions. Therefore conclusions made have the characteristic of setting informative trends.*

As far as possible, typical statistical practices for the analysis of the test results (averages, variation, correlation ranking) were used. Based on the small number of correlatable data gathered, significance tests were not admissible. The evaluation of the psycho-physiological data was done using Balzer-Hecht time-series analysis. Thereby dynamic analysis of regulatory changes was done as verification. With respect to the chronobiological aspects of a biological system, it was possible for the first time to precisely and recursively separate the influence of the individual circaseptian and circadian rhythm from the analysis of the psycho-physiological data gathered. As a result a better comparison of the data measured during the testing was made possible. Additionally, the dynamic analysis made it possible to attribute the summarized data of the various parameters (bodily function) to the previously postulated Yerkes-Dodson Law excitation parameter. It followed that the Yerkes-Dodson postulation that defines a relationship between performance and excitation was true for each test subject studied. Data processing was handled by specially programmed as well as existing software in conjunction with excel (spread sheet) routines.

# 3 Results

## 3.1 Individual Results

### 3.1.1 SNMM Questionnaire

Of the total number of questions (55) in questionnaires A,B,D and E based on the personality of each test subject, eight from A and E are comparable. At the same time there appear to be no clear-cut tendencies. In comparing the questions in Questionnaire E to those in Questionnaire A, none were answered with distinct inconsistencies. Perhaps a slight leaning in a direction could be noted, between „worried“ and „leading“ or „less still“ and „reluctant“.

With regard to questions about the opinion of outside parties relative to any changes as a result of the listening treatments, noticeable improvements in the singing voice and in overall balance of the test subjects was observed.

With regard to their own estimation, subjects sensed the most significant changes in the area of acoustic perception, relaxation ability, equilibrium, attention span, concentration (musical) ability as well as voice perception.

### 3.1.2 Tomatis Questionnaire

With respect to the answers provided in tests A and E of the Tomatis questionnaires, the following could be ascertained:

- greater desire for physical movement for all subjects during the listening sessions
- improved communcation ability and greater attention span
- improvement in hearing and vocal delivery, but with individualized characteristics

### 3.1.3 Blood-Pressure Relaxation Test

The analysis of the six subjects with respect to all of the tests A and E conducted can be discribed as follows:

- four normotonic, one hypertonic and one hypotonic subject
- three normocardiac, one tachycardiac and two hovering between normocardiac and tachycardiac or normocardiac and bradycardiac subjects

Using the relaxation criteria for normotonics (reducing by 13 the systolic measurements), those for hypotonic subjects (reducing by 5) and for hypertonics (reducing by 25) we could characterize one group of 3 subjects as relaxation capable (with respect to

their blood pressure type) and one group of three subjects as non-capabale of relaxation. The calculated averages and deviations of the blood-pressure relaxation tests performed let no conclusion be made concerning the relaxation ability in general or any particular improvement during the period of listening treatment. In general it was observed, however, that the relaxation ability in the majority of the test subjects after completion of the treatments and/or relative to follow-up tests became diminished or was not noticeable.

### 3.1.4 Hemisphere Dominance Test

In view of the data collected two subject groups emerged with respect to the behaviour of the subjects during the treatments. One group (T.B. and M.T) switched to a disturbance signal during tapping; the other (A.P., N.S., M.G., S.H. and F.S.) did not.

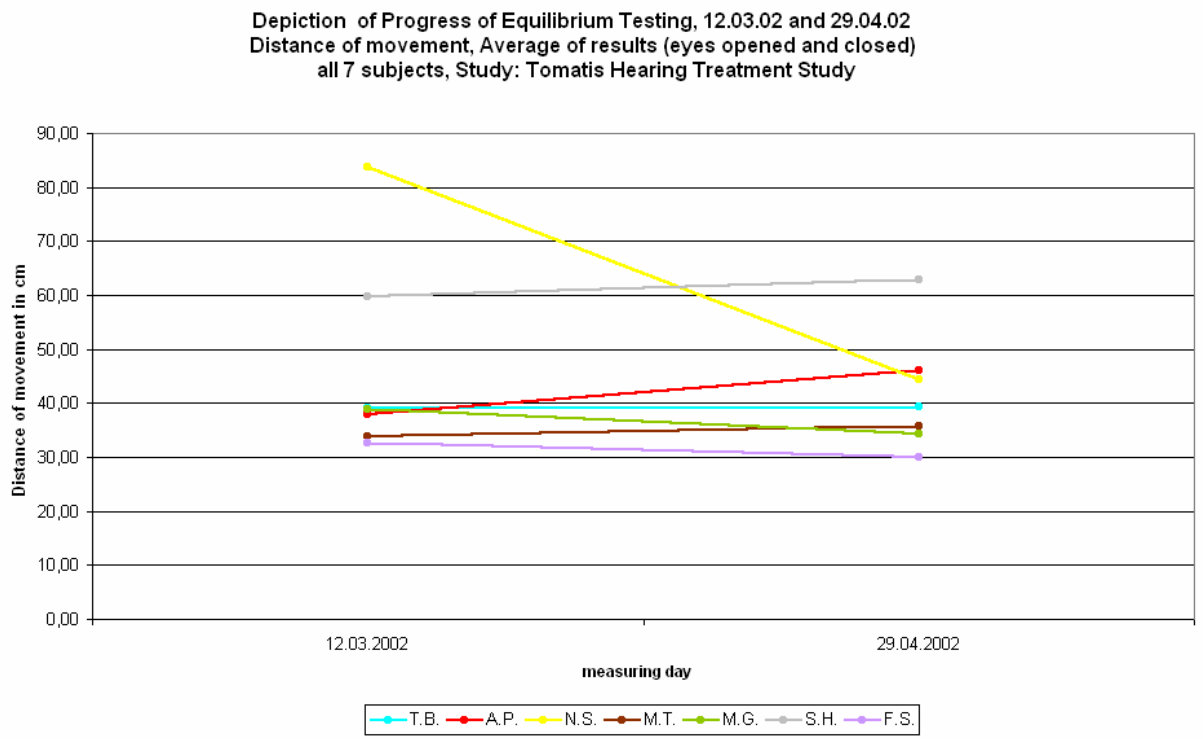
Difficulties were experienced in evaluating the differences between the right and left ears, i.e. between the signal emitted over the left and right ears. In accordance with the order of switching of the signal (whether right was switched sooner than the left) we could determine unanimity only occasionally during a delayed „disturbance signal“ however not during an advanced „disturbance signal“.

A change in the hemisphere dominance from Test A to Test E could not be determined.

### 3.1.5 Equilibrium Test

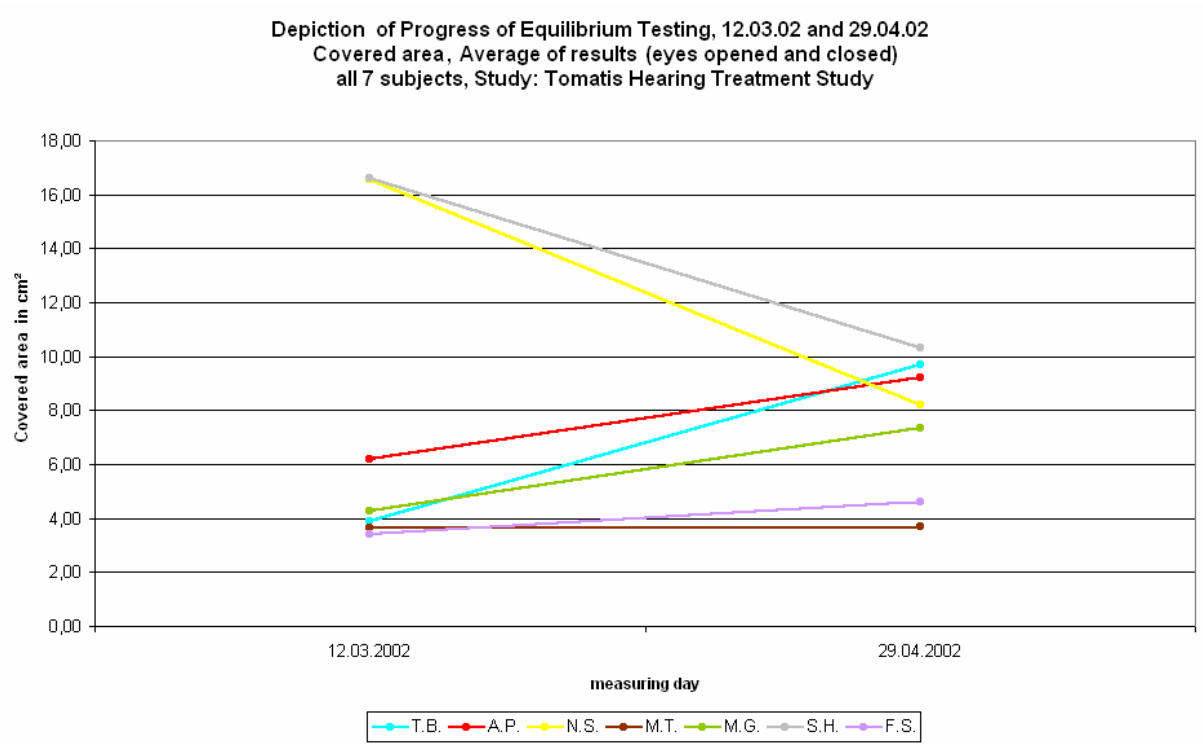
With regard to the analysed parameters *distance travelled* and *area covered* the following trends - measured during the course of the listening treatments in Test A to Test E – were observed:

FIGURE 1




Progression of distance travelled during equilibrium **testing** on 12.03.02 and 29.04.02 (averaged over eyes open and closed) on all seven subjects

FIGURE 2




Progression of area covered during equilibrium testing on 12.03.02 and 29.04.02 (averaged over eyes open and closed) on all seven subjects

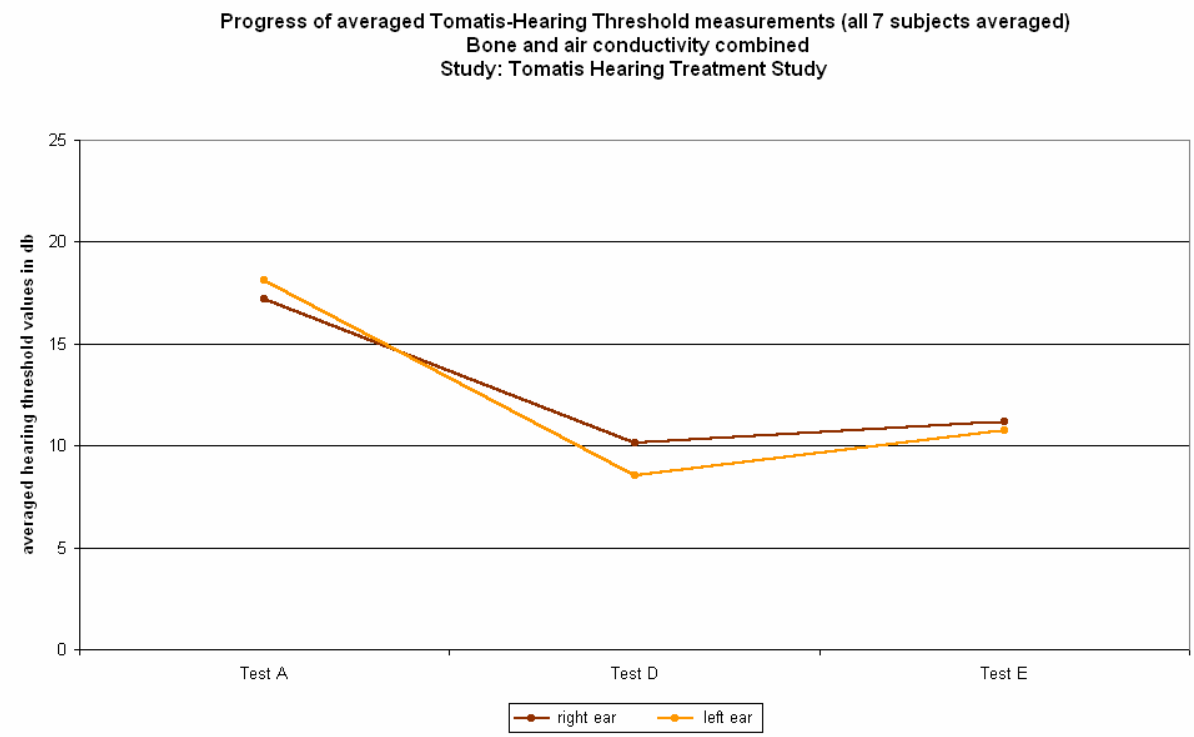
A rising line indicates a worsening of the vestibular activity and a declining line an improvement in the vestibular activity.

The conclusion can be reached that subject N.S., with the demonstratively worst condition at commencement, experienced dramatic improvement while subject S.H., with the second worse condition at commencement, experienced no improvement with respect to distance traveled and shows the markedly worst concluding measurement. Subjects N.S. and S.H., with the largest overall change in value, show the best improvement with respect to area covered – nearly matching the substantially better results of the subjects, who show no significant improvement.

### 3.1.6 Tomatis Hearing Curves

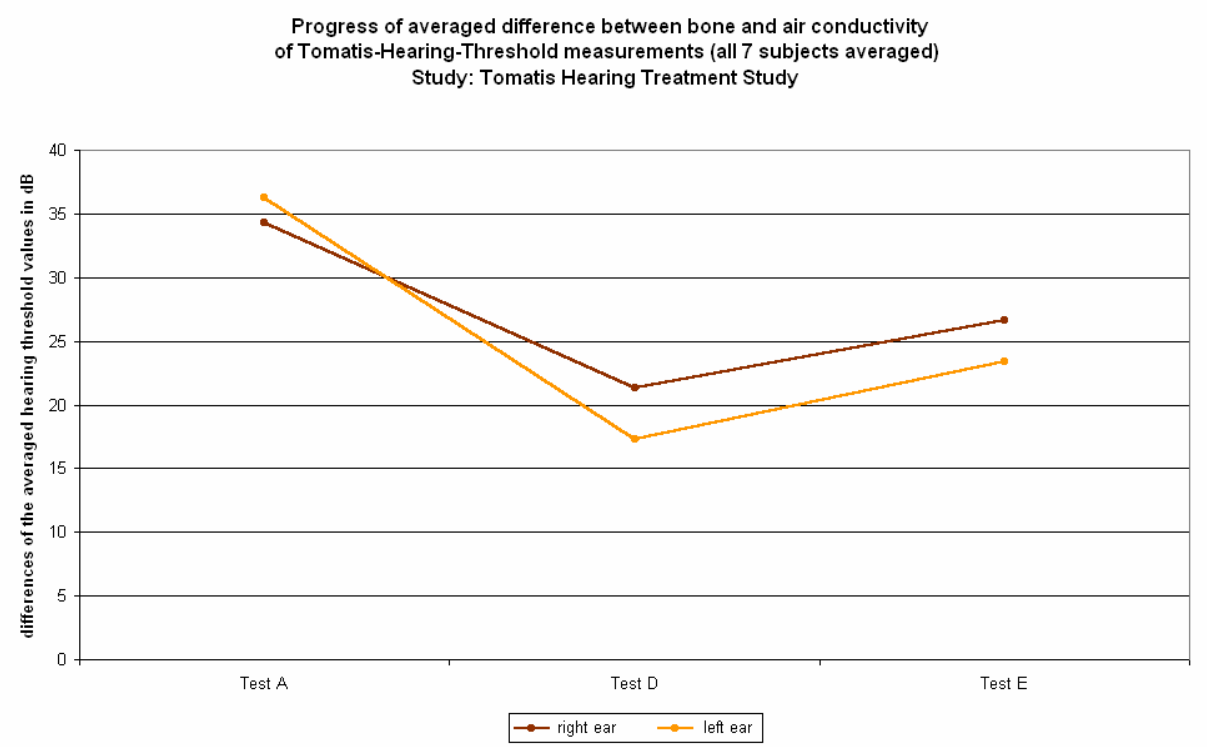
To reach a conclusion about the overall changes in the hearing ability of the subjects, we calculated averages of the single values for the differences between air and bone conductivity of the eft and right ears, along with the averaged values of all seven subjects for air and bone conductivity.

FIGURE 3




Depiction of the course of hearing threshold of all seven subjects, combining bone and air conductivity values

FIGURE 4




Depiction of the course of difference in hearing threshold of all seven subjects, combining bone and air conductivity values

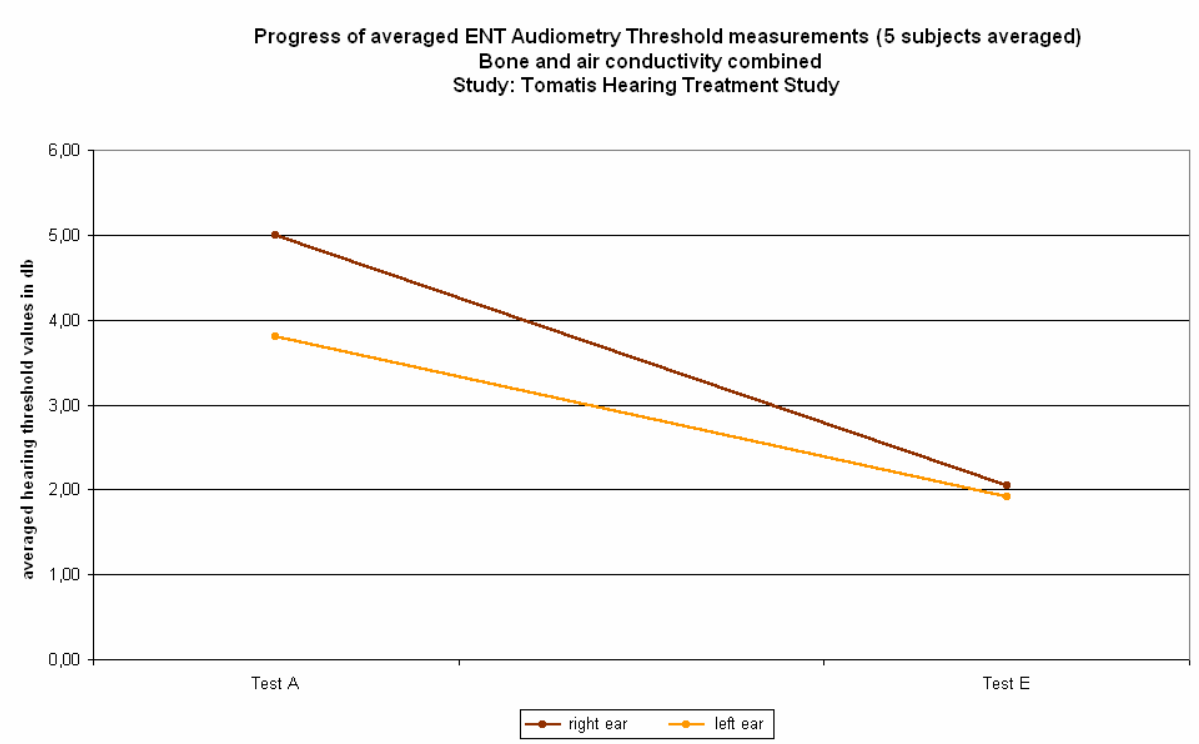
At the start of the listening treatments the subjects showed on average a better hearing capability with their right ear, whereas after Tests D and E this advantage gave way to a slight increase in hearing ability of their left. In total the average value of the hearing threshold in the right ear fell by 7dB in Test A to D, while in the left ear this value actually fell by 10dB. In Test D to E this value rose once again – on the right by 1dB, on the left by 2dB.

Throughout the entire study there was an overall reduction in the values of 6dB for the right and 7dB for the left ears from Test A to E which indicates an improvement in the hearing ability.

### 3.1.7 ENT Audiometry

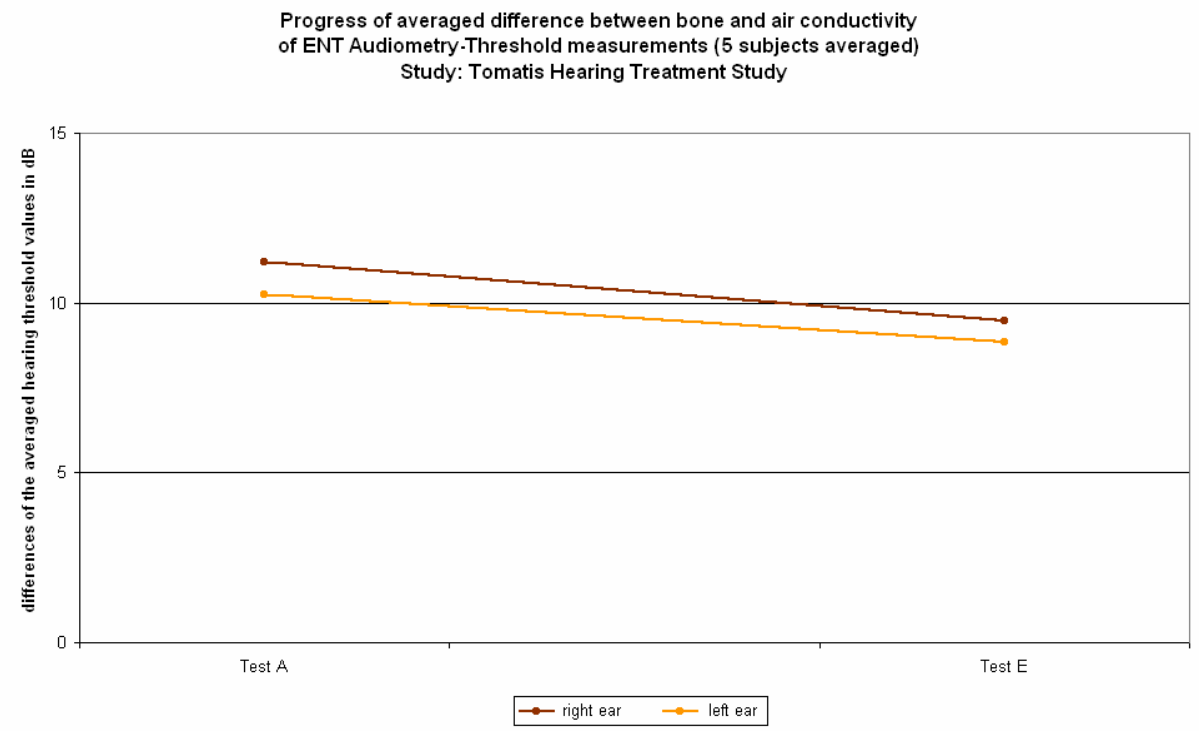
Also included were ENT-Audiometry hearing threshold measurements in our conclusion as to changes in hearing ability of the subjects. Analogous to the Tomatis Hearing Curves showing changes in hearing ability, averages of the single values of the hearing threshold for air and bone conductivity of the left and right ears for each of five of the subjects in Tests A and E were tabulated.

FIGURE 5




Depiction of the course of hearing threshold of five subjects, combining bone and air conductivity

FIGURE 6




Depiction of the progression of the difference in the hearing threshold of five subjects, combining bone and air conductivity

The average hearing capability of the five subjects improved significantly, though the changes in the right ear were the most dramatic. Expressed as dB differential, the average hearing threshold of the five subjects studied fell by 2dB in the left and 3dB in the right ear. These values are of a lower value than even those of the Tomatis hearing curves measurements.

There is even a tendency of lessening with regard to the average differences between the air and bone conductivity. The differences in values between the right and the left ears are relatively minor; the directional changes for both are virtually identical. Over the course of the entire study the differences in value between bone and air conductivity are 1dB on the left and 2dB on the right.

### 3.1.8 Physiological Performance Data

The analysis of the physiological performance data occurred in two stages. In the first stage the process parameters were measured, while the second stage focussed on the analysis of the reciprocity and interaction between measured parameters. As an additional verification, circadian and circaseptian rhythms were used to recursively correct acquired data. This became mandatory in order to eliminate the influence of certain identified bioryhthmical factors and to make the data contrastable.

**Singular Analysis:**

Physiological measurements were taken to document the following parameters and bodily functions during the listening treatments:

- EMG to characterize the muscle activity and the motor function
- Skin potential to characterize the vegetative-nervous condition
- Skin resistance to characterize the vegetative-emotional state

Based on recorded data the following parameters were analysed:

- Dynamic function to characterize the regulatory processes
- Instability of the regulatory processes
- Activation and deactivation relationships of the regulatory processes
- Circaseptian rhythm
- Circadian rhythm

of each of the respective single parameters.

**Complex Analysis**:

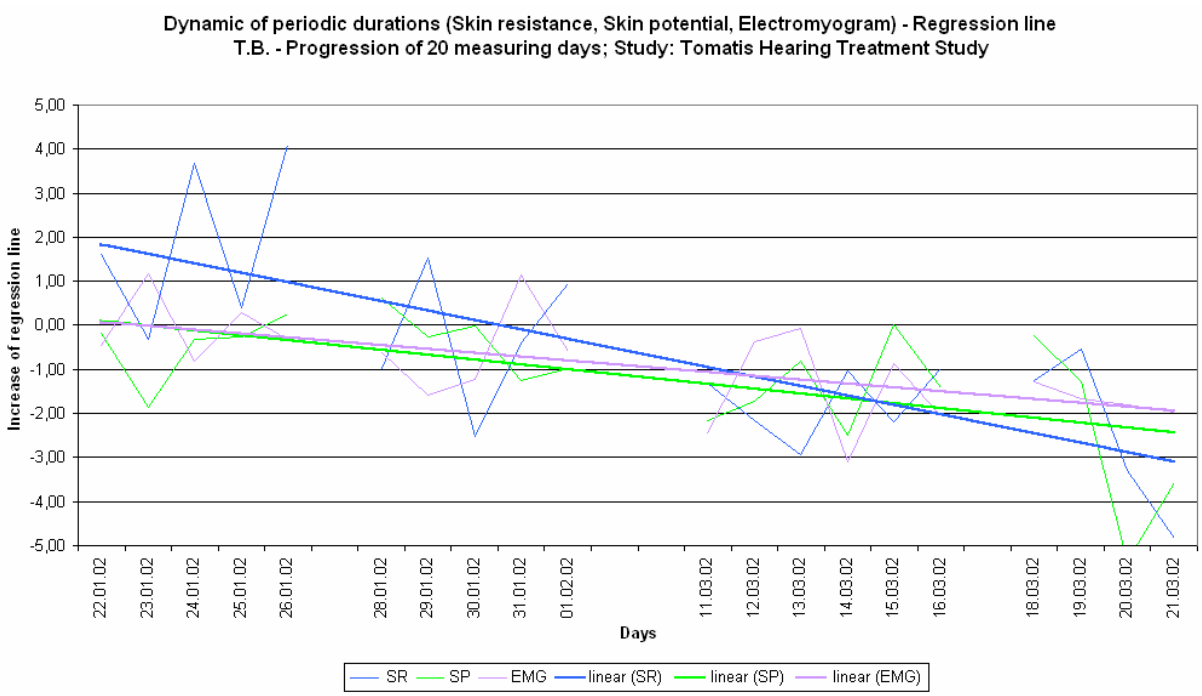
- Determination of the synchronization of regulatory processes of the EMG, skin potential and skin resistance parameters

### 3.1.8.1 Singular Analysis

Typical changes in the dynamic function (regulatory processes) were demonstrated via the three examples in measured EMG, skin potential and skin resistance parameters:

Displayed is the acceleration of regulatory processes of the paramteres EMG, skin potential and skin resistance during the entire hearing treatment relative to the increase of the corresponding regression line.

FIGURE 7




Course of regression line increases in dynamic function cycles with T.B. over 20 days

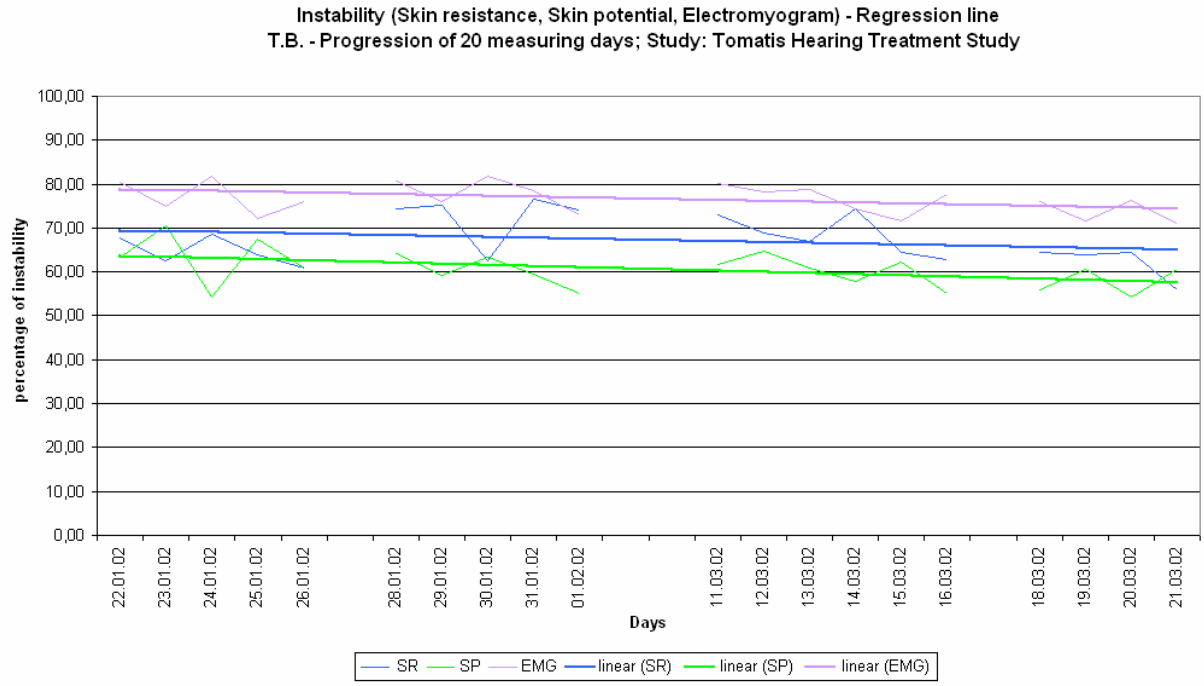
An examination of the regulatory processes of all subjects revealed a clearly identifiable falling of the regression lines of all parameters. This means that during the twenty days of both hearing treatment phases a tendency toward shortened dynamic periods developed and indicates that the hearing treatment did not help subjects attain deeper states of relaxation.

From the data presented in the following table one can deduce that the subjects became increasingly stimulated – rather than less relaxed – during the treatment periods.

| | Average Cycle Duration | | |
|---|---|---|---|
| | Longer | unchanged | shorter |
| Parameters | Number of Subjects | | |
| SR | 0 | 0 | 6 |
| SP | 1 | 0 | 5 |
| EMG | 0 | 0 | 6 |

The typical changes in the stability of one of the regulatory function displayed relative to the instability behaviour of all test subjects:

FIGURE 8




Course of the percentage of instability proportion for T.B. over 20 days measured

| | Instability | | |
|---|---|---|---|
| | rising | unchanged | falling |
| Parameters | Number of Subjects | | |
| SR | 0 | 3 | 3 |
| SP | 1 | 1 | 4 |
| EMG | 1 | 1 | 4 |

In summary it was observed that the instability of the EMG readings rated consistently higher than the two other parameters of skin resistance and skin potential. The single exception was test subject M.T.

Additionally, instability of the EMG parameter in subject S.H. rose considerably while the same parameter became reduced in all other test subjects, most notably with A.P., M.T. and M.G.. Generally there were less noticeable changes in the parameters of skin resistance and skin potential. These therefore demonstrate a consistently stabilizing condition.

A similar picture was revealed with respect to the activation-deactivation rates and for regulatory quality:

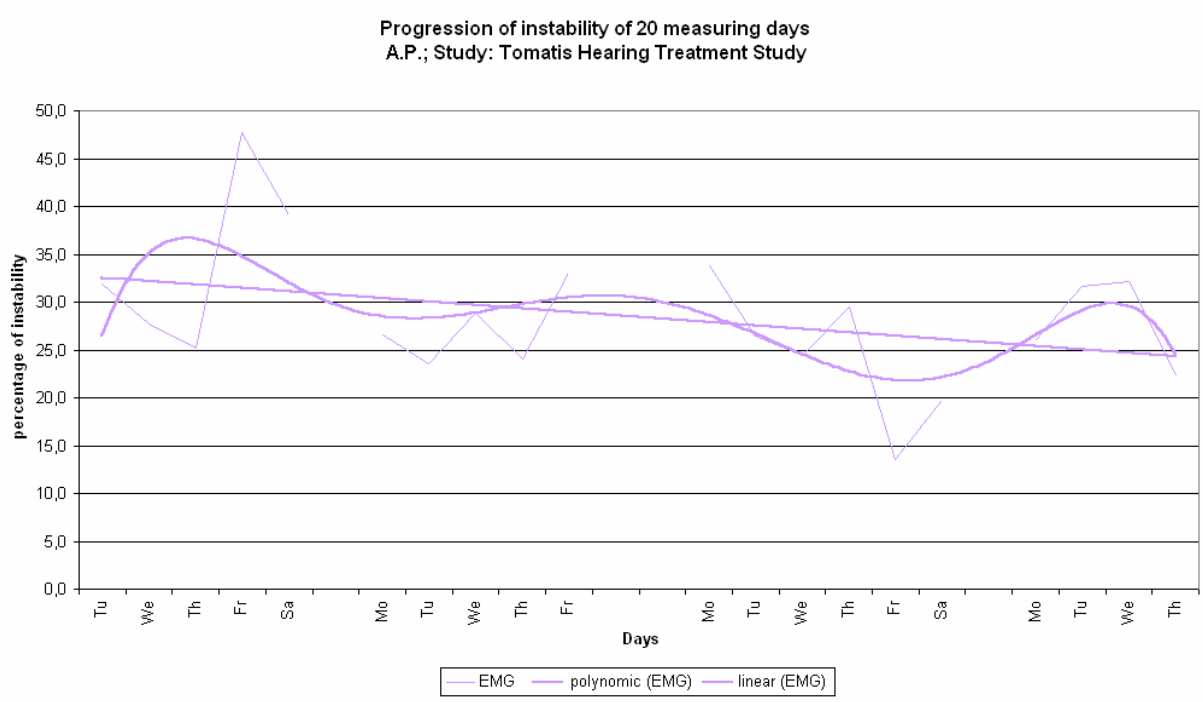
| | Activation Rates | | |
|---|---|---|---|
| | rising | unchanged | falling |
| Parameters | Number of Subjects | | |
| SR | 2 | 0 | 4 |
| SP | 3 | 1 | 2 |
| EMG | 5 | 0 | 1 |

| | Regulatory Performance | | |
|---|---|---|---|
| | better | unchanged | worse |
| Parameters | Number of Subjects | | |
| SR | 2 | 1 | 3 |
| SP | 3 | 0 | 3 |
| EMG | 1 | 0 | 5 |

With respect to the three parameters studied, activation overcompensates for the simultaneous worsening of regulatory quality. The examination further revealed a reduction in the inconsistency of readings in the said parameters – especially after the third week of the hearing treatments.

The circaseptian rhythm (weekly rhythm) was determined by a regression analysis of the summarized proportion of daily instability. Based on EMG readings the following depiction shows an example of the course of verified instability of motor function.

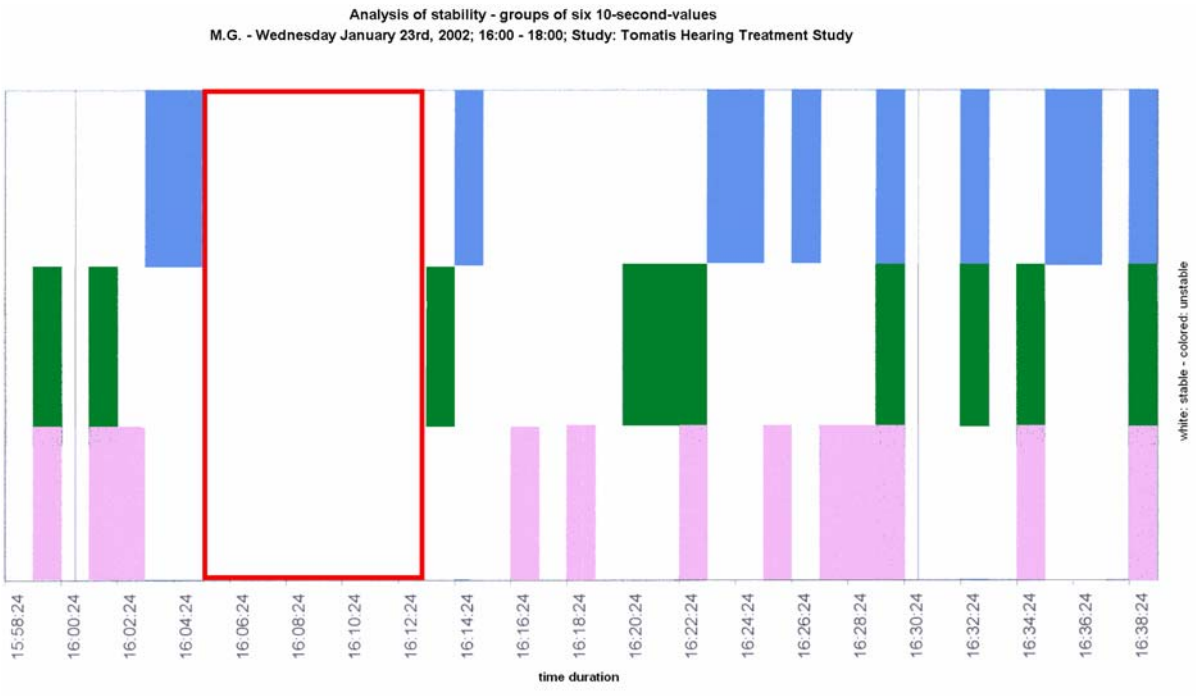
FIGURE 9




Example of a one-week-rhythm of the EMG parameter

The relationship of circadian rhythm relative to the respective person tested is shown one below the other through the acquisition and comparison of the stability maxima of all parameters during each day of testing.

FIGURE 10




Overlap of the stability analysis of the three parameter readings skin resistance (blue), skin potential (green) and electromyogram (violet) to determine circadian rhythm

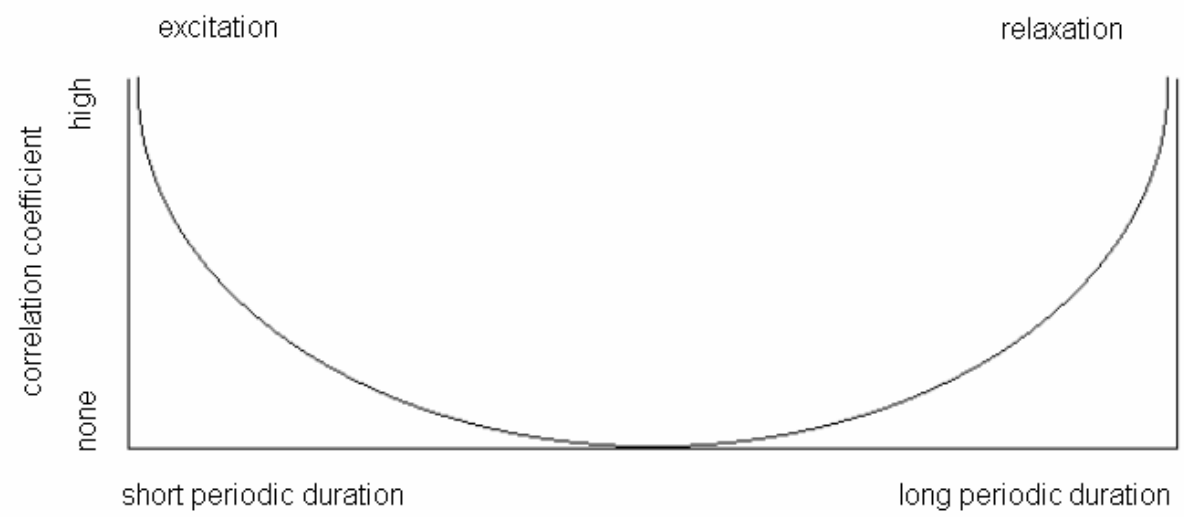
In the above depiction one finds a so-called „sleep-window“ (marked in red) between 4:04 p.m. and 4:12 p.m.

This represents a merging of lengthy stability phases of several parameters. It is our natural tendency toward sleepiness that creates a sleep-window. As a rule, such a sleep-window occurs every four hours within each person. During times where stress is a factor, this window can be shifted by approximately half an hour. The occurrence of the window can also be advanced or delayed through conscious manipulation.

### 3.1.8.2 Complex Analysis – Illustration of Synchronization Relationships

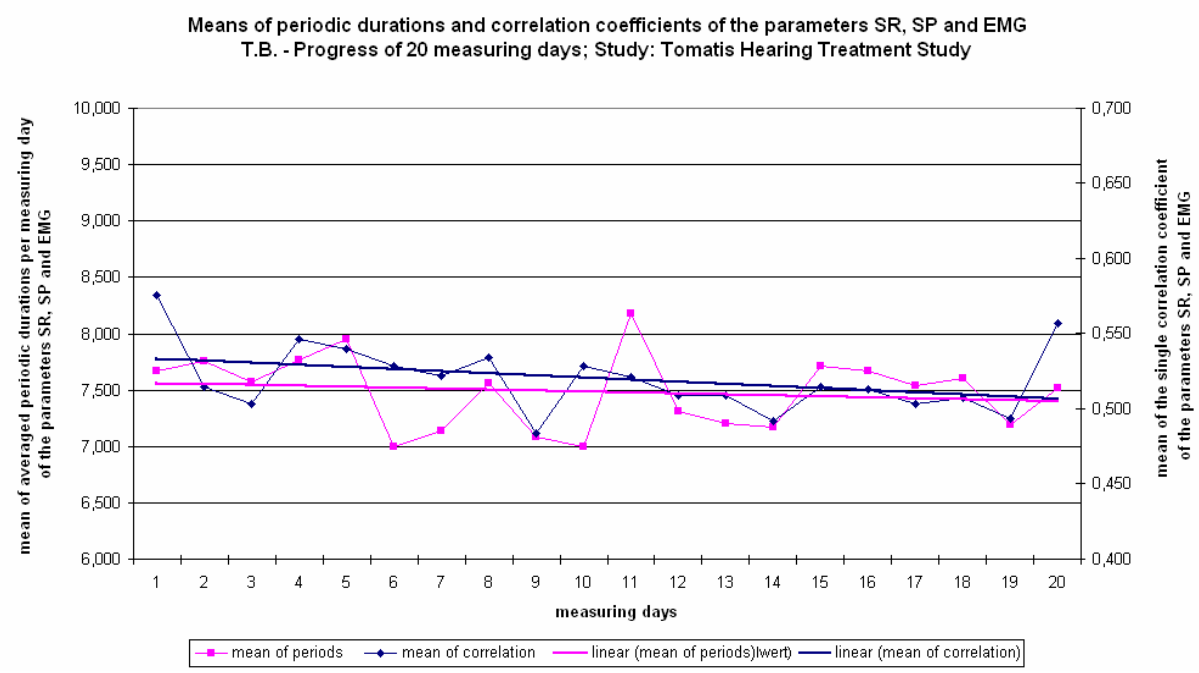
Empirical data has shown a stronger (and therefore higher) correlation between synchronization of regulatory processes of different parameters through excitation – with predominantly short regulatory periods - as well as through relaxation - with consequently longer regulatory periods – than in so-called „normal“ states, where especially the physical and mental regulatory processes work in an antidromic fashion and therefore cause a reduced correlation. The processes described herein can be depicted in the following synchronization model:

FIGURE 11




Model curve: relationship between cycle duration and correlation coefficients. Depending on the area studied the measurement unit of the x-axis can be seconds or minutes or other.

FIGURE 12




Depiction of the one-day relationship when averages of cycle durations and correlation coefficients are superimposed (synchronization)

Actual averaged values of the synchronization between regulatory function of the parameters EMG, skin potential and skin resistance are shown here as an example of one test subject's readings during the listening treatment. Here the synchronization between the named parameters becomes reduced during the course of the hearing treatments while the regulatory processes simultaneously accelerate. A summarizing diagram of all relative results with performance parameters is to follow.

### 3.1.9 Voice Analysis

On account of missing evaluation criteria and because of a too large difference in the occurrence of harmonics, an analysis of the harmonics was not possible[1]. However analyses for three subjects and one reserve subject, performed for the report, were delivered by the deadline of 7.11.2002.

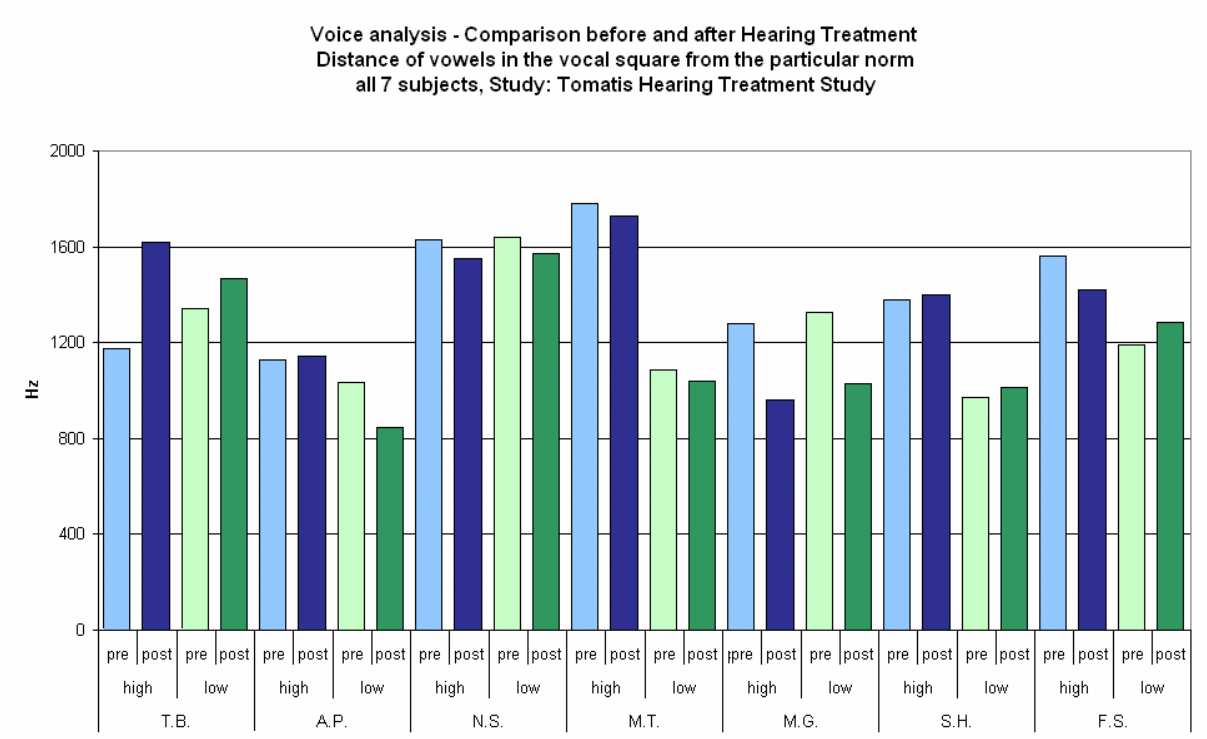
The following examinations:

- vocal formants analysis
- analyses of the tonal range and change
- periodicities analysis (vibrato), and
- analysis of harmonics present

performed for the report were used to compare vocal formant analysis, tonal range analysis and the periodicity analysis (vibrato) between Test A to Test E.

[1] The number of harmonics and their shift in frequency and distance is one of the criteria in vocal analysis, which is why an equal number of measurement values in each recording are required to make an analysis.
The graphical depiction of curves allows us to show more information than the corresponding tables do. The tables are not identical with respect to one another: the harmics have been omitted or other harmonics or numbers of them are depicted. The report does not detail under which criteria the tables were put together or for what reason certain harmonics were omitted. Wherever possible the first, fifth, tenth, fifteenth and twentieth harmonics were selected. In those places where a specific harmonic could not be determined the next neighboring harmonic was used. The numbers in the tables were gathered visually by viewing and copying the data from the computer monitor (telephonic information from Martin Leyrer on 20.11.2002; 14:15 GMT+1)
A programm that converts the depicted graphics into their foundational values is under development.

FIGURE 13




Removal of measurement values from individual vocal deliveries in their respective form

## 3.1.10 Vocal Formant Analysis

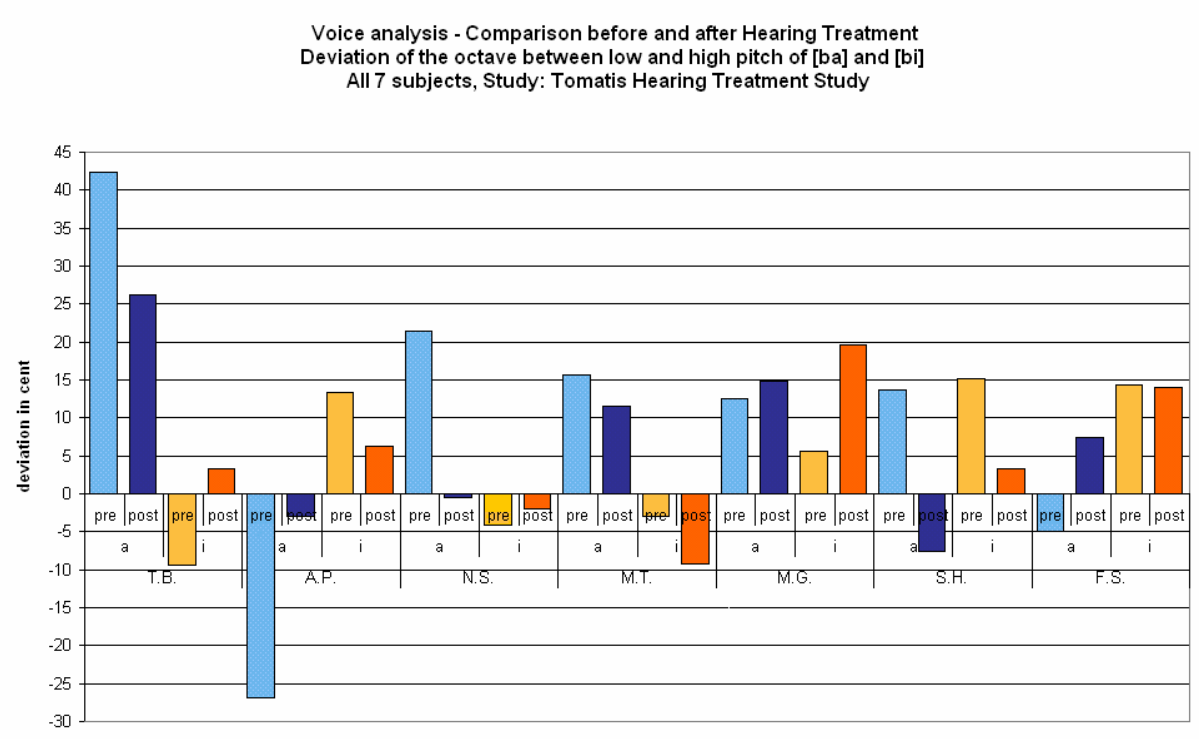
The vocal formant analysis was evaluated on basis of the degree of deviation of the individual vocal measurements from the norm and the voice box covered in each case. Deviations of individual vocals from norm values show a tendency toward a reduction. In subjects N.S., M.T. and M.G. the reduction can be clearly observed, while in subjects T.B. and S.H the deviation from the norm became greater.

## 3.1.11 Tonal Range Analysis

The differences in frequency range between high and low (octaves) for each subject were calculated, and shown as percent deviations from perfect octaves. A small percentage value shows a subject's greater confidence in intonation.

In the following graphic we can see that in comparison of the deviations in voice recordings made prior to and after the treatments, the deviations afterward became significantly reduced. Additionally, it is apparent that in the case of [ba:] the deviations are generally larger than in the case [bi:]. Only in the case of M.G. and F.S. these conclusions are not fully consistent.

FIGURE 14

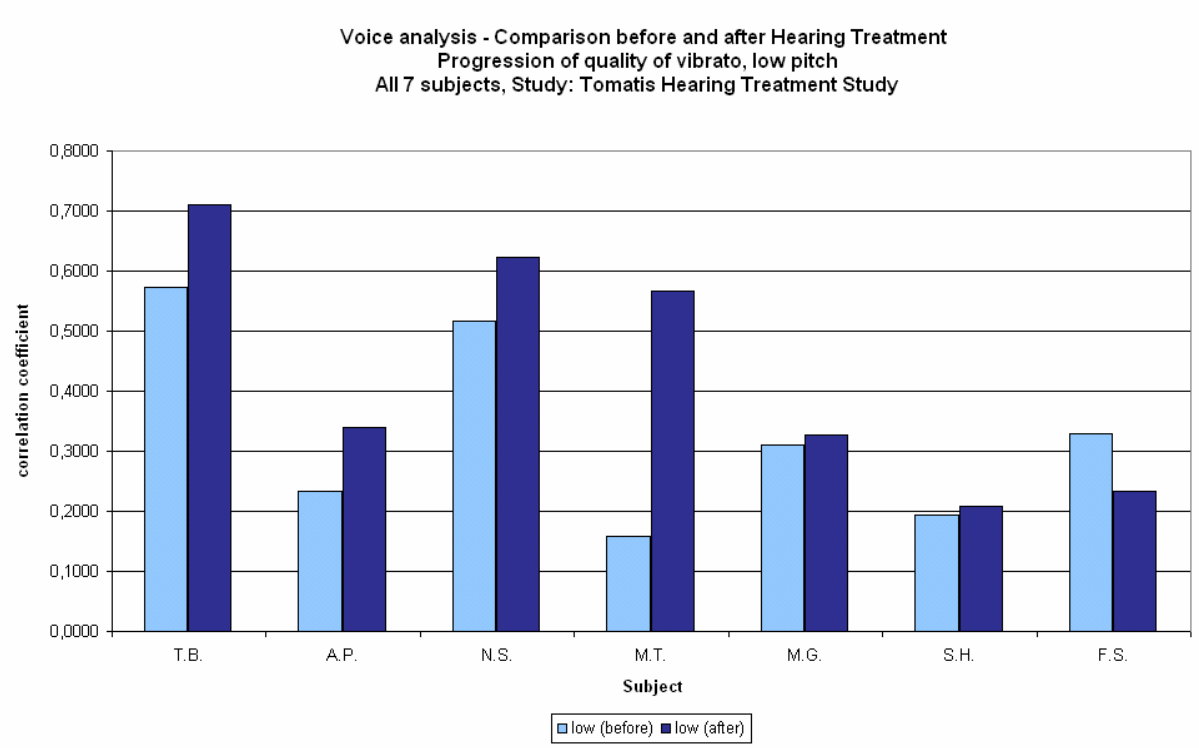



Percent deviation derived from voice recordings, vocal octaves versus perfect octaves.

## 3.1.12 Periodicity Analysis (Vibrato)

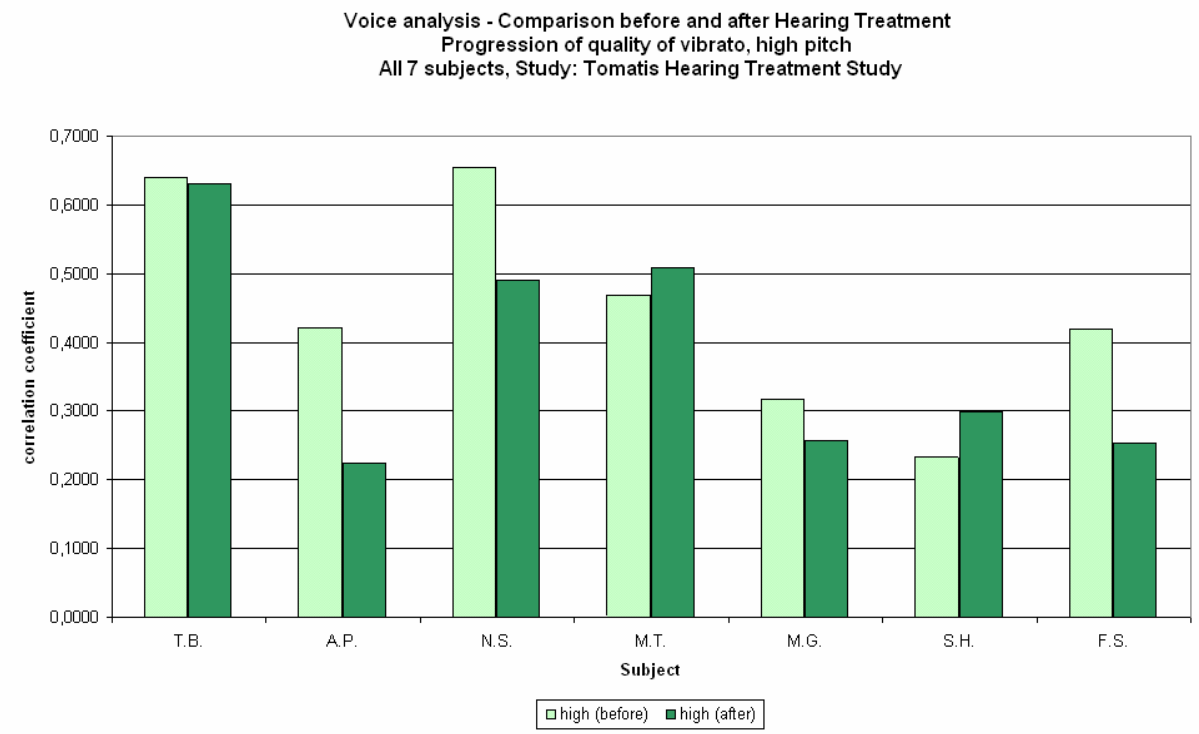
The vibrato was examined with regard to an auto-correlation of its quality. The higher the correlations-coefficient, the more even it was.

FIGURE 15




Development of vibrato quality before and after the hearing treatment in the low range

FIGURE 16




Development of vibrato quality before and after the hearing treatment in the high range

The graphics show that all correlation-coefficients are positive and greater than 0.15. The three subjects T.B, N.S., and M.T., whose vocal studies are directed toward professional singing careers, show, as expected, the highest correlation-coefficients (with exception of the first test on M.T. in the low range between 0.46 and 0.71) i.e. their vibrato is more even (homogenous), while subject S.H. shows the lowest correlation-coefficient. In the case of T.B., A.P. and N.S. it was possible to ascertain higher correlation-coefficients in the low range while not in the high range. S.H. and M.T. showed higher coefficients in both ranges (though in the low range only minimal) while those of F.S. were lower.

## 3.2 Comparative Examinations

### 3.2.1 Hearing Ability

In the hearing curves we saw improvement principally in the form of a decline in the hearing threshold and a reduction in the difference between bone and air conductivity.

Taken individually, measurements conducted of the Tomatis hearing curves in Tests A to E showed an average reduction in compiled hearing threshold values of all subjects studied by 6dB in the right ear and 7dB in the left ear. The improvement could be determined for six of the seven subjects in both ears, while subject S.H. only achieved a lower value in the left ear in Test E. The greatest reduction in the average hearing threshold took place between test A and Test D (7dB in the right and 10 dB in the left ear). Afterward the values measured in Test E rose slightly again. In the case of ENT audiometry the average reduction in hearing threshold lay between 3dB (right ear) and 2dB (left ear).

In the case of the Tomatis hearing curves the differences between the bone and air conductivity readings from Tests A to E were reduced by 8dB (right ear) and 13dB (keft ear) respectively while in the case of ENT audiometry they were relatively slight- only 2dB (right ear) and 1dB (left ear).

This tendency was also verified in the Tomatis Questionnaire with respect to subjective estimation of each of the test subjects in response to the question as to changes in hearing ability were noticed: five of the seven subjects indicated an improvement in their hearing ability. In each case six of seven subjects found an improvement in their acoustic perception (SNMM Questionnaire E) as well as an increase in overall vocal presence (SNMM Questionnaire D).

Additionally a shift in ear dominance (favoritism of the right ear and/or reduced hearing threshold on this side) was examined. A tendency in the direction of an increase toward the already dominant ear was indicated in five of the seven subjects; however no solid conclusion is possible from this. A direct relationship to the ear with the lesser hearing threshold and the one used for telephoning was equally inconclusive.

### 3.2.2 Voice Analysis

Although an acoustic vocal analysis based on Frenkenberger and Leyrer could not provide convincing evidence that the Tomatis hearing treatment had the same effect on all

subjects tested, it does show an individual and variably noticeable change in the singing voice of each of the subjects. The most pronounced effects were those in the timbre and sound complexity generated. With two of the four subjects (S.H. and F.S.) a clear increase in individual harmonics was shown.

More significant changes could be shown in tonality, which pointed to a shift in the values of the higher harmonics after the hearing treatment. In part they approached being a calculated value of the fundamental frequency, and thus increased the subject's ability to hit the correct pitch.

In respect to changes in vowel enunciation it was shown that after participating in the Tomatis hearing treatment, an increase in the voice box size in the lower range was registered, which points to a more exact and decentralized formation of the vowels. The exception was in the high range of subjects T.B. and M.T. (though most noticably in the case of T.B.), and the high range of subjects N.S. and F.S. The most substantial expansion of the voice box in their second recording was by T.B. in the low range and S.H. and F.S. in their high ranges.

With regard to analysis of periodicities, the research report, as well as subjects M.G. (only in the vowel [a:]) and subject F.S., shows irregular fluctuations that turn gradually to more regular ones which can be considered a forming vibrato. In the case of subject M.T. the vibrato improved significantly from the first to the second recording. From the auto-correlation analysis of the SNMM six of the seven subjects tested experienced improvement in the quality of their vibrato in the lower ranges, while in the high ranges this occurred only for two.

A further analysis by the SNMM which calculated the frequency differences between the higher and lower ranges (octaves) and their percent deviation from a perfect octave showed deviations during voice recordings that were performed on follow-up tests. This reveals a distinct lessening than in the pre-study test and indicates a more secure intonation ability. Also noticeable is that in the case of [b:] the deviations are generally larger than with [bi:]. The only exceptions to these conclusions were the subjects M.G. and F.S.

In questionnaires five of the seven subjects felt that their singing voice had positively improved, which was also partly verified by third parties (in five from seven cases). In the SNMM Questionnaire six of the seven subjects came to the general conclusion that they experienced a positive improvement in their musical ability.

The following table shows the comparison between results from voice analysis and questions answered in the questionnaires regarding vocal ability.

TABLE 1

| **Improvement of the Singing Voice** | | |
|---|---|---|
| Test-Methodology | Improvement | Worsening |
| Voice analysis - enlargement of the voice box[2] | 5<br>T.B. A.P. M.T. N.S. M.G. S.H. F.S. | 2<br>T.B. N.S. M.T. F.S. |
| Voice analysis - decrease in distance between vowel measurement and the norm[3] | 4,5<br>A.P. N.S. M.T. M.G. F.S. | 2,5<br>T.B. S.H. F.S. |
| Voice analysis - improvement in exactness of the octave intonation[4] | 5<br>T.B. A.P. N.S. M.T. S.H. F.S. | 2<br>M.T. M.G. F.S. |
| Voice analysis - improvement of the quality of vibrato in the low range | 6<br>T.B. A.P. N.S. M.T. M.G. S.H. | 1<br>F.S. |
| Voice analysis - imrpovement in the quality of vibrato in the high range | 2<br>M.T. S.H. | 5<br>T.B. A.P. N.S. M.G. F.S. |

[2] The subjects T.B. and M.T. improved only in the low range and not in the high; the subjects N.S. and F.S. improved only in the high range (F.S. even dramatically) but not in the low.

[3] Subject F.S. only improved in the low but not the high range. Subject A.P.'s improvement in the low range is only minimal.

[4] Subject M.T. showed improvement only in vowel ‚a', subject F.S. only in ‚i'.

| | | |
|---|---|---|
| Tomatis-Questionnaire B, C and E | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. |
| SNMM-Questionnaire D — self assessment[5] | 5<br>T.B. N.S. M.T. S.H. F.S. | 1<br>A.P. |
| SNMM-Questionnaire E — self assessment | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. |
| SNMM-Questionnaire E — assessment of third parties | 5<br>T.B. N.S. M.T. M.G. F.S. | 2<br>A.P. S.H. |

### 3.2.3 Comparison of the Hearing Ability with Results of the Voice Analysis

In comparing the results of the voice analysis to those of the Tomatis hearing curves as well as those of the ENT audiometry it becomes primarily clear that, with respect to average hearing threshold values, subject N.S. improved in part more than any of the others. The voice analysis also shows he improved in the voice box and particularly noticeably in his confidence in intonation.

These positive changes are substantiated with the results of the equilibrium test, as well as in the self-assessment in the Tomatis Questionnaire, where, in every instance, he claimed the most improvement and/or best experience. With the other three subjects there is no recognizable unifying relationship observed between voice analysis and hearing ability.

### 3.2.4 Psycho-physiological Condition Changes

From the physiological measurement taken, we can deduce that, with exception of subject S.H., the **instability** in the evaluated parameters consistently decreases. In general the parameters skin resistance and skin potential show the least change (toward stabilization) as compared to the EMG readings. The tendency toward stabilization is also confirmed in the results of the **activity** and **regulatory** analyses, where, especially as of the third week, a reduction of the fluctuations in single parameter readings in all subjects was established. All subjects consistently maintained their well adjusted state; the most minimal percentage value of the regulatory analysis lies at a noticeably high 76.65% (with subjects' EMG parameter).

As a basic principle one can deduce that, between the concepts *relaxation level* and *relaxation ability* the following difference can be categorized: the term **relaxation level**

[5] Subject M.G. could not clearly recall.

implies a sense of presently perceived or changing level of relaxation and the ability to enter this level from a present condition or state. In general the difference between these two terms has not been distinguished and the term relaxation is thought to be one and the same as relaxation level (see also Chapter 2.2.3).

To make assertions about the **relaxation ability** of test subjects concerning the physiological measurements taken, we used the criteria of cycle duration. Thus it is recognizable that, in the regression levels of the cycle durations of all parameters, a tendency toward shorter cycles over the course of the twenty day study had set in. Thus we established that during the course of the sessions the hearing sessions do not lead to a state of deeper relaxation in the subjects but rather to a condition where they actually became less and less relaxed but instead more stimulated. This result is confirmed in the blood pressure relaxation readings measured, in which solely two of the seven subjects reached a better state of relaxation throughout the course of the sessions, while the remaining five subjects registered the opposite effect. The **relaxation level** of the subjects measured using a blood pressure relaxation test showed that the relaxation level of three of the seven subjects had improved.

In viewing the following table it becomes apparent however, that these results do not necessarily coincide with the self-assessment of the subjects tested with respect to relaxation in the SNMM Questionnaires D and E. Immediately after the hearing treatments all seven of the subjects found their relaxation ability had improved; in the follow-up test a remaining six of seven subjects.

These seemingly contradictory statements to the measurements for relaxation ability are on the one hand attributable to different measurement times and examination durations. On the other hand there might have been the inability of the subjects to distinguish between the terms *relaxation ability* and the formal term *relaxation level*, since at the start of testing no information was provided to clarify their meaning. Additionally, there is a distinct possibility that relaxation level and relaxation ability proceed contrarily. (See model curve Figure 14 and Example Figure 15).

TABLE 2

| Relaxation Ability | | | |
|---|---|---|---|
| Test Methodology | Improvement | Same | Worsening |
| Physiological monitoring[6] (within 2 hours, over the course of the treatments) | 0 | 0 | 6<br>T.B. A.P. N.S. M.T. M.G. S.H. |
| Blood pressure relaxation test (within 20 min, from Test A to Test E) | 2<br>A.P. F.S. | 0 | 5<br>T.B. N.S. M.T. M.G. S.H. |
| SNMM-Questionnaire D (to Test D) | 7<br>T.B. A.P. N.S. M.T. M.G. S.H. F.S. | 0 | 0 |
| SNMM-Questionnaire E (to Test E) | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. | 0 |
| **Relaxation Level** | | | |
| Blood pressure relaxation test (within 20 min, from Test A to Test E) | 3<br>T.B. S.H. F.S. | 1<br>M.T. | 3<br>A.P. N.S. M.G. |

Comparison of the results from the physiological monitoring, the blood pressure relaxation test and the SNMM-Questionnaire D and E of all six respectively seven test subjects for relaxation ability and relaxation level

From these physiological measurements it could be deduced that the regression level of the subjects T.B. and M.T. moved in opposite directions during the hearing treatment, while those of subjects A.P., M.G. and S.H coincided. A clear tendency in one direction with regard to the quality of progression is not determinable, though it is apparent that the progression of EMG regression levels shows a worsening of regulation. This points to a state of increasing tension - possible because durations of the hearing treatments in these cases were perhaps a little bit too long.

Of interest is also that partially congruent performance values are registered, relative to the regression level tendencies shown in the stability analysis of the physiological measurements of skin resistance, skin potential and EMG, and based upon the progression of normalized blood pressure relaxation values (see for example subject S.H). Here we also see a respective convergence or divergence of the regression levels in stability or a reduction in the variation of the regression levels in the blood pressure levels.

[6] Reserve-subject F.S. was not tested physiologically.

The regression levels of the *instabilities* reflect a pattern that spanned the hearing treatment, while the blood pressure relaxation tests represent a meaurement period of only 20 minutes. The similarities between both regression level values in varying measurement times indicate that the progression of both relaxation or excitation of each subject could be determined.

### 3.2.5 Brain Hemisphere Dominance

The results shown by the hemisphere dominance test provided a comparison between the question in SNMM Questionnaire A about the preferred ear used for telephoning.

If one compares variations in the individual values from the hemisphere dominance tests separated into left and right ears with that of the subjects preferred ear for telephoning we see a high consistency, shown in the table below.

| Subject | Less Variation in Values for Hemisphere Dominance Tests | Preferred Ear for Telephoning |
|---|---|---|
| T.B. | R | L/R |
| A.P. | L/R | L/R |
| N.S. | L | L |
| M.T. | L | L |
| M.G. | R | R |
| S.H. | L | L |
| F.S. | R | R |

We see in comparison of the variation attained from the hemisphere dominance tests to the answers to question 2 out of Questionnaire A regarding the subject's preferred hand for telephoning a consistency of 92.86%. The almost consistently preferred ear for telephoning is also the same ear that had less deviation from the given signal (or disturb signal).

### 3.2.6 Sense of Equilibrium

In the SNMM Questionnaire E four of seven subjects found their equilibrium had improved during the course of the hearing treatment. In the equilibrium test improvements were also registered in four of the seven subjects - however not in the same subjects. Only S.H. and F.S. registered improvements in both processes, while A.P. in none.

### 3.2.7 Questions as to Personality

In accordance with the Tomatis Questionnaire all seven subjects felt an increased desire for physical movement. Six of the seven subjects in the Tomatis Questionnaire also claimed an increased preparedness and ability to communicate, however only three did in the SNMM Questionnaire E.

Other particulars as to self-assessment in the SNMM Questionnaires showed a slight shift in the sense of being „worried“, „leadership oriented“, and „less still and reserved“.

Five of the seven subjects registered an improvement in their personality overall. And increases in alertness (six of seven subjects in Test D – however only 3 in Test E) and mental balance especially (all seven of the subjects tested in Test D and four of the subjects in Test E) were indicated. Positive changes regarding the mental balance (Test E) of the same four subjects were also registered by third parties.

### 3.2.8 Group Formation

Based upon the results of the physiological measurements, two groups (subjects T,M,M, and subjects A,N,S) took form.

When comparing the productivity-excitation curves to the blood pressure relaxation test, the equilibrium test and hemisphere dominance test, the same group formation (ANS, TMM) appears once again (with exception of M.G., who distinguishes himself from the others with respect to the hemisphere dominance test). Noteworthy is the fact that group TMM has a noticeably high correlation factor of 99% with respect to performance-excitation curves. Group ANS has a correlation factor of 88%.

Based on elapsed time during the changes in the performance-excitation curve, the group ANS can be categorized into the left side of the curve progression of the Yerkes-Dodson principle, while the group TMM into the right side. Therefore we can draw the preliminary conclusion that group ANS experienced an improvement in hearing ability through stimulation in the sense of activation or excitation, while group TMM improved with a reduction in excitation. This does not contradict the previous conclusions, that the treatments did not cause relaxation in the test subjects, because excitation is a more complex parameter derived from determining the interaction that synchronizes a variety of bodily functions. The fact that both groups attained a better hearing ability, despite a difference in their performance, is attributed to their initial states. After the results were tabulated it was found that, at the start of the hearing study, subjects of group ANS were still ahead of their performance peak, while the subjects of group TMM had moved into a descending part of their performance-excitation curves. This is also reflected in the results of the blood pressure relaxation tests, which showed group ANS to be principally relaxation capable, while group TMM tended not to be.

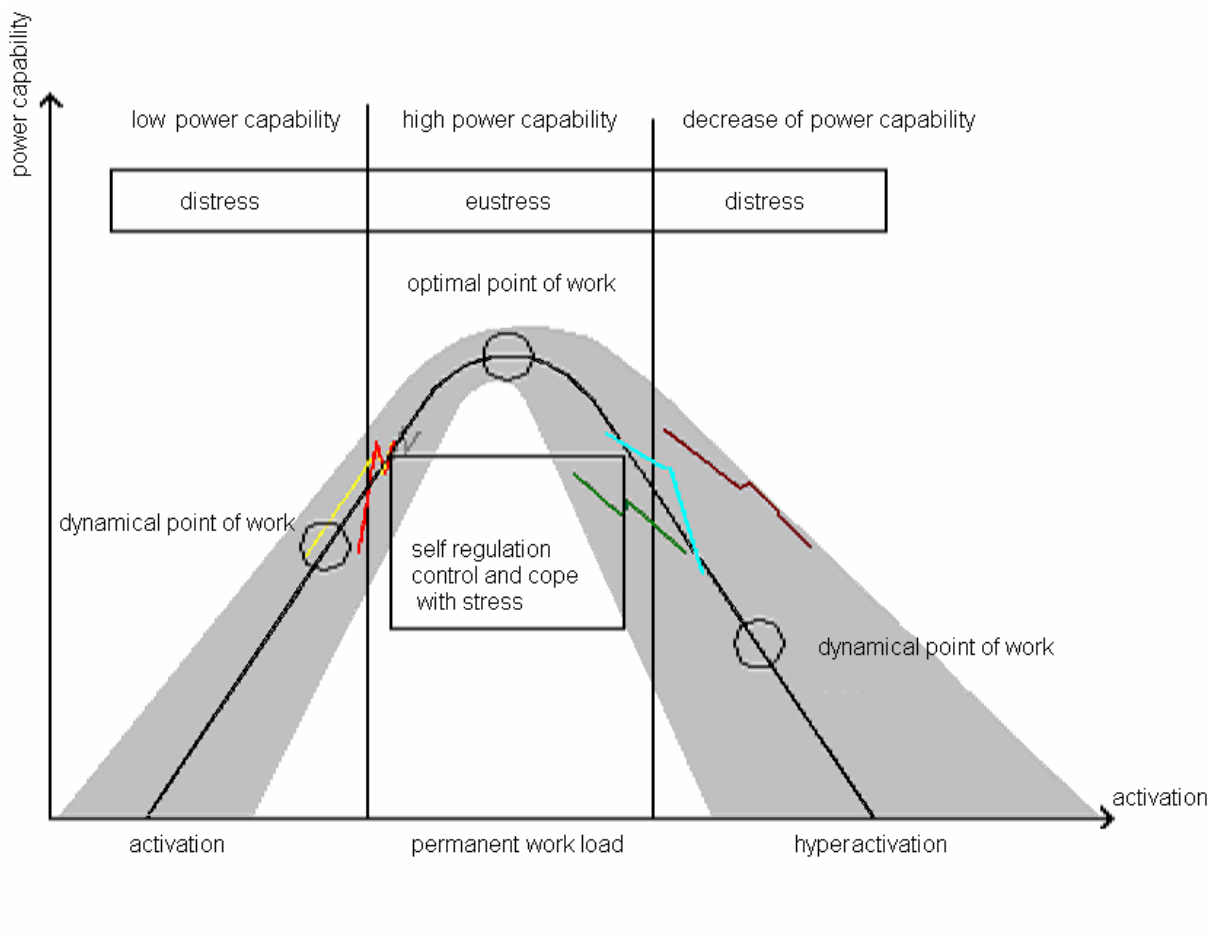
Similar conclusions can be seen in the hemisphere dominance test, whose analysis forms the same two groups described in the previous examination results. In the hemisphere dominance test group ANS shows itself as stable (willful), tactfully opposing, including in part subject M.G. The subjects T.B. and M.T. are so-called „switchers“ that switch to the „disturb signal“ during the tapping.

Essentially the same groups were formed with respect also to the equilibrium test. In comparing the performance-excitation curves we can observe that subject N.S. experienced the most substantial improvement in the performance-excitation as well as the equilibrium test. With regard to test subject S.H. there exists an equal consistency in the results, since a positive result was achieved not only in performance-excitation behaviour but in the hearing curve measurements and in part also in the equilibrium test. Since these changes happen to be relatively near the performance maximums (as determined in the Yerkes-Dodson principle) a relatively stable behaviour overall is indicated.

| Change | Left side of the model curve | | Right side of the model curve | |
|---|---|---|---|---|
| | Subject | Area of performance -excitation curve (in AE)[1] | Subject | Area of performance - excitation curve (in AE) |
| largest | N.S. | $20{,}2 \cdot 10^{-4}$ | M.T. | $45{,}3 \cdot 10^{-4}$ |
| middle | A.P. | $9{,}5 \cdot 10^{-4}$ | T.B. | $33{,}3 \cdot 10^{-4}$ |
| smallest | S.H. | $2{,}4 \cdot 10^{-4}$ | M.G. | $24{,}9 \cdot 10^{-4}$ |

The shift appearing in subjects' „energystore" indicates a general improvement and/or stabilization in performance toward homeostasis. Viewing the results in the table it becomes apparent that the three lowest values stem from the ANS group (on the left side of the Yerkes-Dodson Law) while the largest behavioural changes (on the right side) stem from group TMM.

FIGURE 17




Therefore the influence of each individual's original state is once again reflected. While the group on the left needs excitation to achieve a better hearing performance, the group on the right achieves better results through a reduction in excitation.

# 4 Comments to the Tomatis Hypothesis and its Critics

- ENT physicians point to fluctuations of 5 to 10 dB that can occur with respect to sequentially performed hearing threshold examinations. These fluctuations, however, form the foundation of the Tomatis therapy, with reference to underlying affliction or illness

Comments:

This study of hearing treatment shall not be intended to treat any underlying affliction or illness but, rather, to improve the hearing and vocalization ability of singers. Fluctuations from 5 to 10dB - considered to be normal chronobiologically occurring variances - can occur. In the study detailed herein these were not taken into consideration. Even the so-called „ideal“ Tomatis curve cannot – with respect to chronobiology - be rigidly defined, since the fluctuations would first also have to be compensated for. Only then could the charges of ENT physicians be rebutted so that these slight fluctuations form a useful basis.

However there are not even clear and conclusive data available on the side of present ENT research.

- there is no neurophysiological or neuropsychological evidence for the Tomatis effect

Comments:

In the scope of the study psycho-physiological data was collected, however even if a connection to neurological processes does exist, direct neurological examinations were not carried out.

- improvements and successes after a Tomatis therapy are purely subjective

Comments:

With the psycho-physiological data collected we were able to correlate and partially substantiate the subjective assessments of the changes (improvements and successes)

- The Tomatis method is not a scientifically valid treatment, because there is no evidence to support it based on recognized diagnostical criteria

Comments:

This is a blanket statement about which criteria a value is placed on, without actually stating what it is based on.

The historically used diagnostical criteria do not incorporate the newest research results and thus stands far behind in the integration of newest evidence discovered in chronobiological research. Regulatory processes regardless of bodily function are not as a rule even considered.

- The expression „lateral balance disturbance“ has not been formally defined, however it is used as the criteria for proving the Tomatis effect.

Comments:

The expression „lateral balance disturbance“ has actually not been uniformly defined and as a rule overlooks the cycles of switching that occur between hemispheres which are a component of lateral balance. That is why there are disagreements in the claims and hypotheses. The hemisphere test employed in this study does not permit the verification of cycles of lateral switching.

- The reproduceablility or reliability of the test methodolgies used is determined by age (of the subjects), their ability to concentrate, their motivation and their emotional condition.

Comments:

Here one must ask whether ENT physicians actually do themselves measure and take into consideration these parameters.

# 5 Conclusions

In the following tables are summarized the improvements and/or worsening of psycho-physiological conditions and behaviour in subjects with respect to Tomatis' theses (see also „Goals of the Study").Only those theses that - for the purpose of this study - can be at least in part tested were taken into consideration.

| Hearing Aid and Function | | | |
|---|---|---|---|
| **Tomatis hypothesis** | **Verified using** | **Number of test subjects[7]** | |
| | | **Hypothesis confirmed** | **Hypothesis not confirmed** |
| Reduction in difference between air and bone conductivity in the ear | Tomatis Hearing Curve[8] Test A and E | 6,5<br>T.B. A.P. N.S. M.T. M.G. S.H. F.S. | 0,5<br>S.H. |
| | ENT Audiometry[9] Test A and E (5 of 7) | 3,5<br>A.P. N.S. M.G. F.S. | 1,5<br>M.G. S.H. |
| Improvement in hearing ability | Tomatis Questionnaire Test B, C and E | 5<br>T.B. N.S. M.G. S.H. F.S. | 2<br>A.P. M.T. |
| | Tomatis Hearing Curve[10] Test A and E | 6,5<br>T.B. A.P. N.S. M.T. M.G. S.H. F.S. | 0,5<br>S.H. |
| | ENT -Audiometry[11] Test A and E (5 of 7) | 4<br>A.P. N.S. M.G. S.H. | 1<br>A.P. M.G. |
| Improvement in noise sensitivity | Questionnaire SNMM Test D | 4<br>A.P. N.S. M.G. S.H. | 3<br>T.B. M.T. F.S. |
| | Questionnaire SNMM Test E | 2<br>M.T. M.G. | 5<br>T.B. A.P. N.S. S.H. F.S. |

[7] If one subject cannot be ordered into one category or the other he is placed into both and reduced by 0.5 for the sum.
[8] In the case of S.H. the hypothesis was not verified in the right ear.
[9] In the case of M.G. the hypothesis was not verified in the left ear.
[10] In the case of S.H. the hypothesis was only verified in the left ear.
[11] In the case of A.P. and M.G. the hypothis was only verified with regard to air conductivity.

| CNS Function | | | |
|---|---|---|---|
| **Tomatis hypothesis** | **Verified using** | **Anzahl der Probanden** | |
| | | **Hypothesis confirmed** | **Hypothesis not confirmed** |
| Improved concentration ability | Questionaire SNMM Test E | 3<br>T.B. A.P. F.S. | 3<br>M.T. M.G. S.H. |
| Improvement in musical concentration ability | Questionaire SNMM Test E | 6<br>T.B. A.P. N.S. M.T. S.H. F.S. | 1<br>M.G. |

| Vocal Apparatus and Function | | | |
|---|---|---|---|
| **Tomatis hypothesis** | **Verified using** | **Number of subjects** | |
| | | **Hypothesis confirmed** | **Hypothesis not confirmed** |
| Improvement in voice development (singing voice) | Questionnaire Tomatis Test B, C and E | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. |
| | Questionnaire SNMM Test E | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. |
| Enlargement of voice box surface area[12] | Voice analysis<br>Test A and E | 5<br>T.B. A.P. M.T. N.S. M.G. S.H. F.S. | 2<br>T.B. N.S. M.T. F.S. |
| Reduction in elimination of vowel amount to the norms[13] | | 4,5<br>A.P. N.S. M.T. M.G. F.S. | 2,5<br>T.B. S.H. F.S. |
| Improvement of the exactness in octave intonation[14] | | 5<br>T.B. A.P. N.S. M.T. S.H. F.S. | 2<br>M.T. M.G. F.S. |
| Improvement in vibrato quality in the low range | | 6<br>T.B. A.P. N.S. M.T. M.G. S.H. | 1<br>F.S. |
| Improvement in vibrato quality in the high range | | 2<br>M.T. S.H. | 5<br>T.B. A.P. N.S. M.G. F.S. |
| Improvement in speech development | Questionnaire SNMM Test E | 3<br>N.S. M.G. S.H. | 4<br>T.B. A.P. M.T. F.S. |

[12] The subjects T.B. and M.T. improved only in the low range but not in the high range; subjects N.S. und F.S. improved only in the high range (F.S. very markedly), but not in the low range.

[13] Subject F.S. only improved in the low range but not in the high range. For subject A.P. the change to the low range is only minimal.

[14] Subject M.T. only showed improvemen in vowel ‚a', subject F.S. only with ‚i'.

| Skeletal – and Movement Apparatus | | | |
|---|---|---|---|
| **Tomatis hypothesis** | **Verified using** | **Number of subjects** | |
| | | **Hypothesis confirmed** | **Hypothesis not confirmed** |
| Improvement in equilibrium | Equilibrium test from 12.03.2002 and Test E | 4<br>N.S.M.G. S.H. F.S. | 3<br>T.B. A.P. M.T. |
| | Questionnaire FNMM Test E | 4<br>T.B. M.T. S.H. F.S. | 3<br>A.P. N.S.M.G. |
| Heightened desire for movement | Questionnaire Tomatis Test B, C and E | 7<br>T.B. A.P. N.S. M.T. M.G. S.H. F.S. | 0 |

| Mental Condition | | | |
|---|---|---|---|
| **Tomatis hypothesis** | **Verified using** | **Number of subjects** | |
| | | **Hypothesis confirmed** | **Hypothesis not confirmed** |
| Improvement mental spirit (balanced wellbeing) | Questionnaire SNMM Test E | 4<br>A.P. M.G. S.H. F.S. | 3<br>T.B. N.S. M.T. |
| Ability to cope with stress | Questionnaire SNMM Test E | 4<br>N.S. M.T. M.G. F.S. | 3<br>T.B. A.P. S.H. |
| Relaxation level | BET Test A to E | 3<br>T.B. S.H. F.S. | 4<br>A.P. N.S. M.T. M.G. |
| Relaxation ability | BET Test A to E | 2<br>A.P. F.S. | 5<br>T.B. N.S. M.T. M.G. S.H. |
| | Questionnaire SNMM Test E | 6<br>T.B. N.S. M.T. M.G. S.H. F.S. | 1<br>A.P. |
| | Physiological Monitoring Test A to D | 0 | 6<br>T.B. A.P. N.S. M.T. M.G. S.H. |
| Desire to communicate | Questionnaire Tomatis[15] Test B, C and E | 5<br>T.B. N.S. M.T. S.H. F.S. | 1<br>M.G. |
| | Questionnaire SNMM Test E | 3<br>M.T. M.G. S.H. | 4<br>T.B. A.P. N.S. F.S. |

Based collectively on the individual results herein one can make the following preliminary conclusion: despite the differing individual qualifications of the subjects at the start of this study, the Tomatis hearing treatment led to an improvement in hearing ability and to a more homeostatic condition in the subjects tested. Additionally, on three of the subjects specific characteristics in vocal performance could actually be improved. The

[15] Von Proband A.P. liegt bei keinem der drei Tests bei dieser Frage des Tomatis-Fragebogens eine Antwort vor.

improvement in homeostasis was verified by registering an improvement in the synchronization of regulatory processes of various bodily functions.

It remains unclear at present as to whether it was the music, the entire methodology employed by the hearing treatment or some other unknown factor caused the changes observed in the analysis of the individual measured parameters. Due to the previous results one can anticipate that an analysis of the impact of the specially modified music would reveal a variety of effects.

# 6 Literature

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# CONCLUSION REPORT:

# RESEARCH SERIES AND CLINICAL STUDY ON MUSICO CAUSE AND EFFECT RESEARCH WITH MORBUS PARKINSON PATIENTS

**(2002 – 2005)**

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# Index

# 1 Problem Status

Idiopathic Parkinsons Syndrome is among the most common chronic progressive degenerative diseases of aging persons.

The methods of treatment are improving steadily - especially with respect to the management of symptoms and in curbing the progression of the disease. The cardinal symptoms of the disease are akinesis, rigor and tremor. Additional symptoms include startle-reflex, hypo-kinesis, brady-kinesis, cognitive failure, mental changes and other cause-related illnesses and can make the progression of the disease substantially worse. These disturbances appear to be principally caused by a reduction in dopamine-related activity in the Substantia nigra, should the neurotransmitter dopamine be involved in extra-pyramidal movement control.

Almost all treatments employing medicaments (PRZEDBORSKI S. et al., 2000) against Parkinson's have side effects that can lead to neurological and mental imbalances. The side effects of the various treatments impact the quality of life of the patient as much as the disease itself. Another factor is that the medicaments begin to lose their effect with repeated use.

Thus alternative treatments have begun to take on greater significance. As adjuvant therapies they can have a positive effect on the quality of life of patients. Through the willing compliance of the patient coupled with success of the therapy, a reduction in use of medicaments is possible. Individually adapted adjuvant therapies can also help both to reduce hospital bills and the financial burden upon patients.

The therapeutic application of music is becoming increasingly noticeable in light of recent research (KNEAFSEY R., 1997). Music helps people to „get into stride“ easier (THAUT M.H. et al., 1996). Some patients report an easier rising in the morning while others find it very helpful to carry a portable listening device, especially in „freeze“ situations demanding increased concentration (http://my.webmd.com/printing /dmk/dmk_article_40066).

Numerous studies have already documented the effect of music on humans, though many have concentrated primarily upon the effect of *active* music therapy on persons (Hurt et al., 1998; Jäncke et al., 1998; Mcintosh et al., 1997; Pacchetti et al., 1998; Thaut et al., 1996 and 1999). Worth noting is the study of Thaut et al. (1996) in which an active music therapy was able to significantly impact the motor coordination of patients suffering from Parkinson's disease through acoustic stimuli. They attribute the improvement in speed and gait length to a coupling of the gait rhythm with an acoustical rhythm provided by a metronome. The present study utilized music with no steady persistent rhythm. Test subjects were thus not able to orient themselves to such a rhythm. Instead, our study dealt with the effect of *listening* to music rather than any active form of music therapy.

The reason that our motor system is sensitive to acoustical stimulous can only partially be explained, however the recognition of timing structure in the acoustic stimuli seems to play an important role (Thaut et al., 1999). Further, in his deliberations Thaut pointed to a possible connection relating to an evolutionary development between motor function and the auditory sense. External acoustical signals place people into an alerted state wherein the motor system becomes activated. This activation may have been vitally important for survival at some point in man's evolution. By using a holistic form of treatment, Swallow

(1982) was able to show that tremor and rigor decreased and flexibility increased with music that put the patient into a better mood and relaxed them was used.

Dam (1994) verified the observation that sensory-controlled movement of Parkinson's afflicted patients is often less affected as that directed by the will. One patient group received conventional treatment, while a second group –also supported by rhythmic tone signals – was able to perform more complex exercises. In both groups the degree of difficulty and speed of the exercises was adapted to individual patients' advancement. The result of his research showed that an integration of acoustical stimuli improves conventional physiotherapy. The patients improved primarily in body coordination, gait and precision movement, which in turn resulted in improved execution of day-to-day activities.

Parkinson's syndrome also reduces the ability to execute automatic movement. Fazzini (2000) spoke of how music can help patients regain awareness of subconscious movement patterns. Often it is observed that patients, who have walking disabilities, are transformed into good dancers through the use of music.

Music is a medium that can coordinate movement, however it is not known which specific brain hemisphere is affected or activated by which specific music. Although it was possible to determine increase in dopamine excretion in chickens under the influence of music (BERNATZKY G., et al., 1997 and 1998), it is still not clear which chemical reactions are stimulated by music.

It remains uncontested, however, that music has a multi-faceted psychological and physiological impact upon both humans and animals (PANKSEPP J. and BERNATZKY G., 2002; HESSE H.P., 2003).

# 2 Goal

The current project set forth to measure the short and long term effects of specialized stimulating music (drumming and Radetzky March) on the ability of patients suffering from Morbus Parkinson's disease to execute movement (motor coordination), as well as show a possible effect upon the cerebral cortex activity.

# 3 Task

Music is a medium that improves coordination while Parkinson's is a disease that causes impairment of (motor) coordination. Could music therefore complement the use of medicaments as an effective, easily accessible, side-effect free and affordable adjuvant therapy in treating Parkionson's patients?

On the basis of the following hypotheses

- that receptive listening to a special type of music would improve coarse motor coordination in Parkinson's patients
- that receptive listening to a special type of music would improve fine motor coordination in Parkinson's patients
- that receptive exposure to a special music has no effect upon a healthy control group
- that receptive listening to a special music raises the cerebral activity in Parkinson's patients (brain blood circulation)
- that a daily 20-minute routine listening to drumming music has an influence on the quality of life profile of test subjects suffering from Parkinson's
- that positively perceived music can lead to improvements over a shorter period of time
- that selective and regular integration of music leads to a dissipation of fear and depression
- the result leads to a higher quality of existence
- the psycho-social effects of the disease can thus be positively affected and changed

the following tasks were formulated:

The prime purpose of this study is to measure a) the short term effect that intense, patient chosen drumming music has upon their motor coordination and b) its long term effect on the quality of existence of patients suffering from Morbus Parkinson's disease.

The use of a positively perceived music means a shorter time of exposure is required in order to measure an improvement in the motor system coordination (fine and coarse) in patients who have Morbus Parkinson's syndrome.

# 4 Test Subjects

The subjects taken into the study were informed about its goals and purposes and asked to adapt to its protocol. The recruitment was done at the Christian Doppler Clinic, Salzburg. We selected in-patients both staying at the clinic and those who come to be treated there. 11 patients with Parkinson's disease and 10 healthy subjects were selected as a control group for testing and analysis.

## 4.1 Inclusionary Criteria

- patients who have been diagnosed as having Parkinson's disease
- patients that are between 2 and 3 on the scale named after HÖHN and YAHR
- males only were taken into the study due to the fact that GEORGE M.S. et al. (1996) found women to have significantly greater hemisphere activation around the limbic system when the effect of self-induced memories of joy and sadness was researched. This was also verified by SCHNEIDER F. et al. (1997 und 2000), who discovered differences in activity changes in the amygdalae between men and women.
- age was between 30 and 80 years
- test subjects were right hand dominant
- no intake of stimulants (nicotine, coffee, alcohol) 2 hours prior to commencement of testing
- the patients were tested in the so-called „off-state"; meaning the last intake of prescription medicaments took place on the day prior to testing.

## 4.2 Exclusionary Criteria

- a medical condition which would prevent participation (e.g. hearing disability)
- heavy mental disturbance or illness (claustrophobia, fear, psychosis, amentia)
- defensive posture (aversion to the music)
- patients who are/were professional musicians. According to ELBERT T. (1995) musicians have a greater cortical representation for their fingers.

# 5 Music Selections Used

The music used was selected and compiled by patients suffering from Parkinson's disease. The music was to follow no particular metronomical regularity. Adaptation to an external rhythm stimulus was therefore excluded. The possible effects are thus attributable solely to the physiological effect that the music may have. The musical selections were selected from among the following compositions:

1. Improvisations by Ron Tutt and Jim Keltner, produced 1981 & printed in USA
2. The Sheffield drum record, Sheffield Lab 14 SL 43/44, Direct disc recording limited edition, Santa Barbara, California
3. Radetzky March: CD of military music, Salzburg - Ltg. Major Ernst Herzog Meisterliche Marschmusik. Number 16: Radetzky March by Johann Strauß MaKo Records, CD-459, 2002

The selected music was differentiated by the following criteria for volume, timbre, tonality, sharpness, periodicity fluctuations, timing intervals and timing patterns.

TABLE 1

| **Trommelmusik** "input-files" | Volumen (zusätzlich ohrenphonetisch überprüft) | Klangfarbe | Klanghaftigkeit | Fluktuationen | Auditive Schärfe[1] |
|---|---|---|---|---|---|
| „bass-drum" | dünn (25-1000Hz) | farblos, gleichmäßig abfallend | gering (> 500 Harmonische) | keine (Quasi)Periodizität vorhanden unregelmäßige Fluktuationen | *205.80-205.95: 150ms* Bark 19: **64** dB Bark 20: **62** dB Bark 21: **62** dB Bark 22: **60** dB Bark 23: **58** dB |
| „snare-drum" | sehr voluminös, Gesamtfrequenzbandbreite größer (146-ca. 6000 Hz) | farblos, gleichmäßig abfallend | gering (> 500 Harmonische) | keine (Quasi)Periodizität vorhanden unregelmäßige Fluktuationen | *213.00-213.20: 200ms* Bark 19: **75** dB Bark 20: **74** dB Bark 21: **71** dB Bark 22: **69** dB Bark 23: **65** dB |
| „hihat" | voluminös, Gesamtfrequenzbandbreite groß (29- ca. 4000 Hz) | bunt, abweichend von neutralen abfallenden Form | gering (> 500 Harmonische) | keine (Quasi)Periodizität vorhanden unregelmäßige Fluktuationen | *207.37-207.51: 140ms* Bark 19: **70** dB Bark 20: **71** dB Bark 21: **71** dB Bark 22: **75** dB Bark 23: **76** dB |

Analysis of the drumming music

TABLE 2

| input-files | Abstände in ms (ohrenphonetisches Nachklatschen der rhythmischen Struktur) | Ereignisabstand in ms |
|---|---|---|
| trommel1.1.sd | 123,158,166,111,150,111,325,317,467,190,103,174,97,188,293,317,460 | 3750ms/17 Ereignisse: 220ms |
| trommel1.2.sd | quasi analog trommel1.1.sd | |
| trommel1.3.sd | 236, 287,524,269,259,495,122,245,382,264,264,259,562 | 4168/13 Ereignisse: 320ms |
| trommel2.1.sd | 670,236,231,462,231,670,231,240,448,236,698 | 4353/11 Ereignisse: 395ms |
| trommel2.2.sd | 731,226,250,434,259,694,226,231,487,250 | 3758/10 Ereignisse: 376ms |
| trommel2.3.sd | 254,542,491,458,259,391,259,410,476,245,226 | 4011/11 Ereignisse: 364ms |
| Trommel3.1.sd | 500,434,66,70,321,75,70,269,273,363,70,56,325,84,42,297,70,118,264,288,354, 89,66 | 4564/23 Ereignisse: 198ms |
| Trommel3.2.sd | 679,245,439,491,453,226,245,212,221,207,236 | 3654/11 Ereignisse: 332ms |
| Trommel3.3.sd | 335,132,146,113,151,99,165,321,118,160,127,155,99,151,311,113,155,94,165,1 03,160,302,151,108,127,136,99,151 | 4441/28 Ereignisse: 158ms |
| trommel4.1.sd | 89,108,66,84,132,66,146,80,132,84,103,113,80,127,94,99,160,127,108,118,103, 94,127,80,104,113,108,94,118,203,208,113,122,104,94,85,132,52,151,80,108 | 4503/41 Ereignisse: 110ms |
| trommel4.2.sd | quasi analog trommel4.1.sd | |
| trommel4.3.sd | quasi analog trommel4.1.sd | |
| trommel5.1.sd | zu schnell | Ereignisabstand < 100ms |
| trommel5.2.sd | zu schnell | Ereignisabstand < 100ms |
| trommel5.3.sd | 127,458,136,467,136,472,141,491,151,533,292,528,259 | 3891/13 Ereignisse: 300ms |

Timing patterns in the drumming music

# 6 Methodology

## 6.1 PART 1- (Drumming music; 20-minute exposure)

### 6.1.1 Preparation

The MPS examination took place in specially reserved room at the neurological department in the Christian Doppler Clinic.

The following materials were used:

- CD player, brand Sony
- headphones, stereo, brand Sony
- CD of drumming music
- testing device: MPS Motor Function Performance Series using own software
- various protocols and questionaires

### 6.1.2 Execution

The patients were picked up individually at the men's station (Christian Doppler Ckinic) or received at the radiology department then informed about the goals of the study. The execution of the individual tests were explained to patients and a 15 minute adaptation pause preceded the testing. Initially the four tests were performed using the right hand, then repeated for the left hand. The average duration for the tests was 10 minutes. After basic measurements were performed the patients were further examined in the radiology department using fMRI. Thereafter the second measurement using the Vienna Test System followed.

TABLE 3

| | | | |
|---|---|---|---|
| | **Preparation** | **10 min** | |
| **MPS** | **Measurement 1** | **5 min/hand** | |
| | **Preparation** | **10 min** | |
| **fMRI** | **Measurement 1** | **~5 min** | **3 x finger tapping** |
| | **MUSIC** | **20 min** | |
| **fMRI** | **Measurement 2** | **~5 min** | **3 x finger tapping** |
| | **Preparation** | **10 min** | |
| **MPS** | **Measurement 2** | **5 min/hand** | |

Study design measurements performed, Christian Doppler Klinik (MPS/ fMRI)

## 6.2 PART 2- (drumming music and Radetzky March; 5-min. exposure)

### 6.2.1 Preparation

The MPS examination took place in specially reserved room at the neurological department in the Christian Doppler Clinic.

The following materials were used:

- CD player, brand Sony
- Headphones, stereo, brand Sony
- CD of drumming music
- testing device: MPS Motor Function Performance Series using own software
- various protocols and questionaires

### 6.2.2 Execution

Using the Vienna Test System the effect music had upon the movement ability of Parkinson's patients was examined anew at the Christian Doppler Clinic. The study design was adapted with the test subjects and further testing commenced with the Parkinson's patients. This time specifically the enduring effect of the drumming music using a shorter 5-minute selected sample was tested. As an extension, new music (Radetzky March) was now also introduced.

The patients were picked up individually and received by the examination director (Christian Doppler Clinic) and informed again about the goals of the study. The process of the individual tests was explained to patients and after a 15 minute adaptation pause testing commenced. The testing procedure began with the Vienna Test System. First the four tests were performed using the right hand, afterward with the left. The average duration of the testing was 10 minutes.

After a basic measurement the respective 5 minute music exposure followed. Immediately afterward there followed the second measurement of fine motor coordination. Thereafter was a 10 minute pause. During the pause the patients were required to remain seated. To measure any longer term effect music has upon fine motor coordination of Parkinson's patients the measurements were then repeated. In the first testing procedure the drumming music was applied.

The patients then took part in a second test. The process remained the same as that described above, however different music (Radetzky march) was used. Thus we could assess the differing effects that a variation of music might have.

## 6.3 Examination Methods

### 6.3.1 Motor Function Performance Series (MPS)

Examination instrument: Vienna Test System with Motor Function Performance Series (MPS)

Parameter block S2, with the following subtests for:

- steadiness:

this test checks the ability to make and hold precise hand and arm positions, during which neither strength nor speed play a significant role. FLEISHMAN et. al. designed the test, during which a stylus is placed into a hole and held there while trying not to touch the walls and named the resulting factor „arm-hand-steadiness“ (FLEISHMAN E.A., 1954 und 1972). The duration of errors is measured.

• line tracking:

this subtest records the „precision of arm-hand coordination“. Here the stylus must be moved quickly and precisely without contact through a stencilled line. The total time and the duration of errors is recorded.

• aiming:

in this subtest small area target movements are assessed. 20 circles with a diameter of 5mm are aligned in a single row. The distance separating each is 4mm. The goal of the test subject is to tap the tip of the stylus into each circle as quickly as possible without touching the surface around the circles. The total time and duration of error are recorded.

• tapping:

in this subtest the wrist-finger-speed is recorded. The stylus must be tapped as many times as possible in 32 seconds onto a square within the working surface. The number of hits is recorded.

### 6.3.2 Power-force-working-plate (AMTI)

Examination device: AMTI – power-force-working-plate, Inst. for Sport Science, Rif.

Measured is the direct impact that music has on the gait speed of Parkinson’s patients.

The following parameters are recorded:

• load-phase (t-contact) in milliseconds: time span during which foot has contact to the power-force-working-plate

• release-phase (t-lift) in milliseconds: time span during which foot has no contact to the power-force-working-plate

• total stride (f-stride) in milliseconds: sum of load- and release-phases

• impact-maximum (n): maximum collective impact from each contact with the power-force-working-plate

• frequency: contact of foot with the power-force-working-plate within 5 seconds

### 6.3.3 Functional Magnetic Resonance Imaging (fMRI)

Examination instrument: all examinations were carried out using the full-body scanner Philips Gyroscan 1.5 Tesla, ACS-NT Powertrak 6000, Philips, Best, The Netherlands (Dia. 3) at the Christian Doppler Clinic

### 6.3.4 Questionaire as to Current State of Patient (STFI)

Examination instrument: STFI-X1 current state questionaire (State-Trait-Fear Inventory by Spielberger CS, 1997).

### 6.3.5 Quality of Life Profile of the Chronically Ill (QLP)

Examination instrument: the profile of quality of life of chronically ill (QLP) by Siegrist, Broer and Junge (1996) is a specially developed form for self-assessement by chronically ill persons on their quality of life pursuant to the course of their sickness and/or treatment process.

Measured proportions are: (QLP)

- General Capacities

Spectrum 1 „general capacities“ deals primarily with the aspects of bodily functions and mental capabilities in both private and professional surroundings, such as performing strenuous work loads and ability to concentrate as well as the management of day-to-day chores.

- Enjoyment and Relaxation Ability

Spectrum 2 „ enjoyment and relaxation ability“ as a proportion of mental capacity indicates the individual capability of mental regeneration. Questions about relaxation ability, quality of sleep, appetite and levels of enjoyment are addressed.

- Positive Disposition

Spectrum 3 „positive disposition“ as proportion of a patient’s mental state includes the aspects of positive disposition in the area of interest, good mood, balance and confidence.

- Negative Disposition

Spectrum 4 „ negative disposition“ in contrast to Spectrum 3 essentially covers aspects related to negativity, such as despondency, nervousness, irritability, feeling threatened, and helplessness.

- Contact Capacity

The proportion of „social capacity“ in Spectrum 5 represents the „contact capacity“ of an individual in establishing relationships and continuing communication with others. The

two essential aspects here are the responsiveness to others and the ability to be open and communicative toward others.

- Sense of Belonging

Spectrum 6 „sense of belonging“ as an expression of state of socialization deals primarily with aspects of a person’s feeling of social support, such as nearness, attentiveness, helpfulness, as well as the absence of feelings of loneliness and exclusion.

The Parkinson’s patients were required to listen to our pre-tested music at least once during the day. Thereafter they were given a CD with same to take home and over a three month period were required to follow a daily protocol which included filling out the QCC and GDS questionaires weekly.

### 6.3.6 General Depression Scale (GDS)

Examination instrument: the general depression scale (GDS - Hautzinger & Bailer, 1993) allows for screening of depressive tendencies and is the first stage of a multi-phased diagnostic process outside of the clinical realm for registering depression-related disturbances. The 20 questions posed addressed the presence and duration of disturbances such as despondency, sadness, exhaustion, uncertainty, hopelessness, self none-worthiness, listlessness, crying, withdrawal, fear, bodily complaints and motor coordination impairment.

# 7 Results

## 7.1. Motor Function Performance Series (MPS)

TABLE 4

**Variance analysis – Motor Function Performance Series (MLS)**

| | | | |
|---|---|---|---|
| **AIMING – FD DE** | **Right** | PEIG | F(1,19)= 7.253; p=0.015 |
| | | PEDG | F(1,19)= 5.254; p=0.033 |
| | | G* RMF | F(1,19)= 2.945; p=0.102 |
| | **Left** | PEIG | F(1,19)= 0.399; p=0.535 |
| | | PEDG | F(1,19)= 0.893; p=0.357 |
| | | G* RMF | F(1,19)= 0.760; p=0.394 |
| **AIMING – GD TT** | **Right** | PEIG | F(1,19)= 12.651; p=0.002 |
| | | PEDG | F(1,19)= 1.995; p=0.174 |
| | | G* RMF | F(1,19)= 0.600; p=0.448 |
| | **Left** | PEIG | F(1,19)= 5.371; p=0.032 |
| | | PEDG | F(1,19)= 0.426; p=0.522 |
| | | G* RMF | F(1,19)= 0.000; p=0.992 |
| **STEADINESS** | **Right** | PEIG | F(1,19)= 0.654; p=0.429 |
| | | PEDG | F(1,19)= 4.200; p=0.054 |
| | | G* RMF | F(1,19)= 0.041; p=0.842 |
| | **Left** | PEIG | F(1,19)= 0.551; p=0.467 |
| | | PEDG | F(1,19)= 0.049; p=0.828 |
| | | G* RMF | F(1,19)= 0.369; p=0.551 |
| **LINE TRACKING – FD DE** | **Right** | PEIG | F(1,19)= 14.479; p=0.001 |
| | | PEDG | F(1,19)= 0.575; p=0.458 |
| | | G* RMF | F(1,19)= 0.289; p=0.597 |
| | **Left** | PEIG | F(1,19)= 2.903; p=0.105 |
| | | PEDG | F(1,19)= 1.351; p=0.259 |
| | | G* RMF | F(1,19)= 0.316; p=0.581 |
| **LINE TRACKING – GD TT** | **Right** | PEIG | F(1,19)= 7.567; p=0.013 |
| | | PEDG | F(1,19)= 1.054; p=0.317 |
| | | G* RMF | F(1,19)= 0.010; p=0.921 |
| | **Left** | PEIG | F(1,19)= 5.093; p=0.036 |
| | | PEDG | F(1,19)= 4.813; p=0.041 |
| | | G* RMF | F(1,19)= 0.908; p=0.353 |
| **TAPPING** | **Right** | PEIG | F(1,19)= 1.057; p=0.317 |
| | | PEDG | F(1,19)= 2.929; p=0.103 |
| | | G* RMF | F(1,19)= 0.653; p=0.429 |
| | **Left** | PEIG | F(1,19)= 0.001; p=0.971 |
| | | PEDG | F(1,19)= 1.081; p=0.312 |
| | | G* RMF | F(1,19)= 0.006; p=0.939 |

Values of the variance analysis - MPS

The following abbreviations are used in the table:

- DE = Duration of Errors
- TT = Total Time
- PEIG = Primary Effect Independent from the Group
- PEDG = Primary Effect Dependent on the Group
- G* RMF = Interaction between Group and Repeated Measurement Factor

## 7.2. Pressure Plate (AMTI)

In table 10 statistical data values (variance analysis) collected from the power-force-working-plate tests is compiled and displayed.

TABLE 5

### Variance Analysis – Pressure Plate (AMTI)

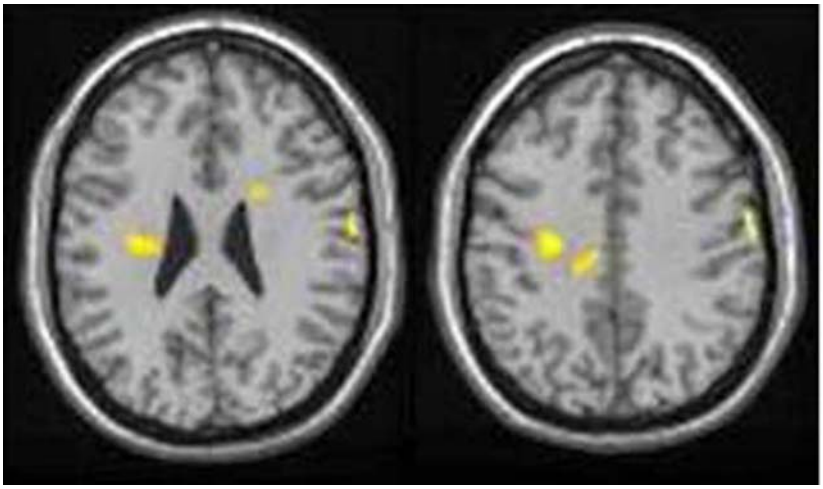
| | | |
|---|---|---|
| **Load – totals** | PEIG | F(6,84)= 2.578; p=0.024 |
| | PEDG | F(6,84)= 2.536; p=0.026 |
| | G* RMF | F(1,14)= 0.716; p=0.412 |
| **Variability coefficient** | PEIG | F(6,84)= 6.241; p<0.000 |
| | PEDG | F(6,84)= 6.546; p<0.000 |
| | G* RMF | F(1,14)= 15.012; p=0.002 |
| **Release - totals** | PEIG | F(6,84)= 0.566; p=0.756 |
| | PEDG | F(6,84)= 0.337; p=0.915 |
| | G* RMF | F(1,14)= 0.082; p=0.779 |
| **Variability coefficient** | PEIG | F(6,84)= 0.299; p=0.936 |
| | PEDG | F(6,84)= 1.236; p=0.296 |
| | G* RMF | F(1,14)= 5.348; p=0.036 |
| **Total stride - Variability coefficient** | PEIG | F(6,84)= 6.296; p<0.000 |
| | PEDG | F(6,84)= 4.910; p<0.000 |
| | G* RMF | F(1,14)= 14.016; p=0.002 |
| **Impact - maximum** | PEIG | F(6,84)= 1.442; p=0.208 |
| | PEDG | F(6,84)= 0.542; p=0.775 |
| | G* RMF | F(1,14)= 0.634; p=0.439 |
| **Variability coefficient** | PEIG | F(6,84)= 2.340; p=0.039 |
| | PEDG | F(6,84)= 0.995; p=0.434 |
| | G* RMF | F(1,14)= 7.895; p=0.014 |
| **FREQUENCY** | PEIG | F(6,84)= 1.611; p=0.154 |
| | PEDG | F(6,84)= 1.165; p=0.333 |
| | G* RMF | F(1,14)= 0.062; p=0.807 |

Values of the variance analysis – AMTI

## 7.3. Functional Magnetic Resonance Imaging (fMRI)

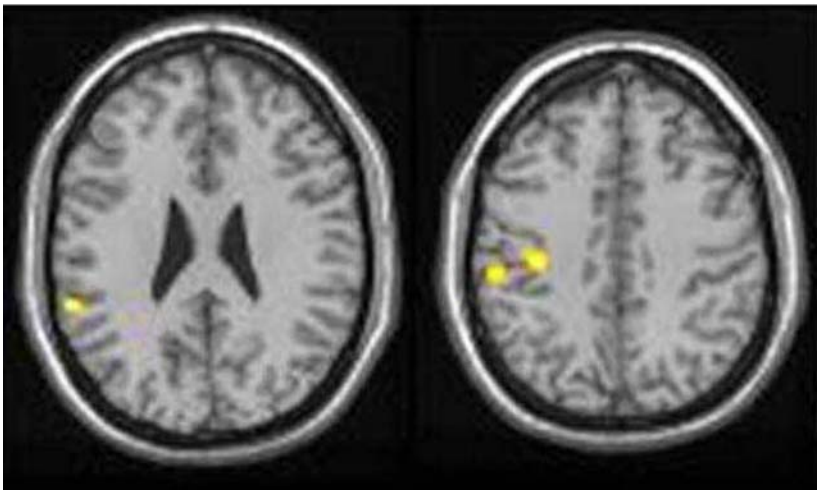
The group analysis of both the Parkinson's and control groups derived from finger tapping while listening to music predictably showed a strong activation in the contra lateral primary motor cortex.

FIGURE 1



Depiction of activation in the brain in Parkinson's group (n=11) BEFORE listening to the music (finger tapping with thumb and index finger of the right hand).

FIGURE 2

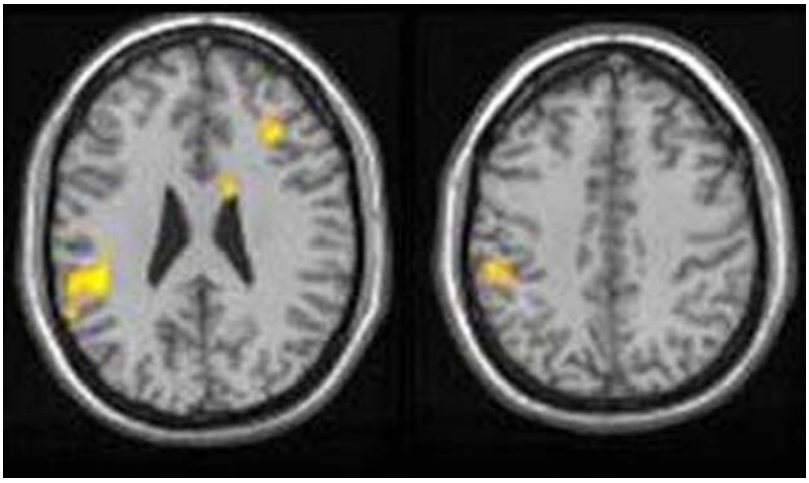


Depiction of activation in the brain in control group (n=10) BEFORE listening to the music (finger tapping with thumb and index finger of the right hand).

Although on a lesser scale, in the first examination the patient group did show activation occurring in the contra lateral primary motor cortex. Compared to the control group, however, when the listening to music was over a change in the activation pattern was no longer visible. In the case of the control group when the listening to music was over the

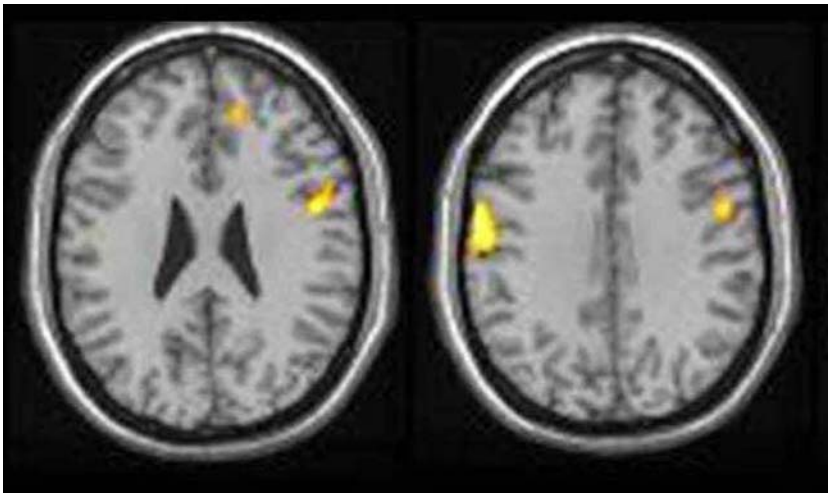
activation pattern expanded also into the regions associated with the right hand ipsilateral primary motor cortex and into the right frontal region of the Gyrus cinguli.

FIGURE 3



Depiction of activation in the brain in Parkinson's group (n=11) AFTER listening to the music (finger tapping with thumb and index finger of the right hand).

FIGURE 4



Depiction of activation in the brain in control group (n=10) AFTER listening to the music (finger tapping with thumb and index finger of the right hand).

## 7.4. Questionaire as to Current Condition (STFI)

TABLE 6

**STFI-G-X1** **Radetzky March**

Current Condition Questionaire

| **n=10** | **before music** | | **after the Radetzky March** | | |
|---|---|---|---|---|---|
| | **Average** | **Std Error** | **Average** | **Std Error** | **p-Value** |
| **calm** | 1,03 | 0,26 | 1,59 | 0,35 | 0,06 |
| **tense** | 0,91 | 0,25 | 1,65 | 0,23 | **0,03** |
| **distressed** | 1,59 | 0,33 | 1,66 | 0,28 | 0,86 |
| **detached** | 1,19 | 0,29 | 1,36 | 0,3 | **0,2** |
| **agitated** | 1,35 | 0,36 | 2,1 | 0,26 | 0,06 |
| **rested** | 1,43 | 0,27 | 1,08 | 0,26 | 0,31 |
| **worried** | 1,01 | 0,26 | 2,04 | 0,25 | **0,009** |
| **I feel good** | 1,05 | 0,17 | 1,78 | 0,21 | **0,002** |
| **self-assured** | 1,01 | 0,18 | 1,63 | 0,13 | **0,014** |
| **nervous** | 1,26 | 0,24 | 1,94 | 0,22 | **0,001** |
| **fidgety** | 1,66 | 0,32 | 1,8 | 0,16 | 0,61 |
| **tense** | 1,21 | 0,19 | 2,09 | 0,14 | **0,005** |
| **relaxed** | 0,96 | 0,22 | 1,43 | 0,21 | 0,09 |
| **contented** | 1,83 | 0,13 | 1,93 | 0,11 | 0,06 |
| **apprehensive** | 1,71 | 0,31 | 1,84 | 0,2 | 0,48 |
| **overstrung** | 1,4 | 0,38 | 2,13 | 0,23 | 0,09 |
| **happy** | 1,28 | 0,25 | 1,36 | 0,21 | 0,63 |
| **amused** | 1,13 | 0,29 | 1,36 | 0,21 | 0,31 |

STFI values, Radetzky March

TABLE 7

**STFI-G-X1** **Drumming Music**

Current Condition Questionaire

| n=10 | before music | | after the drumming music | | |
|---|---|---|---|---|---|
| | **Averages** | **Std Error** | **Averages** | **Std Error** | **p-Value** |
| **calm** | 1,03 | 0,26 | 1,45 | 0,23 | 0,16 |
| **tense** | 0,91 | 0,25 | 1,25 | 0,27 | 0,28 |
| **distressed** | 1,59 | 0,33 | 1,55 | 0,3 | 0,93 |
| **detached** | 1,19 | 0,29 | 1,16 | 0,22 | 0,95 |
| **agitated** | 1,35 | 0,36 | 1,83 | 0,24 | 0,31 |
| **rested** | 1,43 | 0,27 | 0,95 | 0,23 | 0,17 |
| **worried** | 1,01 | 0,26 | 1,69 | 0,18 | **0,01** |
| **I feel good** | 1,05 | 0,17 | 1,38 | 0,29 | 0,22 |
| **self-assured** | 1,01 | 0,18 | 1,59 | 0,23 | **0,05** |
| **nervous** | 1,26 | 0,24 | 1,45 | 0,17 | 0,29 |
| **fidgety** | 1,66 | 0,32 | 1,71 | 0,22 | 0,79 |
| **tense** | 1,21 | 0,19 | 1,68 | 0,25 | 0,14 |
| **relaxed** | 0,96 | 0,22 | 0,79 | 0,24 | **0,02** |
| **contented** | 1,83 | 0,13 | 1,43 | 0,22 | **0,01** |
| **apprehensive** | 1,71 | 0,31 | 1,73 | 0,25 | 0,89 |
| **overstrung** | 1,4 | 0,38 | 1,86 | 0,25 | **0,02** |
| **happy** | 1,28 | 0,25 | 1,23 | 0,24 | 0,61 |
| **amused** | 1,13 | 0,29 | 1,23 | 0,25 | 0,47 |

Table 7: STFI values, drumming music

## 7.5. Quality of Life Profile of the Chronically Ill (QLP)

The statistical results of the primary effects are summarized in the following table:

TABLE 8

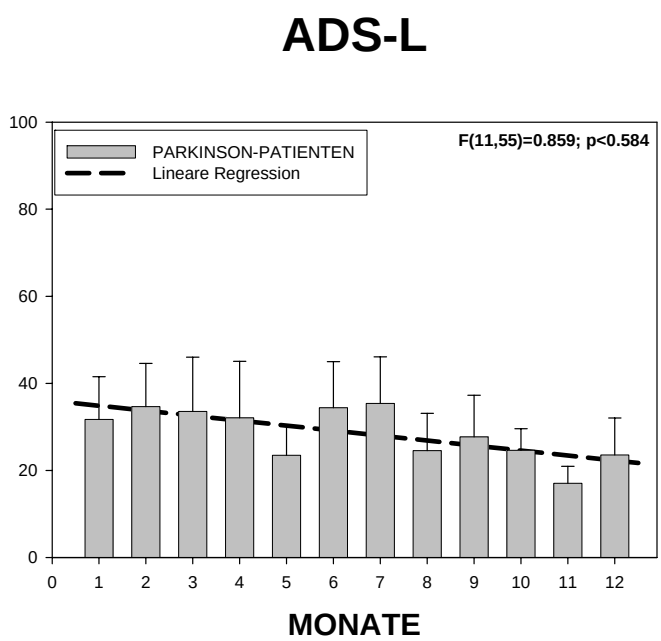
| Measured Proportion | Statistical Improvement |
|---|---|
| **General Capacities** | **F(11,55)=0.746; p=0.690** |
| **Enjoyment and Relaxation Ability** | **F(11,55)=0.687; p=0.745** |
| **Positive Disposition** | **F(11,55)=0.505; p=0.892** |
| **Negative Disposition** | **F(11,55)=0.717; p=0.717** |
| **Contact Capacity** | **F(11,55)=0.633; p=0.792** |
| **Sense of Belonging** | **F(11,55)=1.986; p=0.046** |

QLP – depiction of statistical results

## 7.6. General Depression Scale (GDS; German = ADS-L)

No statistically significant improvement (F(11,55)=0.859; p=0.584) was indicated after factoring in repetition.

FIGURE 5




ADS – General Depression Scale – averages and ±SEM

# 8 Summary

The present work set out to measure the short and long term effects that a specially selected, stimulating music has upon motor coordination of patients suffering from Morbus Parkinson disease.

In the study design, three different tests or measurements were carried out. Using fMRI scans performed at the Christian Doppler Clinic we examined whether the stimulus of music caused an increase in brain activity in the area that affects motor function and whether that change also leads to a subsequent change in the brain activity in other areas of the hemispheres. The changes in fine and coarse motor coordination were then recorded using the Vienna Test System and an AMTI power-force-working-plate.

The primary results from a 20-minute application of drumming music can be summarized as follows:

The testing of fine motor coordination using the Vienna Test System showed in two of four subtests (aiming, line tracking) that in the group of patients suffering from Morbus Parkinson's disease substantial improvement occurred when listening to the music.

Also in the tests using the AMTI power-force-working-plate the Parkinson's group showed a significant improvement in two of five measured parameters (impact, total stride). Especially clear was the difference in the averages of the variability coefficients in the parameters for impact maximum and total stride. Both registered substantial decreases. The change in the variability coefficients after the listening sessions indicates an improved harmony of movement. In the other measured parameters no significant changes were registered.

Therefore the proposed hypothesis – that receptive listening to a special type of music leads to an improvement in the fine and coarse motor coordination of Parkinson's patients – was partially supported. The results achieved indicate that the music we used for the testing is less able to improve upon a person's speed performance than it is their fine motor coordination. The control group showed an improvement in only one (line tracking) of the measured parameters. In all remaining parameters no improvement could be registered.

The primary results from the exposure to 5 minutes of two differing styles of music (Radetzky March, drumming music) can be summarized as follows:

In two of four subtests (aiming, line tracking) performed using the Radetzky March the testing of the fine motor coordination using the Vienna Test System showed a significant improvement when the music was used.

In tests based on the drumming music no significant changes in the subtest measurements were registered after the music had been listened to.

The results of this study indicate that a short term application (5 min) of music with a positive emotional association (Radetzky March) improves the motor coordination of patients suffering from Morbus Parkinson disease.

The results of this study also indicate that the music used herein has the ability to improve motor coordination of patients with Morbus Parkinson disease.

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# Conclusion Report:

# Research Series and Clinical Studies on the Psycho-Physiological Effect of Music on Patients with Musculoskeletal System Pain

**2002 to 2005**

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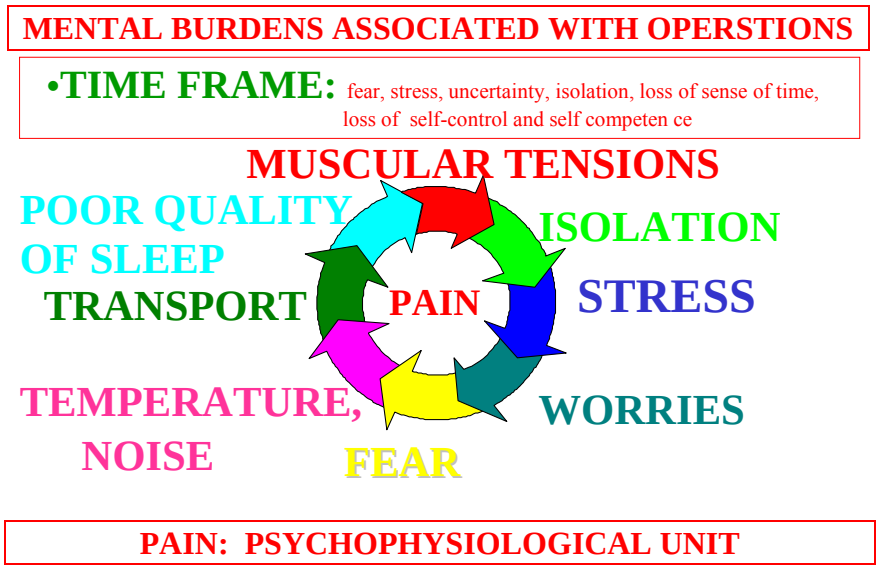
Salzburg, March 27th, 2005

# Index

# 1 Conceptual Formulation, Goals and Hypotheses

The expectation of post-operative pain poses a substantial mental burden to patients (Fig.1) on the one hand, while on the other hand it generates higher costs due from accompanying lengthier hospital stays. Pain is subjective and thus experienced differently in each person. Mental factors such as helplessness, fear, depression etc. work to increase the effect pain as a physiological stress factor and influence its intensity. The expectation of self-effectiveness in this regard is considered to be a facilitating variable. Music in combination with relaxation instructions can have a measured effect upon the influence of affective-cognitive- and sensory processes.

FIGURE 1




Mental burdens associated with operations

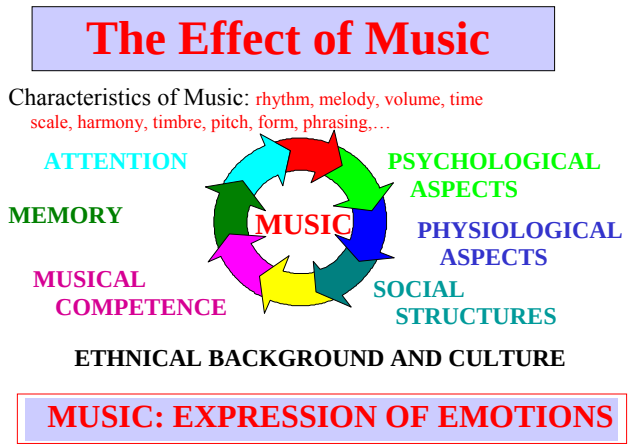
Post-operative pain from surgical intervention is the result of a variety of processes, including fear and stress. Pain and poor quality of sleep reduce the state of wellness and extend the process of convalescence. The goal of this study is thus to evaluate the pre- and post-operative effect of a standardized form of music in combination with relaxation instructions.

The results show that when music is presented with accompanying relaxation instructions it has a positive effect upon the perception of pain and the mental condition of patients.

Patients with a higher degree of self-control have less post-operative pain, require fewer analgesics, have lower levels of cortisol in their saliva and score lower fear and depression values as patients with less self-control: Music combined with relaxation instructions has in turn a positive influence upon self-control, reducing pain, requirement of analgesics, lowering the level of hydrocortisone in saliva, and reducing fear and depression. We can expect that patients in the control group will have higher pain scores, require more analgesics, have higher levels of cortisol in their saliva, and have higher fear and depression

values as the patients in the experimental group (Figure 2). Music and relaxation instructions contribute significantly toward improving the sensation of pain. This study shall also show for which patient types music as therapeutic adjuvant is best suited.

FIGURE 2




The effect of music

In our work group we concentrated on newly composed music that has been tested numerously on ill patients (e.g. CD „Music and relaxation instruction for greater quality of life for illness, sleeping disorders and vegetative disturbances“)

TABLE 1

**Receptive Music Therapy**

Even if music is not self-executed, and only is listened, music affects the listener and can therefore fulfil certain functions:

Physiological level: As a sound, music activates the function of the hearing organism, prodeuces muscular processes and stimulates muscular movements.

Emotional level: As a symbol, music can activate feelings and remind of emotionally mostly positive experiences of the past.

Mental level: music trains the brain and as an acoustic structure stimulates cognitive processes which result out of the relations of the tones and the interplay of tension and relaxation.

Effect-principle of music therapy (source: H.-P. Hesse)

TABLE 2

**Short-term Effects of Receptive Music Therapy:**
Patients have less pain, sleep better, fear less, feel better, have a reduced requirement for attentive care and, lastly, a faster convalescence on account of higher immune system levels.
The degree of self-control is clearly improved. Thus they raise their degree of compliance for requisite therapies.

**Long-term Effect of Receptive Music Therapy:**
Patients are more prepared to take on self-rehabilitation after their release from treatment.

**Economical Aspects of Receptive Music Therapy:**
High cost savings were reached in the group that used music therapeutically. The savings in costs for pharmaceuticals alone in patients of the music group is significantly larger in comparison to the group without music therapy.

Table 2: Short- long-term effect receptive music therapy

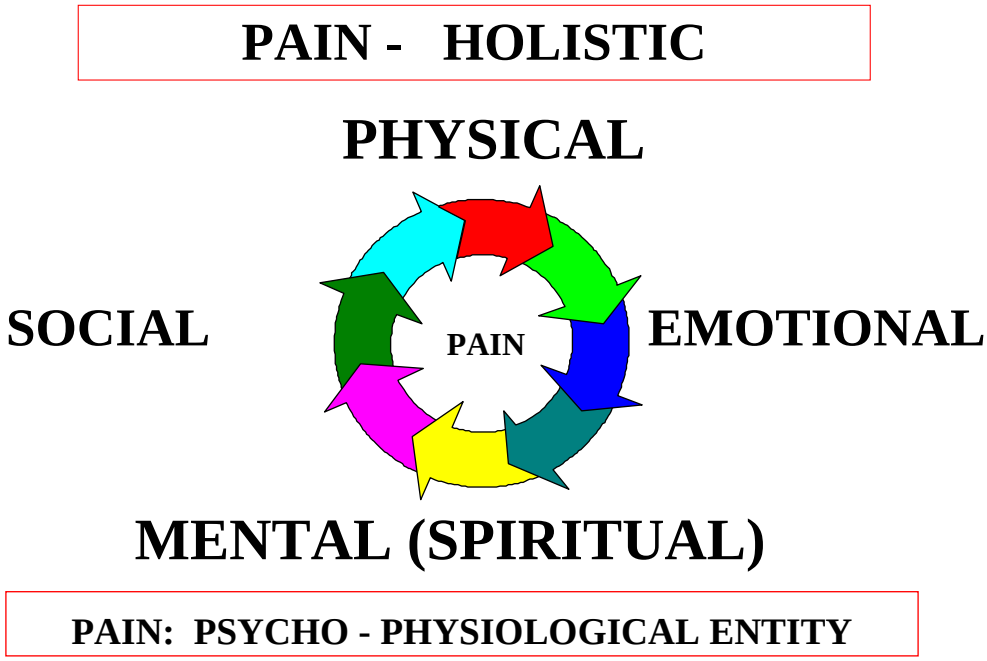
The changes to the musical influence shown in Figure 1 play a role in ascertaining the therapeutic advantage using receptive music therapy that will ultimately be subject to the studies and considered in an overall conclusion.

# 2 Introduction

## 2.1 Pain as a Psycho-Physiological Entity

Pain is a psycho-physiological entity (Figure 3) and shall therefore be treated via a multi-disciplinary therapeutic approach.

FIGURE 3

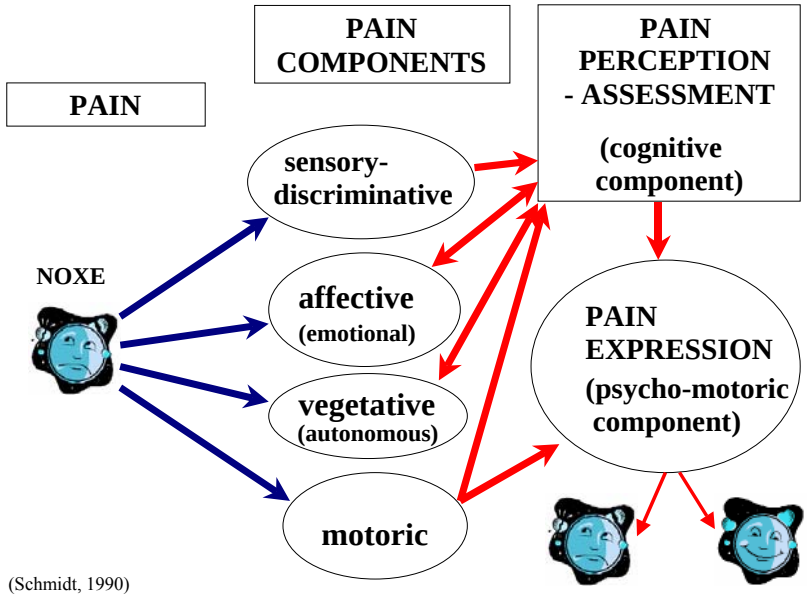



Pain as a psycho-physiological entity

Chronic back pain generates a high percentage of work-related absences and expenses for medical treatment. It has become a prominent socio-medical problem in all western countries. The consequences of chronic back pain are primarily determined by the degree of pain-related impairment and/or encroachment upon the patient as well as the assessment of the symptoms by the patient and his/her surroundings (Ulreich, 1997). Potentizing the complaints of a patient are the fear of pain and what could be its cause. Fears of pain, pain-avoidance strategies and the resultant mental stress often have a greater impact than the pain does itself (Ulreich u. Kullich, 1997).

Only in recent years have more experts (primarily Neurophysiologists und Psychologists) begun to better understand the phenomenon of pain and set foundations for more successful treatment. Today one can find better suited means for reducing and overcoming pain and reaching a pain-free existence (Schilling, 1986). Pain and the experience of pain is a multi-layered issue (Figure 4) which becomes a vital problem in the chronically ill.

FIGURE 4




Pain components and pain perception

In many illnesses fear and depression are accompanying amplifiers. In the case of pain, next to these amplifiers, bodily contortions can also come into play (protective stance) that consequently even generate more pain. It is therefore imperative to find useful strategies to reduce these illness amplifiers in addition to the current therapies and/or if possible to prevent them. For this purpose selectively chosen music and relaxation instruction is well-suited.

## 2.2 Music and Pain

Music is an ancient „healing medium“ whose therapeutic use reaches far into our past. Whether in aboriginal cultures, the high cultures of old, or in Greek and Roman antiquity, music has been a part of medical science.

Music and health – this has always been a subject in human history. Out of the humoral pathology in antiquity developed a philosophical doctrine - with little practical relevance, however - that tried to illustrate that music has an effect upon rheumatic conditions. Thus music played an important role in both pythagorean and hippocratic medicine (Schumacher, 1958). Plinius (23-79 A.D.) reported on the use of music to combat joint pain (Evers, 1990). Unfortunately other than a few vague references we can find no explicit evidence on the use of music in cases of rheumatic illness in antiquity. Despite a causal system of thought music seems to have had more of a psycho-hygenic rather than purely therapeutic function. In 1792 Christian Ludwig Bachmann, in his Medical Dissertation of Erlangen „De effectibus musicae in hominem“ stated that music’s capabilities had use in distracting from rheumatic illness related pain (Kümmel, 1977).

FIGURE 5

LITERATURE OVERVIEW

PubMed., 22.4.02: Pain/Music: 239 Einträge; Pain/Relaxation: 2392

Musikwahrnehmung: EEG(Breitling et al. 87; Petsche et al. 96; Kreutz et al.02 Panksepp et al. 97; Morris et al 99); fMRI (Platel et al, 97; Zatorre et al 94; Bodner et al, 2001; Shaw 02; Blood and Zatorre, 01)

Hormone/Transmitter/Biogene Amine: NE, MHPG, HVA, Cortisol, ACTH, Prolactin, 5-HT, Katecholamine, beta-Endorphine, NGF, CGRP, NK, Dopa, Dopac, Testosteron, ANP, Testosteron, Oxytocin, Melatonin.....

Bettison 96, Bernatzky et al, 97, Panksepp et al, 98, Brownley et al 95, Gerra et al 98, McKinney et al, 97, Miluk-Kolosa et al, 94, Möckel et al 94, VanderArk and Ely 92; Evers and Suhr, 2000, Weinberger N. 97, Hassler M. 99, Freeman W.J. 95, Fukui 01

Conclusion: Music has influence upon the low subcortical regiones in our brain, music has strong influence upon PSYCHIC and PHYSIOLOGICAL situations of an organism. Effects upon human and animal!

Mockel M. et al: Immediate physiological responses of healthy volunteers to different types of music: cardiovascular, hormonal and mental changes. Eur. J. Appl. Physiol. 68: 451-459

Literary overview: a small selection of studies showing that music has definitive influences upon various neural circuitries.

The healing properties of music were known right into antiquity .Music affects body and soul. Many modern studies show that listening selectively to specific music brings marked improvement in acute and chronic pain. The effect of music extends not only to the psyche but also to various bodily changes such as muscle activity, breathing, heart frequency, skin temperature, skin resistance, and thus can lead to the desired effects such as fear and pain relief, healthy sleep and ultimately to an improvement in quality of life.

Tangible results have been registered in the following bodily changes: heart circulation (reduction in heart frequency, sinking arterial blood pressure, anti-arrhythmical effect), breathing (reduction in breath-minute volume, reduction of oxygen consumption, synchronization / harmonization of rhythm), endocrine secretion and metabolism (diminished release of catecholamine, ACTH, cortisol, prolactin, ß-endorphin, reduction of minimum volume exchange, improvement in sleep-readiness), exocrine secretion and expulsion (reduced perspiration) reception, perception (raised pain threshold, reduced pain sensitivity), and psycho-motor function (reduced motor agitation, diminished tonicity, reduced muscle cramping, compare Figure 6)

The study of some of these aspects was previously the subject of one of Herbert von Karajan's motivated research projects of the 1960's (s. Harrer u.a. 1977, 1990). New studies at the Mozarteum University under the direction of professors Dr. Horst-Peter Hesse and Dr. Günther Bernatzky build upon these foundational works (see website: http://www.mensch-und-musik.at).

Many factors influence if and to what extent music has an effect upon humans: thus psychological aspects play a role, for example the musical competence; physiological factors such as sensitivity and reaction times; social structures or ethnic background; as do associations that are connected to music from life experiences. Of important significance is the characteristic of the music itself; such as the mode (minor or major), volume, tempo, melody, rhythm, timbre, harmonics, tone range, phrasing and articulation. General rules are difficult to define, however, as far as is possible must be aimed for.

Through the use of relaxation instruction in connection with music alleviating effects can be achieved with respect to stress, fear or depressive symptoms (Schneider et al. 2001). Thus one was able to show that cortisol in the plasma and systolic blood pressure became significantly reduced and more stable on account of the music in comparison to the control group without music.

In the twentieth century music was utilized in medicine on the one hand as an alone-standing psycho-therapeutic mechanism, while on the other hand as an adjuvant in therapy and rehabilitation of somatic illnesses (Strobel, 1978).

Today we understand music therapy to be the scientifically sound, diagnostic-specific use of music or musical elements for the purpose of treating ailments. It applies either to reception of music (**receptive music therapy**) or to the musical activity of the patient (**active music therapy)** in the form of either directed or free improvisation. Music therapy applies in two separate directions with respect to the dependence on character of the musical selection: either for the purpose of **activating** the patient - wherein it could be purely a bodily activation or an emotional re-orientation – or for the purpose of **relaxation —** whereby the release of bodily tensions or the relief from mental stress such as fear is the goal.

To have an **activational effect** the music must in most cases have a medium to loud volume and fast tempo, with many volume and tempo changes. Additionally a diverse tonal range and an at least medium harmonic complexity should be present. For a **relaxing effect** the music should have a lower volume and slower tempo with few volume and tempo changes. The tonal range should be narrow and the harmonic complexity should remain slight (Gembris, 2002). There are, however, many cases in which music deviates from these rules. The many possible combinations of musical characteristics tempo, rhythm, dynamics, sound color, melody and harmony are so varied that it is impossible to establish a simplified model into which to order musical parameters and musical expressiveness.

Many observations have shown that music effects subcortical centers in the brain and has a strong influence upon the psychological and physiological state of an organism (Hesse H.-P, 2003; Panksepp J. u. G. Bernatzky, 2002). It is known that listening to specific music leads to a reduction in both acute and chronic pain, while improving sleep and quality of life in general (Kullich W., G. Bernatzky u. a. 2003) — in our research the effect music in combination with relaxation instruction had upon the course of acute and chronic pain and upon various life processes was studied with the help of physiological and psychological measurements.

Today it is known that – in the case of chronic low back pain – it makes sense to apply multi-disciplinary rehabilitation concepts. Thus music therapy can intervene as an adjuvant treatment in any pain rehabilitation therapy, since it is apparent that music and relaxation both produce stress- and fear-reducing effects (Bernatzky et al., 1999).

Music therapy as adjunct to medicament-based pain therapy is primarily of importance when routine therapeutic treatment requires alternatives that can work cumulatively with medication and physiotherapy — such as in cases where use of analgesics or non-steroidal antirheumatics for a therapy-resistant and recurrent complaint has reached chronic levels.

## 2.3 Music During Operations

For the most part, psycho-physiological stress is especially strong in patients prior to an operation. In some pre-OP stations today attention is given to not only reducing fear but also

pain through the use of music (Heitz et al, 1992, Cunningham et al, 1997, Spintge, R., 2000). The ambient sounds are thus compensated for. A requisite relaxation-promotive effect is just as much the goal here as improved quality of sleep. Ultimately the goal is to reduce the need requirement for pharmaceuticals. This also benefits by reducing side-effects and costs. To this end studies by Frandsen (1990) showed that music can be an alternative to using pharmaceuticals that, in addition to its known influence upon heart circulation and the metabolic system, has a large impact in reducing fear before an operation. In that particular study the music selected was based on the patient's preference.

Even in OP rooms relaxing music has successfully been used. Amodei and Kaempf (1989) showed that a patient group exposed to music had significantly lower breathing rates and fear levels compared to patients without music intervention. Systolic blood pressure in the experimental group indicated a slight reduction. In this study the same opinion - that patients, themselves, should select the music - was held.

Godbey and Wolfe (1997) were able to show that - in operations of the bowel area - patients who were exposed to music 3 days prior to as well as during and after their operation, had only half the post-operative fear levels and half the requirement for analgesics.

Further studies that were able to show reduced post-operative pain levels have been published by Good M. (1995, 1998), Zimmermann L. (1997), Good M. und Stanton-Hicks (1999, 2001), Mariauzouls (1999) and Rawal (2001). Long-term effects were not researched in these studies. Also, much too little information about the type of music used is provided in these studies. Ultimately it was shown that blood loss in patients that were offered music was significantly (43%) lower as that by patients without (Dreher, 1998). In that particular study a shorter duration of stay at hospital was also indicated.

The diversionary and relaxing effect of piano and guitar music is just as welcomed as is soft hit parade music. The work group surrounding the German doctors Spintge and Droh recorded reduced secretion of plasma-ACTH and plasma-beta-endorphin after birthing operations in women who had been exposed to music during the birth. During peridural catheter applications it was also shown that blood pressure increase was significantly lower as in the control group. Additionally music leads to an improvement in the total emotional atmosphere within the room.

In a study by Guzzetta, C. (1989) it was researched whether music and relaxation therapy made it possible to lower the stress level for patients with myocardial infarct delivered into intensive care. 80 patients selected in random order were split into three groups: relaxation group, music therapy group and control group. The music used was calmative classical, soothing pop and non-traditional music. What was shown was that a lowering of peak values in heart frequency and raising of peripheral body temperature was more easily reached by patients in the relaxation and music therapy groups as by patients in the control group. Both the music therapy and relaxation were effective strategies for stress reduction for these patients. It could also be clearly shown that listening to music is far more effective as solely relaxing without music. After a series of sessions the peak values heart frequency could be reduced even further through the influence of music.

In some work the effect of music especially with respect to breathing was observed (Fried, 1990). The integration of music in breathing and relaxation exercises was scrutinized. A direct positive bodily influence was revealed as an increase in breath volume due to the breathing exercises. Fear-prone patients however displayed typical shallow and rapid chest inhalation and tended to hyperventilate. Music has a paradoxical effect upon such

persons: although they find the music to be relaxing, calming and de-stressing, their physiological measurements show contradictory values.

Music and breathing play an important role in goal-oriented state-of-consciousness alteration. This is used for example in nursing care, where the fear-inhibiting quality of music works in conjunction with a combination of massage and breathing techniques (Lehrer et al, 1994) and provides substantially improved results in diverse illnesses – especially those in connection with strong pain.

An American study was able to show that, in the case of newborn premature babies, a potential US$ 3.5 million can be saved annually (ca. $1,000 – $2,000/day) when the children are treated to music (Schwartz, 1997). The study showed that neural growth was stimulated and skull growth accelerated in comparison to children with no musical exposure (Fred J., 2002). The children in the music group could leave the hospital on average 3-5 days earlier. This amounts to a cost saving of US$2,000 to 9,000 per child.

# 3 Test Patients and Methodology

**65 patients with painful spinal-syndromes** (low back pain, Study 1) were placed randomly (prospective) during an ambulatory rehabilitation procedure into a group exposed to either music and relaxation instruction plus a standardized physical therapy or into a second group with no music application. The music therapy comprised of specially-designed music for use in treating pain (Entspannung bei Schmerzen, Mentalis Verlag Essen, ISBN-Nr. 3-932239-95-4), which was played through headphones in the evenings for 25min. while lying in bed, at least once daily over the course of three weeks. In further prospective and randomized studies by our work group a total of **126 patients** having undergone lower abdominal operations, tonsillectomies and operations relating to the changing of knee prostheses were studied to determine the effect of relaxation music and relaxation instructions focusing on pain reduction, quality of sleep and well being. Patients heard the standardized music on the evening prior to their operation, as well as immediately before or rather after. In the case of the tonsillectomies and knee prostheses studies, patients heard the music post-operatively.

# 4 Results

## 4.1 Back Pain

65 patients with painful spinal-syndroms (low back pain, Study 1) were placed randomly into a group exposed to either music and relaxation instruction plus a standardized physical therapy or into a second group with no music application during their ambulatory rehabilitation procedure. The music therapy was comprised of specially-designed music for use in treating pain which was played through headphones at least once daily over the course of three weeks.

As seen with the aid of a visual analog scale (VAS) the overall sensation of pain significantly lessened and pressure-pain along the spinal column was reduced through the application of music therapy. The subjective impairment – analysed with the help of a Roland & Morris questionaire – could be substantially improved only in the music group. Interestingly, the music therapy had a positive influence upon sleeping disorders in chronic back pain subjects, which we verified with the aid of the Pittsburg Sleep Quality Index.

### 4.1.1 Pain Measurement

During the 3-week ambulatory stay of low back pain patients who had their daily dose of music and relaxation text (Group I) a significant improvement in the overall sensation of pain (shown using VAS) was registered (Figure 6). When observing the data it becomes apparent that this pain reduction in the music group was far more defined than in the control group, becoming statistically significant in just 10 days. Also pain from pressure along the spinal column became significantly reduced with the exposure to music therapy, so that on average the pressure pain was reduced to „light“ from „medium“ on a score of intensity. Comparing 10 patients with moderate and 11 with strong pressure pain after 21 days, only half – or 5 and 4 respectively – still felt moderate or, rather, strong pressure pain along their spines. By comparison in this score group control subjects only registered improvement in one subject per respective category. This amounts to 3% (Group II).

FIGURE 6

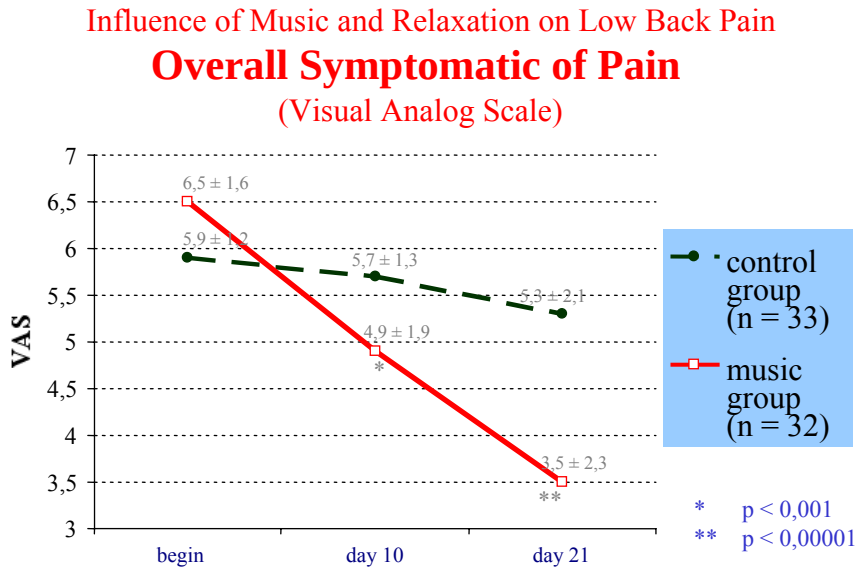



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Fig. 6: Measurement of pain levels using VAS

## 4.1.2. Roland & Morris-Questionaire for Low Back Pain

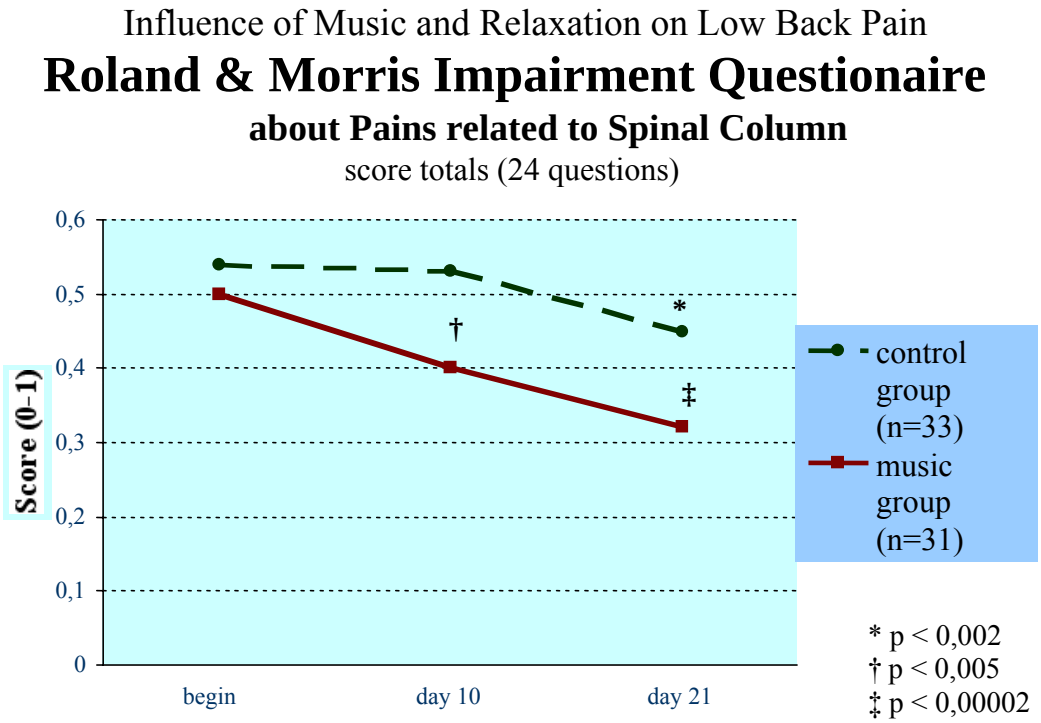
In a total of 24 questions posed through careful logging of subjective impairment scores with the aid of the Roland & Morris (1983) questionaire it was shown that a significant improvement had occurred in both treatment groups after three weeks (Figure 7). However in the music group (Group I) the score reduction was more defined ($p < 0.00002$) as in the control group ($p < 0.002$) with a standardized physiotherapy program and no music. Interesting is the fact that the multi-disciplinary therapy program using music and relaxation was able to reduce the Roland & Morris score totals significantly after just 10 days ($p < 0.005$) while the group with no music only registered improvement in their spinal-syndrome complaint-related impairment after 21 days.

In the analysis of the individual questions we found equally interesting results. In question 3 „I walk more slowly than usual as a result of my back problem“ we observed an improvement in a large number of patients of both treatment groups, though a comparison of the differences between the groups proved statistically insignificant.

A different result was shown in the case of question 5 „Because of my back, I need to use the handrail to climb stairs“ of the Roland & Morris scores. At first the same number (9) of patients in both groups answered they needed no handrail. After 21 days, however, the advantage shifted to the music users, with 16 compared to 11 patients of the control group no longer requiring the handrail.

Also in question 12 „ I find it difficult to get out of a chair because of my back“ it became statistically verifiable ($n = 3$; $p < 0,01$) that the number of patients with complaints was reduced (answer “yes”, $n = 18$) in the music group after 21 days as compared to the non-music control group.

FIGURE 7

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Results of the Roland & Morris impairment questionaire

The picture regarding frequency of recurrence in question 13 „My back is painful almost all of the time“ also shows clearly that the number of patients who indicated they felt no more pain after 3 weeks was increased (reduction from 23 to 14). This is confirmed by the results in pain reduction shown previously in the analog scale (VAS). A slight advantage from the music therapy was shown surprisingly also in question 17, which dealt with impairment in walking short distances.

In the case of question 14 – dealing with complaints from turning over in bed – a significant improvement was registered by both groups.

The analysis of question 18, „I sleep less well because of my back“, showed that under the influence of daily application of the music the number of low back pain patients suffering from sleep deprivation was reduced by half. Without music this positive development could not be registered. This result was mirrored in the subsequently described analysis of the Pittsburg Sleep Quality Index, which more accurately depicts details about changes in quality of sleep.

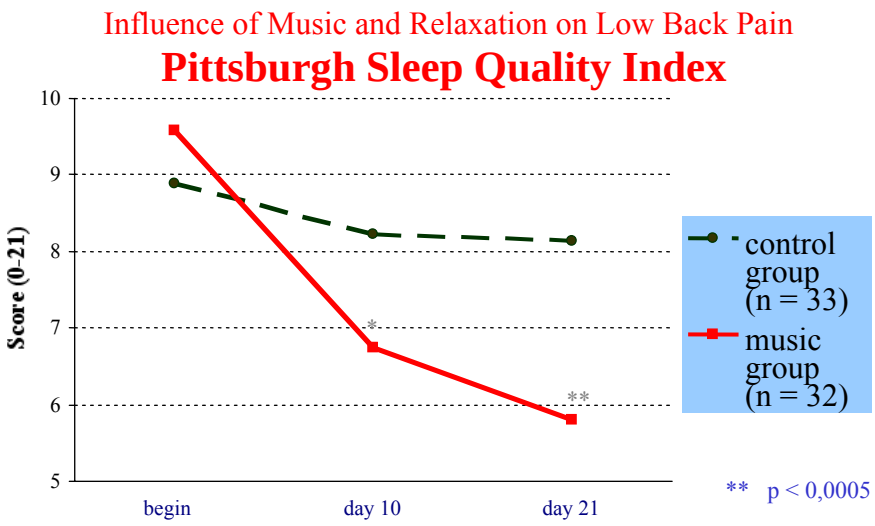
In regard to the remainder of the 24 detailed questions of the Roland & Morris questionaire that have been left out herein, there were no statistical relevant changes recorded during the 3 weeks in which the study was carried out, and no statistically relevant differences between the music and control groups were found.

### 4.1.3 Sleep Analysis Using the Pittsburgh Sleep Quality Index (PSQI)

The analysis of the Pittsburg Sleep Quality Index (overall score) for which zero means no sleeping disorder while a total score of 21 indicates a serious sleeping disorder, showed that on average the music group's scores dropped significantly from 9.59 to 5.81 after 21 days, whereas what stands out is that, at 6.74 after only 10 days, the PSQI score total in the music plus relaxation text instruction (Group I) group was already substantially reduced. By comparison the reduction of 8.88 to 8.22 and 8.13 in the control Group II (no music) was not significant.

The analysis of 7 **partial results** (=components, Table 4) tabulated from 19 self- and 5 third party assessments, in the case of the **subjective parameters of 5 partial components**, shows a subjective result with respect to **quality of sleep**, subjective assessment of the **extent of the sleeping disorder**, the assessment of the **causes of the sleep disturbances**, indications as to **tiredness during the day** as well as **energy disturbance**.

FIGURE 8




24 questions, 19 questions about self assessment, 15 questions about third party assessment, sleepiness during daytime; sleep quality increased significant in both groups; duration of sleep for example no changes in control group .

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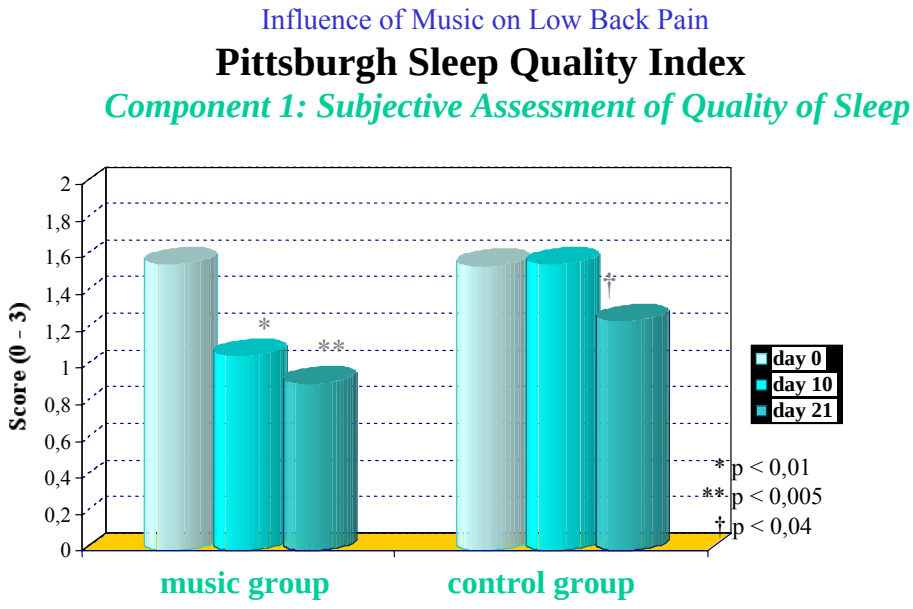
PSQ Index – Results

Thus it was possible to show that the subjective assessment as to quality of sleep significantly improved in both the music group as well as the control group after the 3 weeks. However the spinal-pain patients undergoing music therapy registered a substantial improvement in their subjective assessment of quality of sleep after only 10 days. Even the subjective assessment of sleep disorders showed a clear advantage for the music group: after 21 days a significant improvement with respect to sleep disorders could be determined for this Group I (music). Thus in the scope of the multi-disciplinary treatment concept for patients with chronic back pain the factor of daytime fatigue could also be improved.

FIGURE 9




PSQ Index – subjective assessment of quality of sleep

One **objective parameter** of the sleep analysis using PSQI is the **determination of sleep duration**. It could be clearly shown that the score pertaining to sleep duration in the music group significantly lowered while by comparison that of the control group (Group II) remained unchanged. In this case a lower score means a longer sleep duration (score 0 = > 7 hours of sleep) while a higher score indicates very short duration (score 3 = <5 hours of sleep). Based on the sleep duration plus the time spent in bed the PSQI also calculates the objective parameter **habitual sleep efficacy**.

Thus from the questions pertaining to sleep hours and time of waking, minus the time spent in bed a score for sleeping effeciency is calculated, which spans from 0 = 85%, >1 = 75 – 84%, 2 = 65-74%, up to 3 = less than 65%. Because sleep efficiency is derived out of the sleep duration the results here also showed significant improvement in sleep efficiency, expressed by a reduced score in patients in the music group with spinal column complaints.

With respect to the use of sleeping substances or disfunction during the day, neither of the groups studied registered statistically significant changes (Table 3).

TABLE 3

| Comp. | Description | ***Music Group*** | | | | ***Control Group*** | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | day 0 | day 10 | day 21 | Significance (p) | day 0 | day 10 | day 21 | Significance (p) |
| 1 | Subjective sleep quality | 1,56 ± 0,91 | 1,06 ± 0,81 | 0,91 ± 0,89 | < 0,005 | 1,55 ± 0,75 | 1,56 ± 0,7 | 1,25 ± 0,84 | < 0,04 |
| 2 | Sleep latency/ Sleep entry phase | 1,75 ± 1,05 | 1,37 ± 1,13 | 1,34 ± 1,12 | n.s. | 1,61 ± 1,12 | 1,56 ± 0,97 | 1,69 ± 1,12 | n.s. |
| 3 | Sleep duration | 1,84 ± 0,81 | 1,19 ± 1,11 | 1 ± 1,05 | < 0,0004 | 1,79 ± 0,96 | 1,74 ± 0,76 | 1,88 ± 0,94 | n.s. |
| 4 | Sleep effectiveness | 1,59 ± 1,24 | 1,1 ± 1,14 | 0,78 ± 1,07 | < 0,01 | 1,61 ± 1,12 | 1,48 ± 1,09 | 1,69 ± 1,15 | n.s. |
| 5 | Sleeping disturbances | 1,38 ± 0,49 | 1,16 ± 0,58 | 1,06 ± 0,56 | < 0,03 | 1,33 ± 0,54 | 1,22 ± 0,42 | 1,16 ± 0,45 | n.s. |
| 6 | Sleeping substances used | 0,09 ± 0,53 | 0,35 ± 0,88 | 0,22 ± 0,71 | n.s. | 0,3 ± 0,88 | 0,11 ± 0,32 | 0,22 ± 0,66 | n.s. |
| 7 | Daytime fatigue | 1,22 ± 0,91 | 0,45 ± 0,72 | 0,34 ± 0,6 | < 0,0003 | 0,7 ± 0,81 | 0,41 ± 0,64 | 0,31 ± 0,59 | < 0,02 |

Pittsburgh Sleep Quality Index

## 4.2 Perioperative Application of Music

### 4.2.1 Stomach Surgery

Both groups studied, where surgical intervention was performed on the stomach, offer comparable data with respect to pre-operative body mass index, PSQI as well as the state of wellbeing index. The PSQI in Group A was significantly better as compared to that of Group B. The use of analgesics by Group A was lower as was the use of barbiturates. In Group A no post-operative psycho-pharmaceuticals or sleeping substances were administered, while in

Group B in 3 of 10 patients requested post-operative sleeping substances. The VAS shows Group A to have less pain. In the wellbeing scale Group A posted significantly better scores.

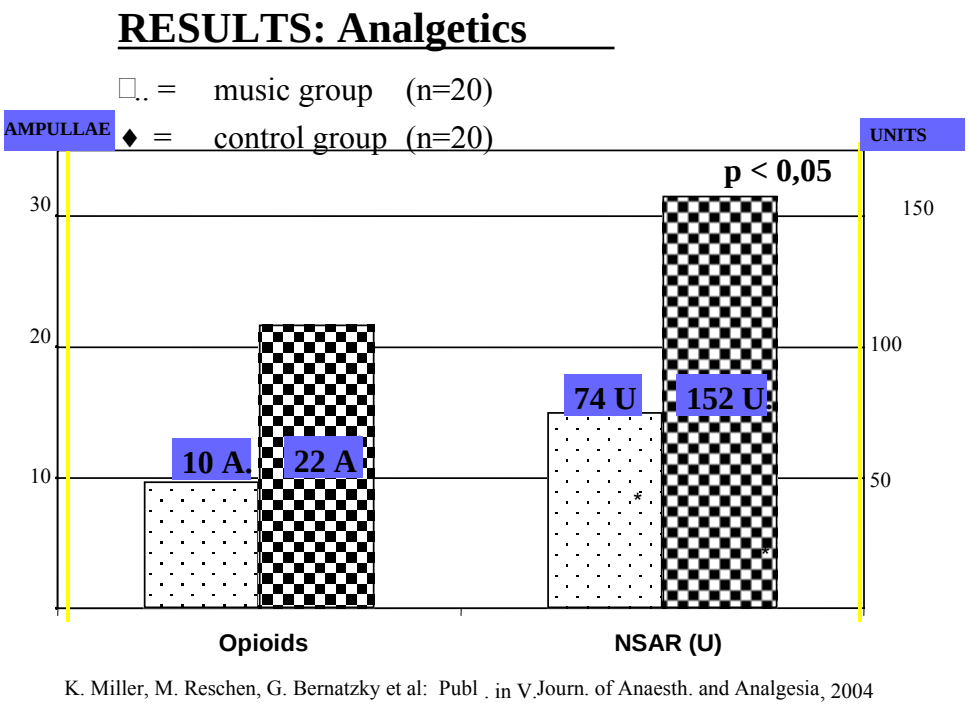
TABLE 4

# RESULTS

| | Group A (n=20) music group | Group B (n=20) control group | p |
|---|---|---|---|
| Well Being | 1,3 ± 0,84 | 1,8 ± 0,84 | < 0,05 |
| Pain | 2,6 ± 0,84 | 3,4 ± 0,85 | < 0,05 |
| Opioids (mg) | 0,97 ± 1,75 | 2,17 ± 3,08 | < 0,05 |
| NSAR (U) | 0,69 ± 0,51 | 1,52 ± 0,65 | < 0,05 |
| Sleeping substances (U) | 0,12 ± 0,22 | 0,3 ± 0,41 | < 0,05 |
| PSQI | 19 ± 4,2 | 25 ± 6,8 | < 0,05 |
| Degree of need for care | | | |
| S | 1,45 ± 0,4 | 1,72 ± 0,52 | 0,061 |
| A | 1,30 ± 0,4 | 1,68 ± 0,49 | 0,062 |

Depiction of the completed results of the Hallein-Study

FIGURE 10

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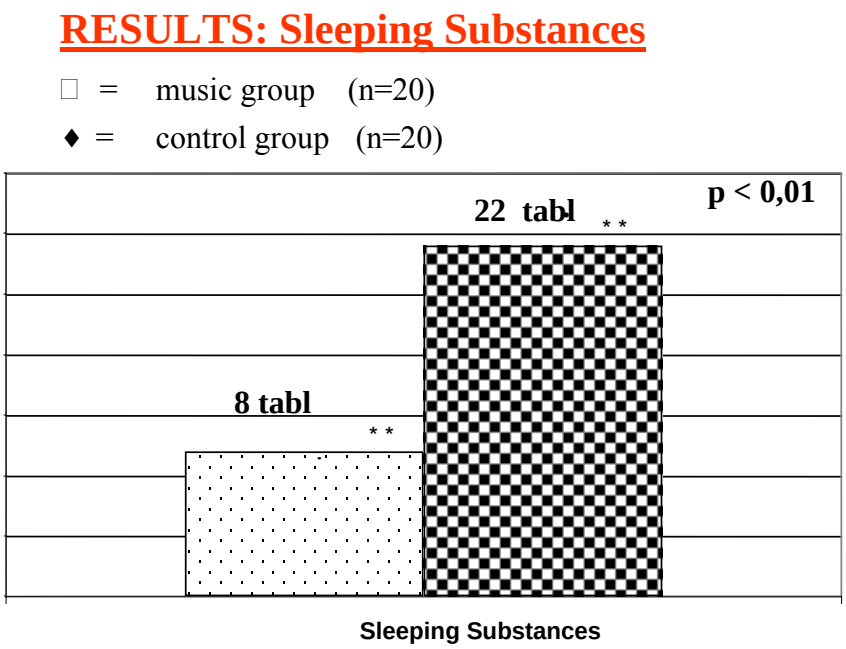
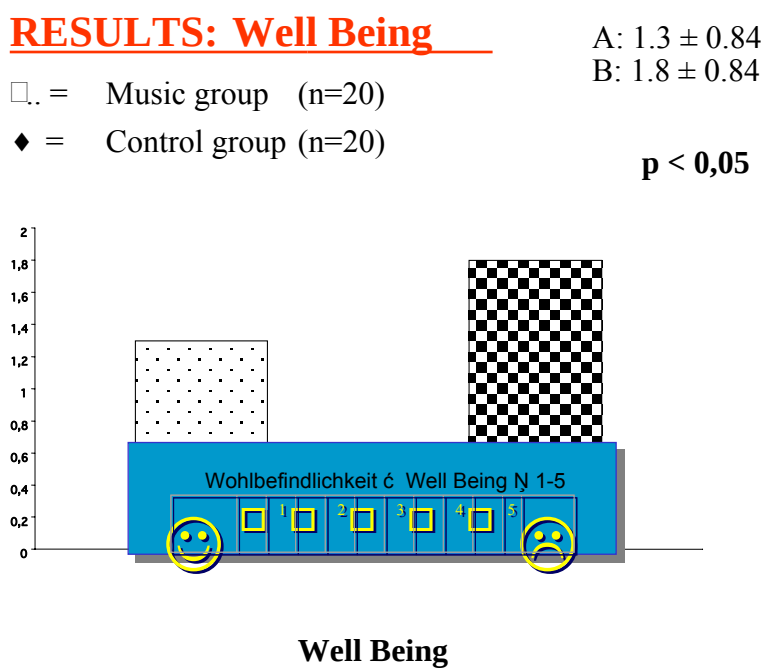
Amounts of opiates and NSARs in both study groups.

FIGURE 11




Amount to sleeping substances used by both study groups.

FIGURE 12



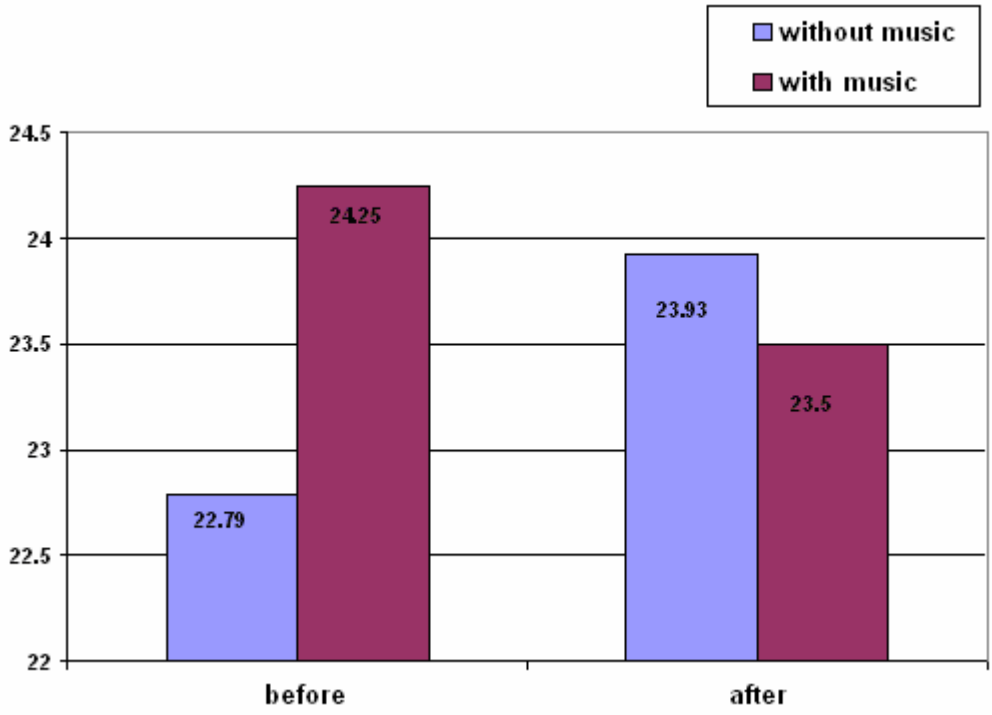

Depiction of state of wellbeing, derived via the Wellbeing-Index of both groups

## 4.2.2 Knee Endoprosthesis

**CIH:** (Questionaire as to survey control over illness and health).

The statistical analyses showed a clear indication that the therapeutic application of music substantially reduced the feeling of *social externality* (one dimension of the CIH) in patients of Group I from their pre- to post-operative state of being.

FIGURE 13




Externality of both patient groups before and after surgery.

This indicates that post-surgically aptness to take self-initiative in influencing the bodily condition rises, although inclination to follow the orders of a doctor remains the same. The opposite effect is shown in the control group, who had no exposure to receptive music therapy (an almost non-significant trend, with a level of significance of $p < 9\%$).

**HADS:** (Questionaire to ascertain states of anxiety and depression in somatic medicine).

The analyses of HASD data of both groups showed neither statistically relevant differences between the groups, nor in the analyses of the parameters for anxiety and depression between pre- and post-surgery. This leads to the conclusion that, in the patient group that was studied, medical and/or medicinal treatment or receptive music therapy has no influence upon the dimension of anxiety and depression during treatment.

VAS: (Visual Analog Scale to measure level of pain felt).

In a design of Typ SPFp.qr the following factors were considered:

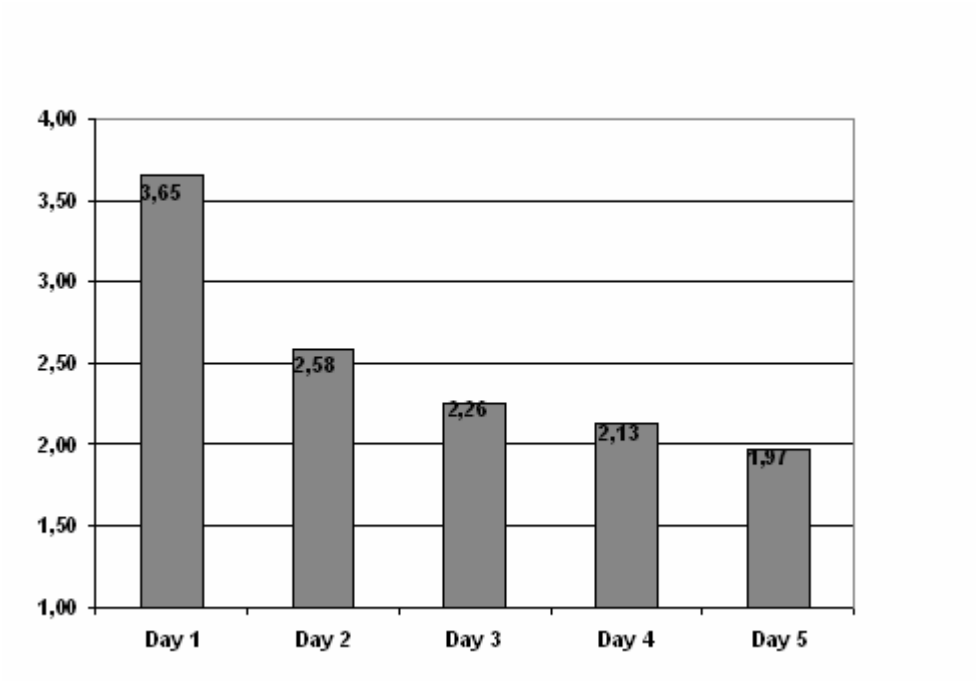
- group factor (with/without music)
- measurement repeatability factor 1 (days 1 to 5)
- measurement repeatability factor 2 (per day 3 measurements: 8:00,12:00,18:00 hours)

N=18 (Group 1)

N=16 (Group 2)

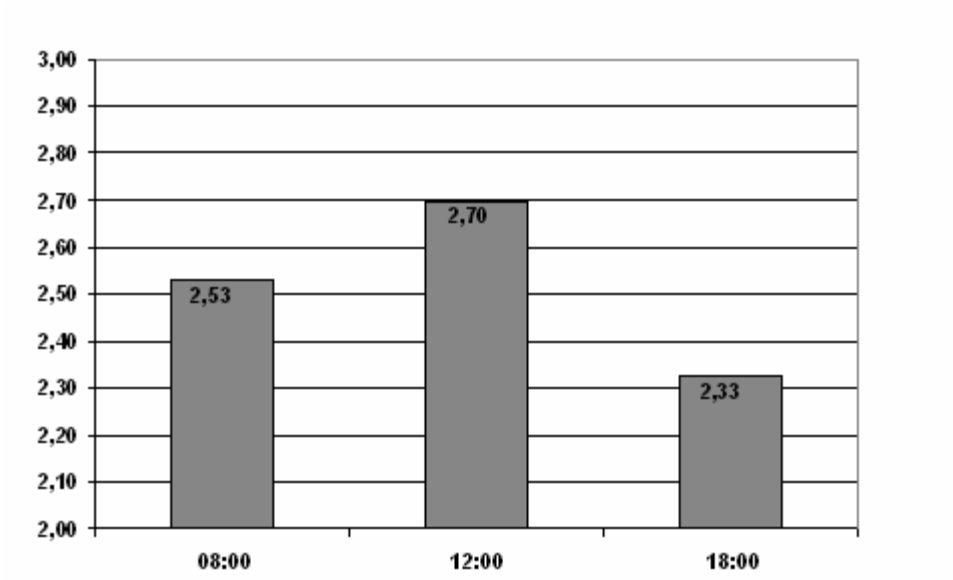
The result showed two highly significant statistical prime effects independent of the group factor with respect to the two measurement repeatability factors ($p=0.01$ bzw. $p=0.011$).

FIGURE 14




Progression of subjectively felt pain in all patients up to fifth post-op day.

FIGURE 15




Progression of subjectively felt pain in all patients for all three times measured (8:00, 12:00 and 18:00 hours respectively)

We see a continual statistically significant improvement in both groups with respect to feeling pain, measured from the day prior to the surgery to the second day after surgery (with VAS) , independent of the group factor (in each case a statistically highly significant degree of uncertainty of $p < 1\%$ for the factors day and time of day).

In the group with music application these changes may have been more clearly defined as in the control group, statistically, however, they are not relevant.

### 4.2.3 Tonsillectomy

The data analysis from the PSQI to ascertain quality of sleep provided in its total result, as well as in 4 of a total of 7 subtests, statistically significant (level of significance $p < 5\%$) and/or to a large degree highly significant (level of significance $p < 1\%$) differences between the three groups and/or the measurement times (pre-surgery or second day after).

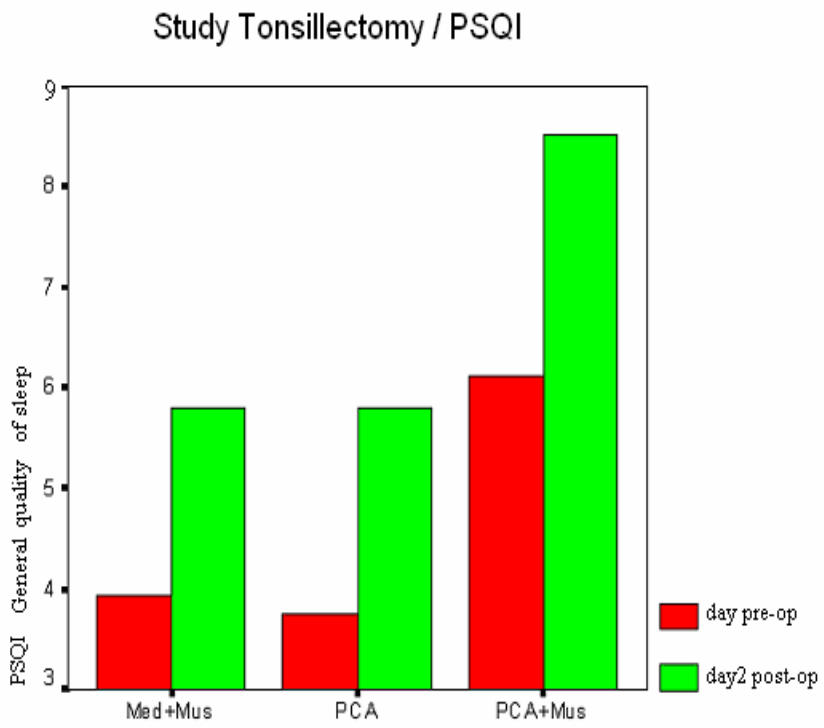
The 4 dimensions deriving from the PSQI pertain to:

General quality of sleep, subjective quality of sleep, sleep efficiency, and sleeping disorders.

► General quality of sleep: Group Factor and Day Factor highly significant (level of significance $p < 1\%$)

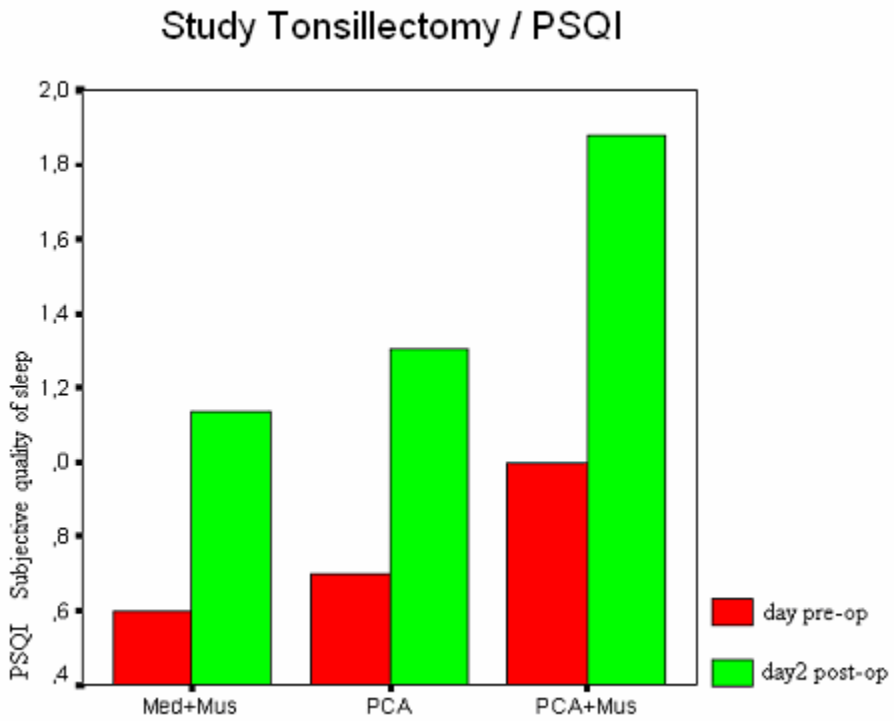
► Subjective quality of sleep: Group Factor and Day Factor highly significant (level of significance $p < 1\%$)

FIGURE 16




Quality of sleep of all patients who received a tonsillectomy, surveyed with the Sleep Quality Index

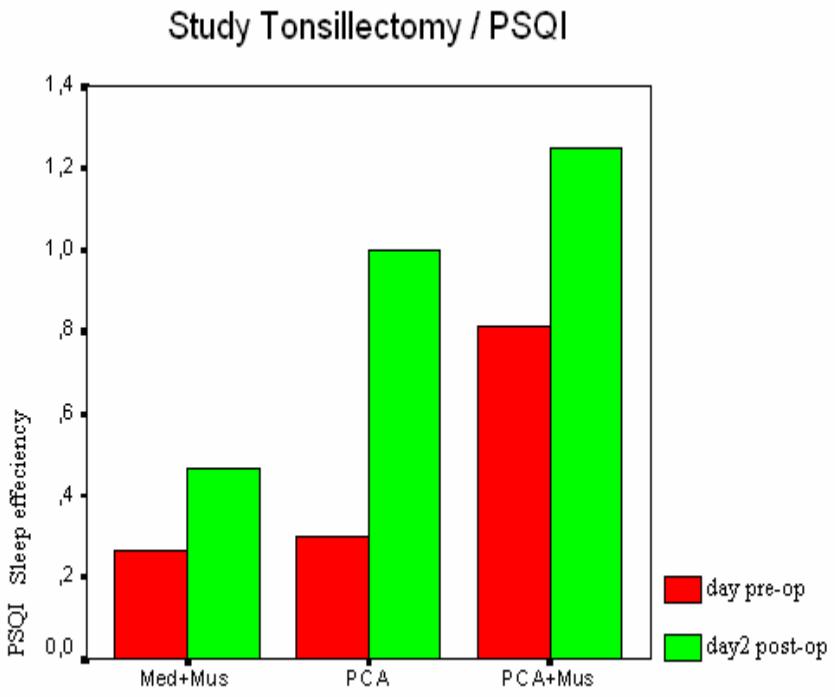
FIGURE 17




Sleep quality of all patients who received a tonsillectomy, surveyed by the Sleep Quality Index comparing pre-op to second day post-op.

► Sleep effeciency: Group Factor significant (level of significance $p < 5\%$),
Day Factor highly significant (level of significance $p < 1\%$)

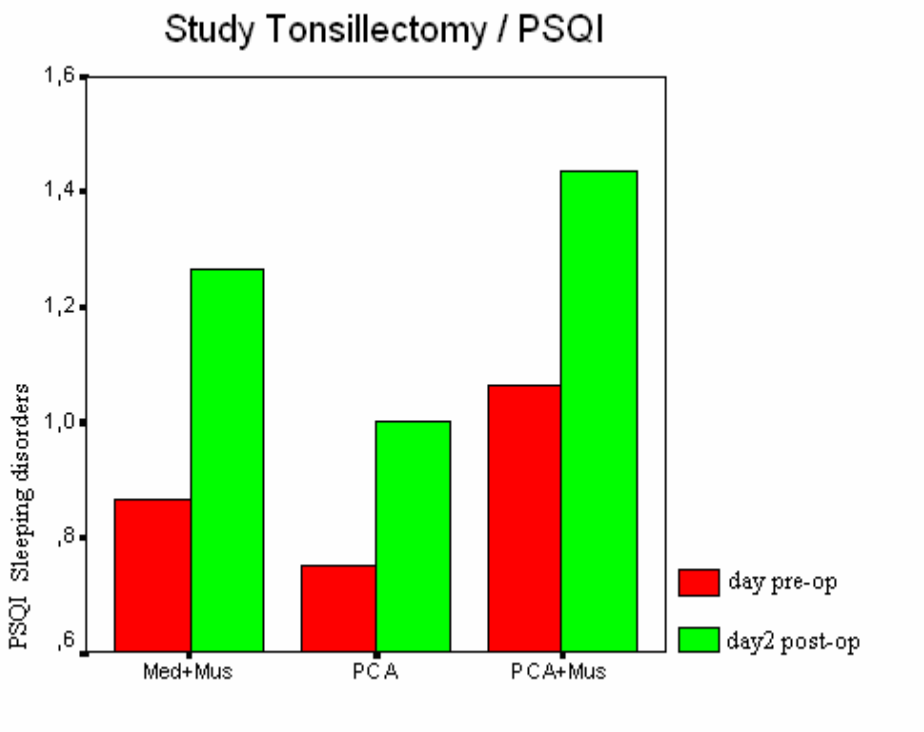
FIGURE 18




Sleep efficiency of all patients who had a tonsillectomy, surveyed by the Sleep Quality Index comparing pre-op to second day post-op.

► Sleeping disorders: Group Factor significant (level of significance $p < 5\%$),
Day Factor highly significant (level of significance y $p < 1\%$)

FIGURE 19




Sleeping disorders of all patients who received a tonsillectomy, surveyed by the Sleep Quality Index comparing pre-op to second day post-op.

## 4.3 Summary of the Results

### 4.3.1 Back Pain

It was shown in all studies, with the aid of the visual analog scale VAS, that the overall sensation of pain including pressure pain along the spinal column was significantly reduced through the use of music therapy. Even subjective impairment, studied with the aid of the Roland & Morris questionaire on back pain, could be substantially improved in the group using music. The music therapy had a significant impact on the sleeping disorders in cases of chronic low back pain. Immune system factors were not influenced. In the further studies the applied use of receptive music in peri-operative areas showed significant improvement with respect to pain and quality of sleep. The doseage of strong pain supressors used could also be significantly reduced, as could the doseage requirement for sleep inducers. The results show decidedly that self-confidence in the patients rose. Their feeling of wellbeing was clearly greater than that of those in the control group.

### 4.3.2 Peri-Operative Pain

With regard to the sampling of tonsillectomy patients this study demonstrated that medication used in connection with music application (Group I) produces the most definitive improvements in all four variables (general quality of sleep, subjective quality of sleep, sleep

efficiency and sleeping disorders) in comparison to the two other groups (Group II: PCA and Group III: PCA + music).

The visual analog scale (VAS), in measuring the subjective sensation of pain in the group of tonsillectomy patients that were studied, showed no relevant or interpretable results, in statistical analysis, with respect to possible differences between the three groups (Note: comp. knee-prosthetics study).

This indicates that neither medication in connection with music therapy, patient-controlled analgesics, nor patient-controlled analgesics with music had differing effects upon the subjective feeling of pain in the tonsillectomy patients.

Of note, however, is that in Group I the requirement for sleep inducing medication fell to 0% as compared to Group II and III, although in the pre-operative stage all three were the equal!

# 5 Conclusions

The use of selected music as an additive, non-pharmacological, side-effect free form of therapy exposes an easily practiceable therapeutic approach in treating painful chronic spinal column syndrome. The improvement in therapeutic effect of 60% speaks for itself. Music therapy as a complementary form of treatment to medicamental pain therapy is particularly indicated in cases of chronic pain resulting from tension, fear and other disturbances related to states of being, and should definitely be experienced with a high quality CD and headphones at the appropriate volume in order to be the most effective in relieving pain.

Somatoform-related pain is considered to be an indication for its use. In acute surgery-caused pain music application is useful even if there is a need here for some standardization in the form of its application. Music in combination with relaxation text instructions clearly improves the quality of life and - on account of its lesser side effects - should ideally be used in any daily interdisciplinary extensions to pain therapy. Diagnosis-specific music therapy should occur in every form!

A standardized peri-operative form of music with relaxation text instruction represents an effective and affordable addition to health promotion.

Listening 1-2 times daily to standardized music with relaxation instructions supports and promotes ongoing therapies in the daily routine of interdisciplinary pain therapy and improves the treatment success in a multifactorial therapy program by as much as 40%. In the sense of a holistic pain therapy, standardized music thus represents an ideal possibility as an adjuvant therapy addition.

The goal of further studies is the formulation and presentation of scientifically sound methods showing in what manner music can be effective in therapy and in the realm of new educational concepts.

By comparison to medicamental therapies there exist in music therapy hardly any authoritative guides. The long-term effects of music remain completely unexplored. At present many research sites are working intensively on evaluating the exact scientific correlation between various forms of music and the psycho-physiological reaction of different people (e.g. in this work group in Salzburg: www.mensch-und-musik.at). Music thus as „medicament“, effectively applied as a „musicament“ (personal message, Luban-Plozza, Ascona) would be most desirable.

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# Study Report Summary:

# Music and Relaxation

**October to December 2003**

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Salzburg, October 14th, 2003
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# Index

# 1 Goal

The goal of the study is to verify that music has psycho-physiological effects on a person. These effects can be categorized into long-term effects (from several weeks up to years) as well as short-term effects (directly after hearing a piece of music or during the experience). In the current study the short-term effects will be examined.

A further thesis, that shall be examined, asserts that people recognize the character of a musical composition and can describe this relatively uniformly. For this purpose a list of adjectives to describe the music breaks those definitions into eight characterizing types. Also explored will whether differences emerge between test subjects as a result of differing musical preferences, tastes and experience, and, whether categorization of the musical pieces using characterizing adjectives relates in some way to the psycho-physiological effect the music has on the listener.

A third thesis states that a state of relaxation brought on when listening to a piece of music can in fact be brought on by a diverse variety of music. The questions that emerge out of this hypothesis will explore how popular musical pieces cause a wide-spread relaxation or excitation in persons regardless of their social standing, as well as if and/or why musical pieces that are well known or valued have such effect.

It will be a priority to find music that will most likely have the same effect on the majority of the listeners regardless of popularity. In this way consistent predictions could be made possible.

# 2 Methodology

## 2.1 Study Execution

### 2.1.1 Test Subjects

28 subjects (8 males, 20 females; 11 professional musicians, 17 non-professional musicians [= non-musicians as well as non-professional]; age between 19 and 73 years)

### 2.1.2 Study Sequence

- Questionnaires (Musical preferences, listening habits)
- Blood pressure measurements (in 2-per-minute cycles)
- Physiological readings using a bio-feedback system during the following phases

TABLE 1

| Stillness phase 1<br>5 min. | Music phase 1<br>8 min. | Stillness phase 2<br>5 min. | Music phase 2<br>8 min. | Stillness phase 3<br>5 min. |
|---|---|---|---|---|
| 5 | 13 | 18 | 26 | 31 min. |

- Blood pressure measurements (in 2-per-minute cycles)
- Objective assessments of the musical pieces with the assistance of adjectives
- Hearing threshold measurements (the dial has 37 settings ranging from 100Hz to 14703 Hz, in intervals of 240 cents[1]. On every setting test subjects must turn the volume dial down to the point he/she can barely hear the piece. The device's software saves these settings for each.)

This process is then repeated with every test subject after completing the session (1-3), however using different pieces of music (listed in the table shown below.)

[1] The increase by 240 cent is equivalent to the multiplication of a frequency by $\sqrt[5]{2}$ (=1.148698).

### 2.1.3 Musical Pieces Used

TABLE 2

| Session | Selection Nr. | Title of Music |
|---|---|---|
| 1 | 01 | Mozart: Sonata for 2 Pianos, D major KV448, 1st movement |
| 1 | 02 | Relaxation music (mentalis „Relaxation during Pain“) |
| 2 | 03 | Sibelius: Violin Concerto in D minor op. 47, 2nd movement |
| 2 | 04 | Ravel: Pavane pour une infante défunte |
| 3 | 05 | Mozart: Violin Concerto G major KV216, 3rd movement |
| 3 | 06 | Mozart: Clarinet Concerto, KV622, 2nd movement |

### 2.1.4 Measured Parameters Using Bio-Feedback Device

Skin conductivity, temperature, pulse-amplitude and pulse-frequency (measured with a multi-sensor on the ring finger of the non-dominant hand)

Frequency of breathing and amplitude (measured using a contact-free infrared sensor)

EMG (measured using three sensors placed in the neck area)

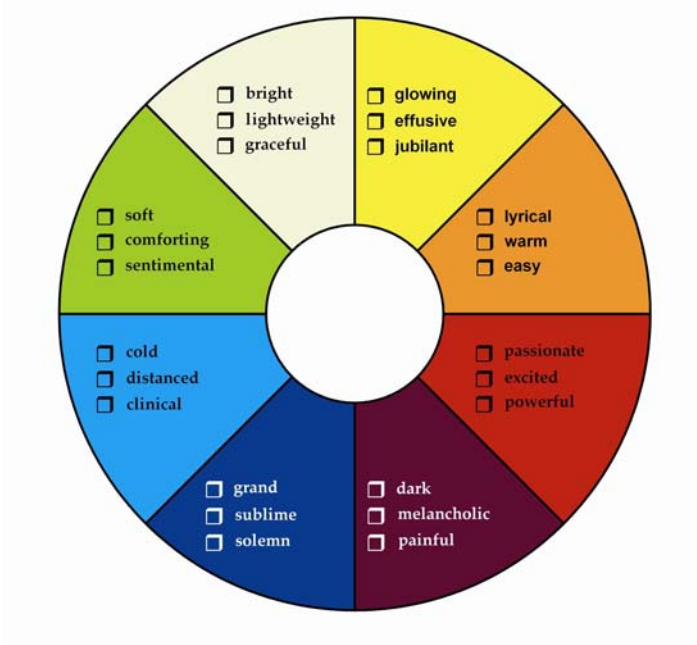
### 2.1.5 Physiology

To assess whether the music has had any effect at all the advancement of measurement curves was observed and the musical phases were compared to the stillness phases. Each of the seven parameters was broken down into sections (such as the two music phases and the three stillness phases) and the averages calculated for each section. The calculated averages were then combined into an order representing the timing sequence of the music and stillness phases. The differences between averages of the music phases and stillness phases of individual parameters were then accrued and their differences expressed as percentage values. After that, the two musical pieces from each single session were compared parallel to one another (in the sessions, the first piece of music tended to be more active while the second tended to be quiet) and the values of the averages of each parameter compared once again.

### 2.1.6 Colour Circle

To compare individual answers, each adjective was rated based on the total number of times it was checked off by the subjects. The rated adjectives were then summed for each musical piece and placed into the eight colour-separated groups. For each piece of music it thus became possible to determine which colour area of the circle the most answers were recorded in, in other words which adjective expression was attributable to each piece of music.

FIGURE 1

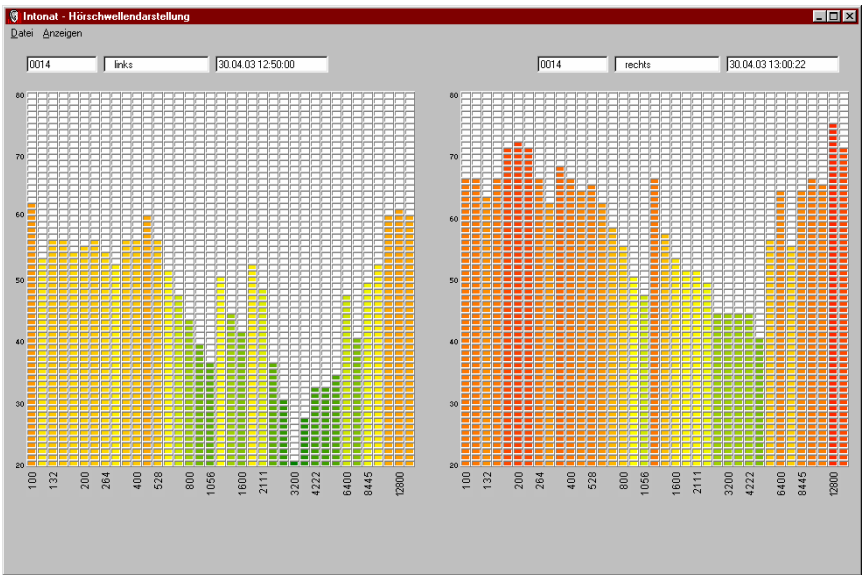



Adjective colour circle

## 2.1.7 Hearing Threshold Measurements

To enable a graphical depiction of the data collected after completing the tests the software program IntonSchwelle 1.01 was developed. It is able to import either the Intonat (measuring device) data or the data exported from IntonAus 1.0 then convert the hearing threshold data into a graphical depiction. The lower the value the greener the colour of the column becomes, while the higher values are depicted moving gradually into red. Lower values indicate a low hearing threshold - thus a better hearing capacity for that frequency.

FIGURE 2



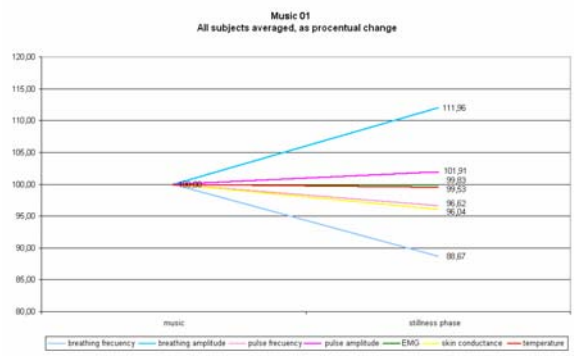

An example of an Intonat data, displayed using the program *IntonSchwelle 1.01* separated into the left and right ear

# 3 Results

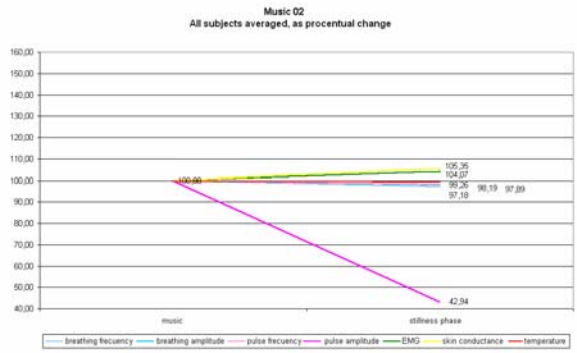
## 3.1 Physiological Readings

Overall it was verified that music has a definite effect. Only in two of the 48 readings taken - in one of the parameters - did we see no clearly recognizable change between the music phases and the immediately subsequent stillness phases. All other measurement readings (424 individual measurement rows[2] - or 99.3%) showed a definite change between music and non-music sections, and, there are clearly defined differences between the still and active musical pieces also.

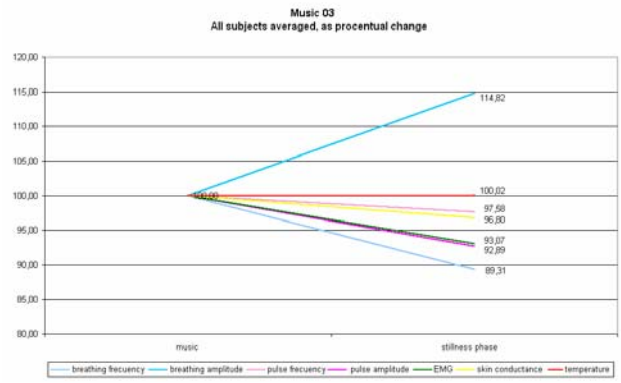
FIGURE 3



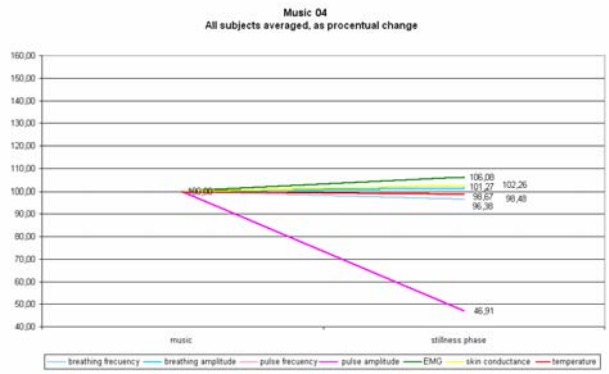

Noteworthy here is a clearly defined increase in breathing amplitude with a simultaneous decline in breathing frequency




Here we see a large decline in pulse amplitude

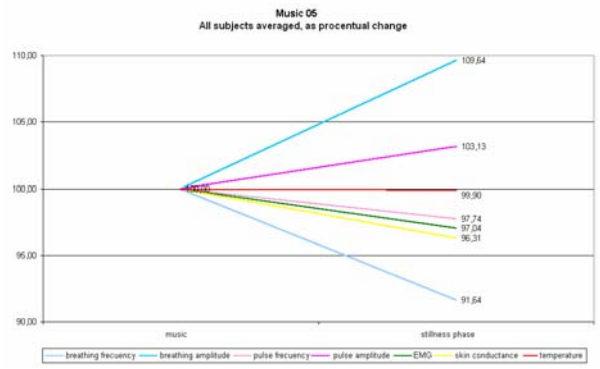



Qualities are similar to music piece 1

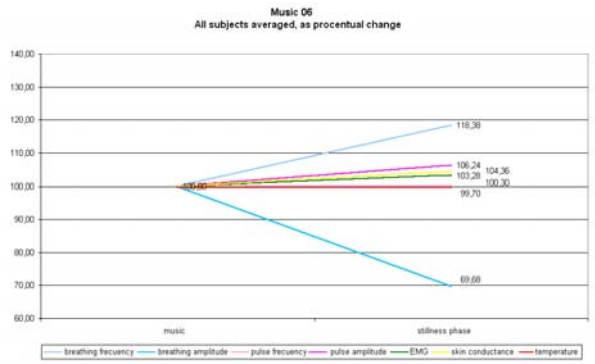



Qualities are similar to music piece 2

[2] From seven parameters in each of the 61 measurements carried out, 427 individual series of measuring values result.




Qualities are similar to music piece 1 and 3




Noteworthy here is a clearly defined decline in breathing amplitude with a simultaneous increase in breathing frequency

Summarizing all of the test subjects the readings indicate a breathing amplitude in all odd-numbered pieces (active music) distinctly higher at the conclusion of the piece in the subsequent stillness phase, while in the even-numbered (still) pieces amplitude fell (in the case of piece 06 drastically). The parameters breathing frequency and skin conductivity behave in exactly the opposite way as breathing amplitude. The pulse amplitude shows a clear reduction in value in the stillness phases after music piece 02 and 04. The EMG parameter values are higher in the stillness phases after pieces 02, 04 and 06 respectively, while music pieces 03 and 05 generated lower readings. Only in piece 01 do we see no change in the average value.

Thus in regard to non-professional and professional musicians we see a significant difference in the parameter breathing amplitude. The average values in the stillness phase are much lower in the case of professional musicians as opposed to non-professional musicians. While the value subsides in professional musicians during the stillness phases, it rises in the non-professional musicians (with exception of music piece 06). Similarly, a further difference between professionals and non-professionals – although not so distinguishable – is seen in the parameters EMG and skin conductivity. In the EMG readings for non-professionals during the stillness phases the value becomes higher (or doesn't fall as abruptly) as in the professionals. The percentage value of the changes is always greater in the non-professionals as in the professionals. Also in the case of skin conductivity do the values rise a little higher (or don't fall as abruptly) during the stillness phases for the non-professionals as those for the professionals (with the exception of music piece 06). Here, too, with exception of piece 06 the percentage change values are higher with the non-professional musicians as with the professionals.

## 3.2 Adjective Colour Circle

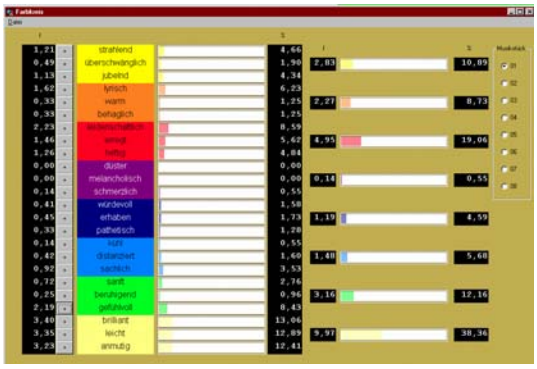
As a whole there emerged a recognizable colour scheme concerning each piece of music for the subjects. This consistency of characterization was most pronounced in the music pieces 01, 04, 05 and 06.

TABLE 3

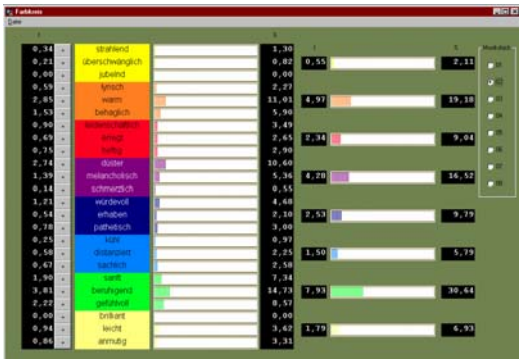
| | glowing effusive jubilant | lyrical warm easy | passionate excited powerful | dark melancholic painful | grand sublime solemn | cold distanced clinical | soft comforting sentimental | bright lightweight graceful |
|---|---|---|---|---|---|---|---|---|
| Music01 | 10.89 | 8.73 | 19.06 | 0.55 | 4.59 | 5.68 | 12.16 | 38.36 |
| Music02 | 2.11 | 19.18 | 9.04 | 16.52 | 9.79 | 5.79 | 30.64 | 6.93 |
| Music03 | 3.63 | 19.46 | 24.86 | 14.38 | 9.03 | 4.90 | 16.58 | 7.16 |
| Music04 | 3.53 | 23.80 | 1.76 | 5.64 | 7.70 | 7.84 | 38.55 | 11.18 |
| Music05 | 27.42 | 10.23 | 4.55 | 3.03 | 2.95 | 3.03 | 5.30 | 43.48 |
| Music06 | 1.30 | 32.63 | 1.30 | 8.71 | 7.58 | 0.00 | 43.02 | 5.47 |

Summed answers per colour group expressed in percentage values

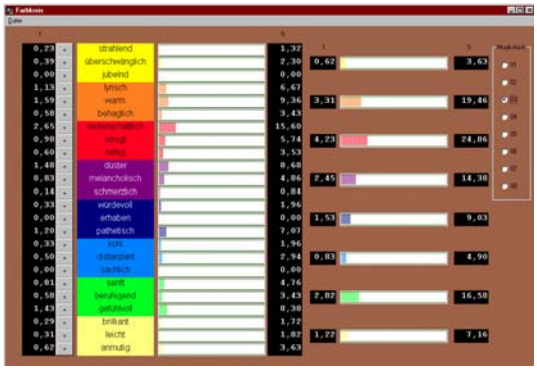
FIGURE 3



Music piece 01

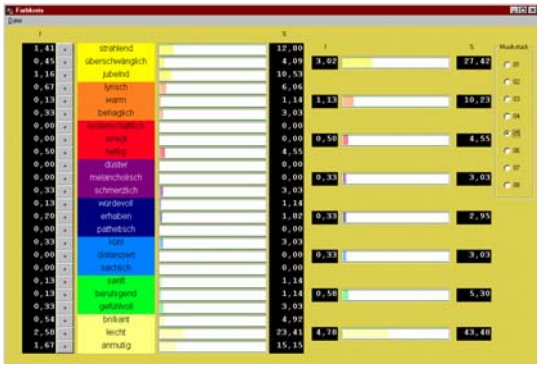


Music piece 02



Music piece 03

Music piece 04



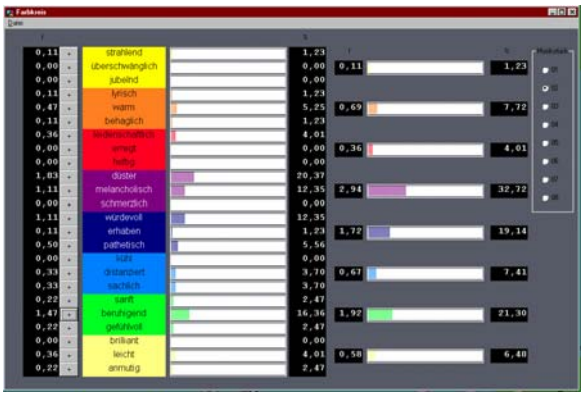
Music piece 05

Music piece 06

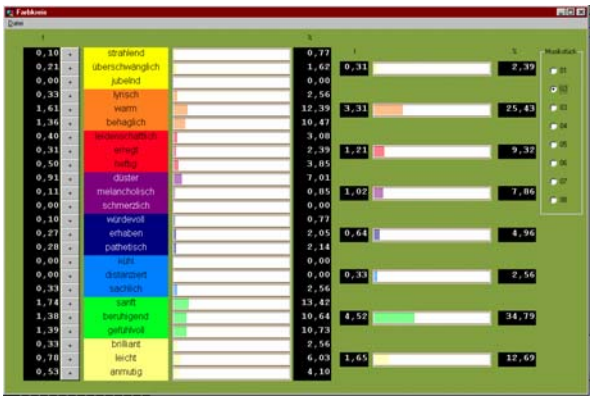
Depiction of the resultant colour scheme generated for each individual piece of music from the answers of all test subjects

The music pieces 01, 04, 05 and 06 (all of which stem from Mozart and Pavane von Ravel) were characterized by all test subjects – regardless of their musical preferences and their musical skill - with similar adjectives. But in the case of music piece 02 (relaxation music) and 03 (Sibelius) a separation in opinions between non-professional and professional musicians became very apparent.

FIGURE 4

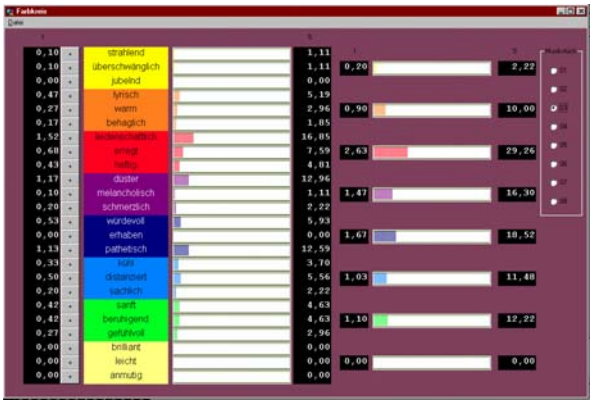


Music piece 02 (Relaxation-music), Professional musician



Music piece 02 (Relaxation-music), Non-professional musician

Music piece 03 (Sibelius), Professional musician



Music piece 03 (Sibelius), Non-professional musician

Depiction of differences in resultant colour spectrum chosen for pieces 02 and 03 by professional and non-professional musicians

A possible explanation for the variation in characterization of music piece 02 in relation to the answers in the questionnaires could be that professional musicians were not inspired - perhaps even bored or irritated - by the relaxation music, while non-professionals found it pleasant and relaxing. Consequently it could well have been a factor that non-professional musicians had a difficult time connecting with piece 03 (Sibelius) and were thus unable to objectively characterize it.

# 4 Literature

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http://www.insight.co.at

http://www.nmz.de/nmz/nmz2000/nmz04/rumpf/doss-hofmann-inton.shtml

Mozart: Sonate für 2 Klaviere D-Dur KV448, 1. Satz (Einspielung mit Güher und Süher Pekinel)

Mozart: Violinkonzert G-Dur KV216, 3. Satz

Mozart: Klarinettenkonzert KV622, 2. Satz

Ravel: Pavane pour une infante défunte

Sibelius: Violinkonzert d-moll op. 47, 2. Satz

# Preliminary Report

# SMARD-Watch System validation study based on psycho-physiological response measurements under defined stimulus-response conditions

**(28.10.2003 – 10.12.2003)**

Prof. Dr. Hans-Ullrich Balzer

Univ.-Ass. Mag. Dr. Kai Bachmann

St.-Ass. Mag. Elisabeth Ferstl

St.-Ass. Mag. Florentina Maria Fritz

**Forschungsnetz Mensch und Musik**
**Universität Mozarteum Salzburg**

Salzburg, March 30th, 2004

# Summary

## Task

The goal of this study was to validate the SMARD-Watch system by undertaking a controlled comparative analysis with other, reliable Blood Pressure Measurement (BPM) systems used in the study of human relaxation or excitation ability. Specific examination techniques with respect to relaxation were applied, supplemented with Blood Pressure Relaxation tests (BPR) and Stress-Relaxation tests (SRT). The validity of the criteria for parameters SR (skin resistance), PR (pulse rate) and EMG (HR, heart rate) as well as relaxation ability, however, remain to be ascertained.

Three males and nine females of diverse age groups (25 to 50 yrs.) partook in the validation study. The duration of the examinations was 41 minutes for each, which included a Blood Pressure Relaxation test (BPR) and a Stress-Relaxation test (SRT). Subjects were required to undergo a total of four examinations, in one-week intervals.

During each examination psycho-physiological parameters were measured in order to record subtle changes in the vegetative and emotional states of the subjects, and motor and circulatory systems activity. The SMARD-Watch system was used to measure pulse rate at the wrist and for taking skin resistance and myographical (muscular contraction) readings. Heart rate measurements were read (from the chest cavity) using a Polar system while a Bio-Feedback system recorded skin conductivity (from the finger tip on the ring finger of subjects) and muscular contraction rate (at the underam, above the location of the SMARD-Watch).

For the purpose of the analysis, the time interval readings of the BPR and SRT were kept separate. With regard to the BPR, data records for skin resistance and skin conductivity were correlated with blood pressure readings. Additionally, all readings were recorded in time series according to an analysis of periodicities procedure developed by Balzer and Hecht that dynamically plots changes in regulatory cycles over time correlated with the subjects' blood pressure readings.

To ensure consistency the subjects were split into two control groups; those capable of relaxation („relaxation capable“) and those incapable of relaxation („non-capable“).

With regard to the SRT evaluations, the measurements for pulse rate, heart rate, skin resistance and skin conductivity were plotted over time relative to each other and thus combined to graft a correlating coefficient. 4th degree polynomic approximations were also correlated. Here as well, the heart rate readings were divided into three distinguishable variables: falling, steady and rising rates.

To factor in a repeatability quotient, the process was further subjected to a „split-in-half-test“, whereby a correlation between two halves of the same readings from the same subjects could be calculated.

During a condition of homeostasis the activity of the sympathetic nervous system correlates with the blood pressure levels. Skin resistance is measured by secretions of the eccrine sweat glands. These are stimulated to 90% by the sympathetic nervous system. However the secretion process itself is also regulated by a thermoregulatory sub-function that determines where and how much to secret according to the number of glands available at a given location in the body. On our finger tips it is to be expected that the thermoregulatory effect, followed a sympathicotonic innervation, is at its most minimal.

Therefore a correlation coefficient of only 0.5 can be calculated when measuring the effect of systolic blood pressure on skin resistance at this location. At the underarms, in proximity of the wrist, one can expect a thermoregulatory proportion upon the sweat glands of up to 20%. Out of this we may establish a correlational factor between systolic blood pressure and skin resistance of approximately 0.4. In calculating our correlational coeffients we factored in normalization.

## Results

In consideration of the BRT, the data indicates that a correlation between the reduction of systolic blood pressure, a decline in eccrine sweat gland secretion (increase in skin resistance) as well as a slowing of the regulatory functions that accompany eccrine sweat gland secretions does indeed exist.

A direct correlation between skin conductivity (Bio-Feedback system) and systolic blood pressure of a coefficient of 0.47 in the group of „relaxation capable“ subjects was also shown. This measurement point indicates a correlation to sympathetic nervous system stimulation of a factor of 0.94, normalized to 1. A correlation coefficient of 0.06 can also be demonstrated between skin resistance readings (SMARD-Watch system) and systolic blood pressure data in the group of „relaxation capable“ subjects. The result is a (normalized to 1) correlation coefficient at this point of measurement of 0.12.

As expected, during skin resistance measurements the values reached by correlational coefficients after an analysis of periodicities indicate even better results than the original data. A correlation coefficient of 0.34 between the skin resistance values (SMARD-Watch) recorded via an analysis of periodicities and the systolic blood pressure levels as measured in the „relaxation capable“ group could be observed. This represents a correlation coefficient (normalized to 1) of 0.85 at this point of measurement. A correlation coefficient of 0.12 between skin conductivity values (Bio-Feedback) recorded via an analysis of periodicities and the systolic blood pressure values as measured in the „relaxation capable“ group was observed. This represents a correlation coefficient (normalized to 1) of 0.24 according for sympathetic nervous system activity. The less apparent correlation shown by the analysis of periodicities of the SCL (skin conductivity level) values is the mathematical result of much lower data resolution of the measurement device (Bio-Feedback).

An analysis of the questionaire filled out by the „relaxation capable“ group shows a correlation between an objective reply (measured through a reduction of the systolic blood pressure levels) and the subjective statement: „in my present state I am capable of relaxation“ of a coefficient of 0.82.

In analysing the SRT results an overall consistency of the values was shown when comparing the pulse rate values (SMARD-Watch) with heart rate values (Polar system). The calculated median of the correlational data of single measurements taken for both systems was at 0.59 for the original data and 0.88 for 4th degree polynomic approximations, whereas the averages calculated for the original data were 0.54 and 0.77 for the polynomic approximations respectively.

Worth noting is that, especially in the case of the polynomic approximations, over half of the measurements show a correlational coefficient that rounds to between 0.9 and 1.0, while most of the original data shows a correlation coefficient that rounds off to between 0.6 and 0.7.

Once the groups were split, an average correlation value of 0.63 with regard to the original data and 0.81 in the case of the polynomic approximations within the group with increasing heart rate was observed. The median was 0.66 and 0.87 respectively. In the group without any significant change in heart rate an average value of 0.45 for the original data and 0.65 for the 4th degree polynomic approximations was calculated. The median was 0.46 and 0.75 respectively. Compared to the non-segregated group these results are lower while results from both groups with measureable heart rate changes were altogether higher. The average of the original data from the group with reduced heart rate was 0.51 while the polynomic approximation value reached 0.83, the median being 0.58 and 0.90 respectively. Overall the 4th degree polynomic approximation values proved to be the highest here out of the three groups.

On account of the difference in measurement values, a comparitive analysis between skin resistance (SMARD-Watch) and skin conductivity (Bio-Feedback) predictably showed no clear correlation like that found in heart rate - pulse rate comparisons and, as a result, the correlation coefficients proved lower. The median of the correlative values from individual measurements of both systems consisted of 0.36 for the original data and 0.61 for the polynomic approximations. The average values for the original and the polynomic approximations was 0.23 and 0.35 respectively.

Worth noting is that over one quarter of the correlation coefficients calculated, based on the original values, rounded off to 0.4. In almost three quarters of the cases the 4th degree polynomic approximations spanned from 0.6 to 1.0.

If one organizes the groups according to the heart rate pattern, the resultant picture compares similar to that of heart rate vs. pulse rate. The averages and median values of the „relaxation capable“ group are strikingly higher than that of the total. However, compared to the heart rate analysis the average skin resistance values of the group with rising heart frequencies are below that of the total.

Due to the more homogeneous nature of the data from the group with falling heart rates one derives a distinctly strong average of 0.42 (original data) and 0.56 (polynomic approximations) respectively. The median values are 0.42 and 0.69 respectively. By comparison, in the group with rising heart frequencies the averages are 0.09 (original data) and 0.17 (polynomic approximations) respectively. The median values however reach practically the same values as those in the group with falling heart frequencies, i.e. 0.28 and 0.66 respectively. For the group with relatively stable heart rates an average value of 0.19 in the original data and 0.32 in the 4th degree polynomic approximations is seen. The medians here comprise 0.18 and 0.49 respectively. If one takes into consideration differences in location of measurement for the group with falling heart rates, which basically matches that of the group considered „relaxation capable“, one can determine a correlational coefficient (normalized to 1) of 0.86 between skin resistance and skin conductivity, relative to sympathetic nervous system stimulated sweat gland secretions.

## Validation

As means to ascertain relaxation ability via skin resistance measured at the under side of the wrist using the SMARD-Watch system the BPR method (blood pressure relaxation tests) has been determined valid. A correlational coefficient of 0.85 was attained.

A correlative coefficient of 0.82 was observed when comparing blood pressure measurements with subjects' claims of being „relaxation capable". As such the criteria for proving validity was satisfied.

We were thus able to show the construct validity of our theory „Functionality of Biological Systems".

Our comparison of the different systems SMARD-Watch, Bio-Feedback and Polar showed that with respect to the measureable parameters (skin resistance, skin conductivity, pulse- and heart rate) in consideration of test locations there is a (high) correlation coefficient of between 0.7 to 0.9.

The repeatability factor for the parameters we studied was between 0.7 and 0.8.

## Repeatability

Where the analysis of the original data from the skin resistance and/or skin conductivity measurements with respect to systolic blood pressure was concerned we reached the highest rate of repeatability ($r_{tt}$) in the original SCL-values, with 0.620 in the „relaxation capable"group, followed by the original skin resistance values of the „non-capable" group of 0.60. The highest repeatability rate ($r_{ttc}$) after the Spearman-Brown adjusted correlation once again reaches the original SCL-values of 0.77 in the group „capable" followed by an SR-value of 0.75 in the „non-capable" group. The entire group results, 0.24, are clearly under these.

The highest repeatability rate ($r_{tt}$) attained in analysing periodicity values was via skin conductivity, with 0.60 in respect of 4th degree polynomic approximations in the group „capable". It was followed by skin resistance– dynamic original – in the group „non-capable" at 0.58. In both cases the repeatability rates were calculated via a even/uneven process. The slightly higher figure of the SCL-values as compared to the skin resistance values can be explained by different measurement positions with higher numbers of sweat glands per cm directly related to sympathetic nervous system stimulation from blood pressure and skin resistance. As a result SCL measurements at the fingertips are more favorable when proving correlation to blood pressure. Similar relationships occur with respect to the repeatability rate ($r_{ttc}$). The values recorded via the analysis of periodicities with regard to 4th degree polynomic approximations in the SCL were 0.75 in the „capable" group, followed by skin resistance values (periodicity analysis) in the „non-capable" group of 0.74. In both cases the values were put through our even/uneven process to calculate the repeatability rate.

Thus we determined that the overall repeatability rate of the process lies between 0.7 and 0.8, a figure that met with our expectations. Of note also is that, in consideration of all repeatability rate calculations performed, the repeatability rate resulting from the correlation of values caculated by analysing periodicities in skin resistance proved to be the highest.

The highest repeatability rate comparing heart- and pulse rate values is reached in the „relativly steady heart rate" group, a factor of 0.56 (coefficient $r_{tt}$). Predictably, on account of non-homogeneousness, the reproducibility of all tests of the whole group is, with $r_{tt}$ = 0,16, at its lowest capacity. The groups with increasing and/or decreasing heart rates show repeatability rates that lie somewhere between the results attained from the whole group and the group with relatively steady heart rates. The highest coefficient $r_{tt}$ was reached by the

group with the relatively steady heart rates, with a value of 0.72. Of interest here is that, in view of the respective mathematical methods used to calculate the results, the group with the highest proven correlation (validity) is dinstinguished by its difficulty in reproducibility. Thus the validity-repeatability dilemma is demonstrated, which states that the higher the validity (i.e. correlation) between measurements is, the more difficult it is to reproduce the result.

Therefore we conclude that the SMARD-Watch system can be considered a valid measurement system with respect to relaxation relative to skin resistance and pulse rate.

Summarizing all results it has been demonstrated, that all goals indicated in the validation study task were reached.

Conclusion Report:

# Musico Cause & Effect Under Clinical Conditions

# Morphological Effect Analysis

(04.12.2004 – 15.02.2005)

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Commissioned by the Science Network Man and Music
of the Mozarteum University of Salzburg

Salzburg, March 15th, 2005

# Content

# 1 Introduction

The sense of hearing in humans is the most important with regard to sensory perception, since in comparison to seeing it covers the full 360 degree range of our surroundings. The development of language represents the most decisive factor in man's evolution. Tone, volume and pitch are integral and essential musical aspects of speech. Music can be categorized as the most effective emotional and aesthetic means for communicating in the culture of man. Music has effectively been used in cults and festivities, while also prevalent in the early history of the high cultures of China, Egypt, and Arabia and throughout antiquity as a healing method.

Today the study of *musico cause & effect* has again come to the forefront, especially in regard to the science of learning and in brain research. Musical elements are being brought into psycho-therapies as a type of sensory communication where speech has failed. However in the realm of medico-functional music effect research in modern medicine, to date the musical-physiological relationship in so-called *anxio-algolytic* (fear and pain reducing) music therapy remains relatively unresearched.

Insofar as the psyche plays no unimportant role in the healing process, the question begs to be asked whether hospitals have been optimally constructed or whether they have instead been designed to take into consideration primarily the optimal technical procedures of treatment. The process of „getting well" relies upon both factors: the appropriate medical application as well as health-promoting surroundings. Over and above the illness itself a view toward the socio-psycho-physiological make-up of the patient would be advantageous in optimal health regeneration.

Of course all hospitals cannot now be newly reconstructed, albeit there are already resolute attempts to offer patients more in this regard. However it is possible to undertake to provide a patient with a supportive means to improve mental harmony and resonance during the hospital stay.

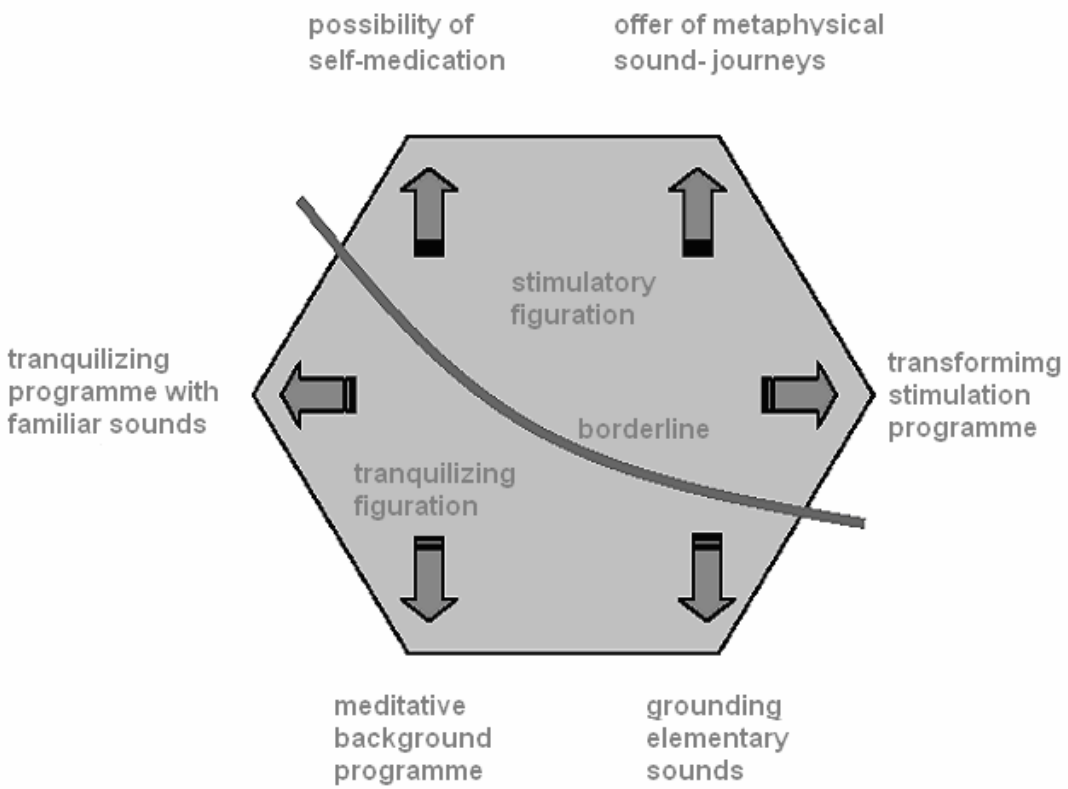
Afterall „getting well" is not about diversion, but rather about the inner contest and learning to cope. For this we regard the appropriate musical accompaniment as an optimizer. This even further when the musical offering provides the patient with a choice relative to his/her condition. In this sense a treatment must be structured - in our case this was achieved by exposing the patient to a diverse palette of music, selected according to time of day and activity curves. On the other hand, each patient should be provided with their own means to measure and determine their condition.

Music is a cultural asset with which we have all grown up and which has touched and touches each of us in diverse ways.

# 2 Task

The mental state patients in a hospital are in is bio-rhythmically not the same as that which they are in in their normal daily lives. Due to a change in patients' mental and physical states the activational and de-activational phases are differentiated in most cases from those of „healthy" people in daily life. In a hospital each patient exhibits their own unique biological rhythms with respect to states of tranquility and stimulation.

With respect to the previously exhibited tranquility/stimulatory figurations, the sound offering either fits well to the acute physiological state of a patient or it doesn't fit at all. In the presently researched offering, this problem leads to the psychological phenomenon of a „borderline" that is pulled between tranquilizing and stimulatory figuration.



# 3 Goal

Hospital and music – goal of the present study is to explore and explain the psychological form of effect of such an offering. What motivational possibilities and specific solutions does a healing-supportive listening program offer the spirit of the recipient?

This study delivers essential introductory psychological information about the state of patients in hospitals which, in consideration of such knowledge, can lead to a deeper understanding about the extent to which music can provide adequate treatment support under clinical conditions when a listening program is conceptualized for this specific target group.

The study researches how life's companion music is accepted in hospitals, what the current situation for patients is, how and when a new context can be set with music that is of use to patients in their health recovery. It is to be anticipated that such patient ‚activity' in the sense of active listening will lead to a change in their state and finally greater satisfaction.

# 4 Conceptual Formulation

To realize the goal the psychological question with respect to *musico cause & effect under clinical conditions* shall be researched individually as follows:

- How do patients experience the new musical/sound offering?

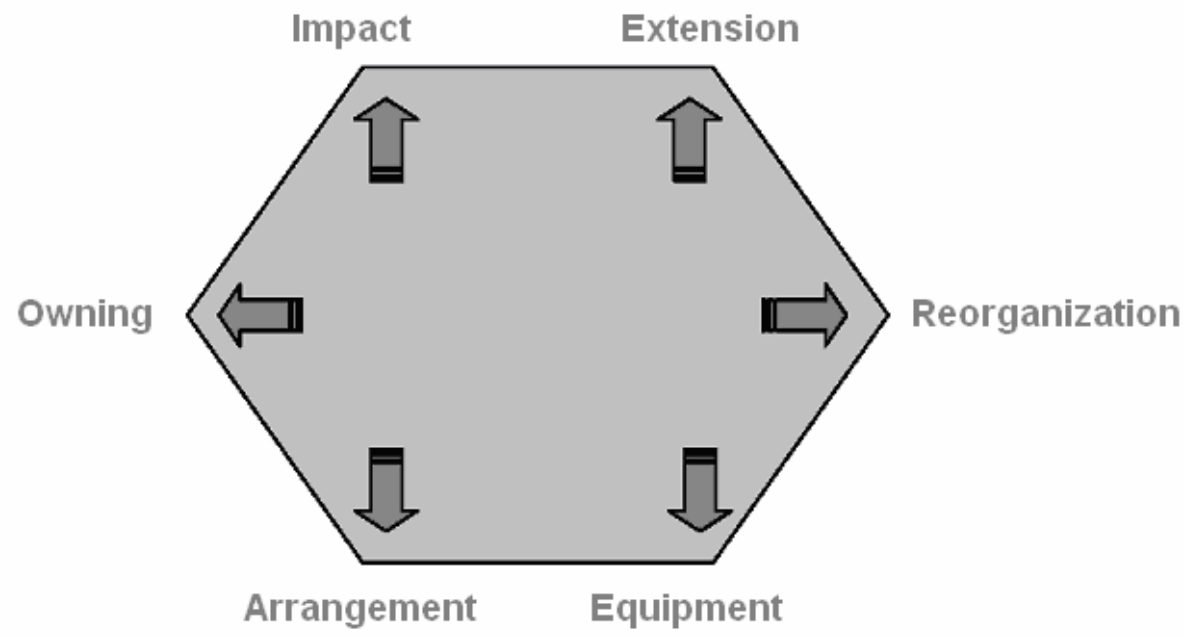
- What are the mental effects that the program produces?

The purpose of the research is to work out and explain the psychological form of effect the program being offered has utilizing the concept of „ product effect units“ (PEU) along with psychological (morphological) instrumentalities (interviews).

The following individual parameters will be studied:

| | |
|---|---|
| “Impact” | = possibilities of self-application |
| “Extension” | = invitation to metaphysical sound journies |
| “Reorganization” | = transformed vitalization program (energization/sedation) |
| “Equipment” | = grounding, elemental tones |
| “Arrangement” | = meditational background program |
| “Owning” | = intimately structured sedative program (sleep assistance/ swan song) |

The results of the research shall be represented as form factors in the shape of a hexigrams.



# 5 Test Subjects

19 males and 8 female patients took part in the study. The average age of the subjects was 50 years. The spectrum of illnesses typically found in hospitals was covered by the interviewees. Location of the study was *Landeskrankenhaus Salzburg*. (Regional Hospital Salzburg)

# 6 Music Selections Used

As a test run a listening program was implemented within the Landeskrankenhaus Salzburg. The program, based on a collection of music, tones and nature sounds, was formulated to stimulate the healing process, bring pain relief and sedate patients.

Examples

Early morning – stimulation
“Selim” from Miles Davis
sung and played by Bobby McFerrin and Russel Feranti

Forenoon and afternoon. Stimulating relaxation entertainment
“Triste Verdad” from Juvenal Ramiro Paredes
played by Juvenal Ramiro Paredes and his Combo
Length: 04:18
Southamerican

Noon. Table concert
“Künstlerleben” from Johann Strauß jr.
Strauß Festival Orchestra, André Lenard (conductor)
Length: 08:34
Vals

After the noon (until ca. 14:30) — relaxation
“Entspannung bei Schmerzen”
from and with Robert Kovar
Length: 25:20
Instrumental

Before evening. Entertainable listening (alternative to TV)
“Ask” from S. Sagbas
arranged and played by Brian Keane & Omar Faruk Tekbilek
Length: 06:24
Worldmusic, Turkey/United States

Night. Energetic relaxation and sleeping help
“Light as a Feather” from and with Christian Bollmann
Length: 12:20
Monochord

The quickening effect of the program's music upon the healing process has been verified in various empirical studies and is known to reduce the complication rate and duration of stay for patients when applied for just 30 min/day.

# 7 Methodology

## 7.1 Study Execution

After primary preparations a handbook containing questions that formed a foundation for the interviews as well as a detailed „screening“ for test subject recruitment was formulated. Using the handbook appropriate interview subjects were then searched for and contracted. All interviews were recorded on tape and upon conclusion the material was condensed for psychological consistency. A total of 27 interviews averaging 60 minutes each forms the basis for this empirical study. The study took place from December 2004 to January 2005. The interviews were recorded during this time.

## 7.2. Morphological Method

### 7.2.1 Theoretical Background

Morphology is understood as the doctrine of guises and their changes. Morphology can be defined as seeing things in their relationship to one another and to observe how such relative factors work together (Melchers / Ziems, 2001, S. 13). Morphology allows for building of functional fluid models that analyse moving reality and provides a coherent system of explanation. Additionally it demands not only that the „inner“ picture is grasped - as often happens in psychology - but that also the outer surface is considered. It also incorporates personality-transcendent effect systems (vgl. Melchers, 1993). To grasp mental and other multi-faceted effects and consequences of cultural upheavals, a special approach is required. For the study of these phenomena morphology-based market and media psychology has developed specific concepts that take into consideration the fluid nature and unique qualities of mental processes as well as psychological relationships. Relevant here is the concept of *product effect units* (PEU) which are further elaborated below.

### 7.2.2. Product Effect Units (PEU)

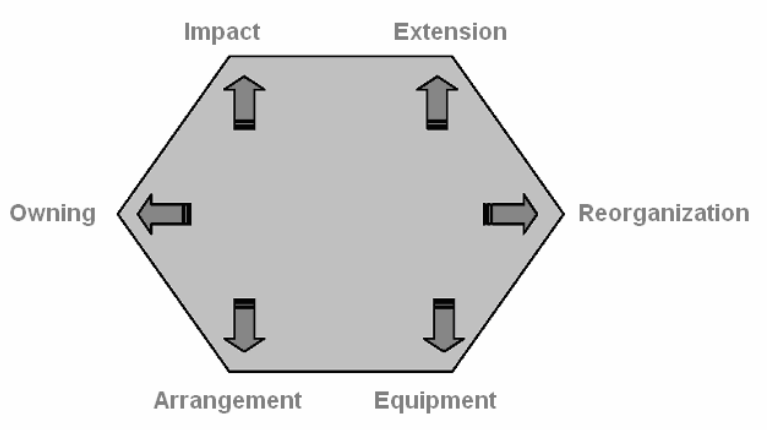
The concept of PEU’s studies the motivational factors of products (and brands) in their general context. Differing – partially even contradictory – motives seek to be fulfilled simultaneously. During a product’s use often entire *mini-dramas* are played out - depending upon how suspenseful or interesting the motivational concept - which seeks to sustain said motivation as much as practically possible. The use of PEU’s can help to ascertain the motivational structures of these complex motive-inducing factors as they occur in everyday life.

### 7.2.3. Form of Effect – Form Factors

Morphological market- culture- and media-psychology defines guises as something fluid and changing which can be experienced, described and converted into pictures (vgl.

Salber, 1991). Such forms show mental events as a work in progress that „in its genesis traces polarities of two sides, two opposite movements – as if something was being worked out between "Owning" and "Arrangement", between acting on and reshaping or "Extension" and "Equipment"" (Salber, 1991, S. 76f).

The six formational factors ("Owning"/"Reorganization", "Impact"/"Arrangement", "Extension"/"Equipment") embody universal foundational principles of mental form-building that can be graphically depicted and structured into a hexagram. The form factors work supplementary and conditionally; they stand in a dynamic relationship to one another and thus remain in a state of constant flux.




The depiction of a complete structure requires determination of individual factors dependent on the subject of investigation and explained in respect of their own form-logic.

## 7.2.4. In-depth interview and psychological description

Psychological in-depth interviews and descriptions serve as effective means and processes in morphological market- and media research with which to capture psychological relationships in their complexity. They can be used to trace empirically based underlying mental relationships that motivate the secret logic of each consumer.

As previously stated, the purpose is to ascertain (micro)structures and motivational pictures. These can be determined only when interviewees can speak in such a way as to say only what comes spontaneously to mind without limitation or any predetermined logic by an interviewer.

The as a rule ca. 90-minute interviews were based on a specific guiding principle (see Appendix) wherein questions were asked in a spontaneous fashion in no specific order which were, however, based on certain foundational perspectives that ensure a central theme (vgl. Melchers/Ziems, 2001, S. 76f).

The interviewer's intention was to uncover the hidden dynamics of various experiential qualities via an intentional directional and stipulatory focus. Goal was to bring to the fore (unexpected) twists and turns, unconscious influencial factors and ambivalences which are not often clearly defined (vgl. Schulte, 1999).

A further important characteristic of morphological in-depth interviews is the analysis of their substance, since (avoidable) perceptions resulting from revelations of the interview partners are analysed during the interview itself, then reintegrated to pose more specific

questions (vgl. Melchers, 1993, S. 44f). Revelations made by interviewees serve to increasingly lay bare the underlying motivational factors, while the interviewer develops a fuller understanding through an intensification of his or her questions and underlying hypotheses. Thus the in-depth interviews serve as a transition and eventually reveal a clear motivational structure in their completion.

The psychological description forms the basis of the analysis method of the in-depth interviews. In these, information about the mental effect gathered from the interviews is analysed descriptively with respect to the goal of methodically developing an effect-correlation that encompasses all phenomena. The description delivers explanatory and functional models that - in a last step - are unified into a final research result.

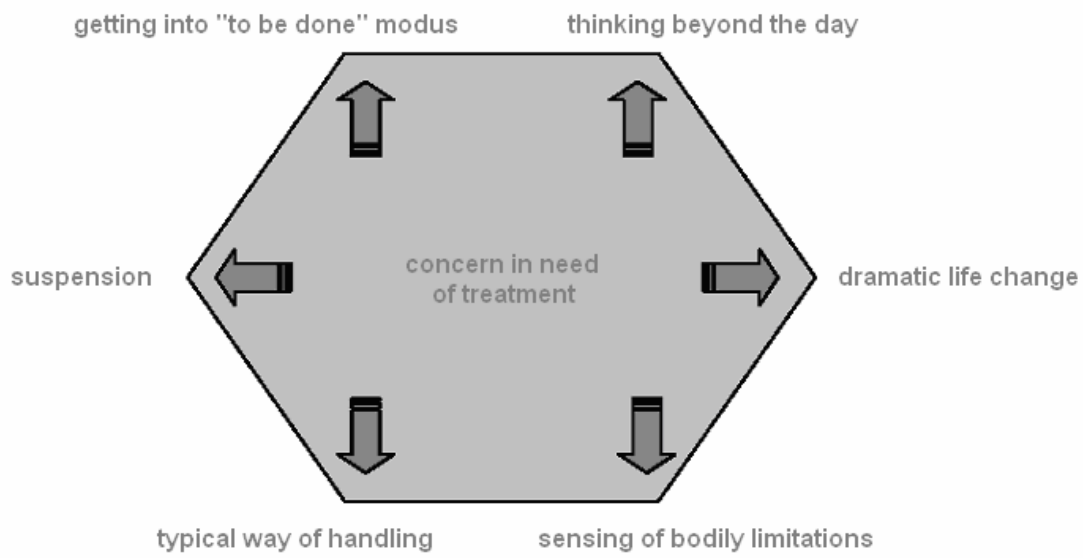
# 8. Results

## 8.1. Preliminary Remarks:

### 8.1.1. Psychological Prospects and Hurdles Due to Hospitalized Condition of Patients

Over the previously illustrated background were superimposed compiled results of the research with respect to construct description from the study; the six formation factors are described as follows:

| | |
|---|---|
| "Owning" | = suspension |
| "Reorganization" | = dramatic life change |
| "Impact" | = getting into „to be done" modus |
| "Arrangement" | = typical way of handling |
| "Extension" | = thinking beyond the day |
| "Equipment" | = sensing of bodily limitations |




In summary we found, psychologically speaking, that the research subject matter „patient condition in hospitals" can be described as a „concern in need of treatment". A contracted illness which can no longer be self-managed by a patient – in this case one that

develops dramatically – causes a diversity of problems and makes treatment in a hospital unavoidable. The patient experiences the limitations of his/her self-treatment. The admission into a specialized hospital world - one that primarily deals with illness and its treatment - in which the patient must release the self into the control of others forces an acceptance of a reality with its own set of specific complications. However this same illness-related problem also implies – in the case of a beneficial solution – a renewed sense of assurance which can metamorphose a problem into a new set of possibilities.

### 8.1.2. Unified Description

The unified description portrays the circumstances under which patients learn about the offering of a clinical radio program, how they are to use it, where they find information and what the program is all about. Almost universally patients describe an effect of reassurance from the listening program. Mild, soft harmonies and – most important – trusted and familiar sounds become instrumental in the „process of acclimatization“ pleasantly influencing relaxation and diversion from circumstance. The selections have the capacity to transport a listener into a mellow, peaceful and worry-free trancelike state.

The program is also found to be a sonic mood-enhancer; rhythmical, zestful, energetic, life-stimulating. In this environment it has the qualities of being friendly, light, buoyant, awakening while producing a positive motivational disposition. When it is perceived as too strange, aggressive, overpowering and churning – musical qualities included in the first version – vitalizing energy can become overly aggressive and is converted instead into a disturbance, causing feelings of insecurity and even pain.

Some of the patients used the program as their own private acoustical treatment method. It offers them an effective way to counteract the ‚being done to’ situation created by their illness and presence in hospital. One listens attentively and concentrated, allowing the music to work upon the self. Others use the program passively and allow the music to ‚pass over’ them. One surrenders to the music and enters a state of affusive passivity, which calls for a slightly more attentive and concentrated listening. Primarily calming sounds and tones help to let go, release and lose the self.

Besides the obvious use of music and sound as a sedative and for vitalization – which in essence bases on a more „classic“ song structure - the program also offers simple even trivial structures. Pure and foundational especially ‚clean’ and trusted nature sounds, single voices, ethnic instruments, and more grounded sounds come to the fore here. The patient is in the truest sense ‚grounded’ – experiences sonic earthiness and feels bound to the ‚nature of the situation’. Other patients describe the program as working more in the direction of „Extension“. „One goes on a thought-journey away from the hospital“. There is a clear increase in instrumentation, tonal variation and stylistic multitude; through ‚listening-in’ to artistic to experimental or spheric sound carpets, the patient can overcome feelings of being ‚locked down’ and ‚on a bed of clouds’, reaches another place entirely. Thought-based sound-journeys can displace a person into a healing, pleasant, expansive, harmonious and conciliatory state. Patients feel freed, weightless and ‚boundlessly light’.

Beyond that – and here lies an apparent problem – the interviewees described an experience of incongruity between the sonic offering of the program and their mental state(s) during the day and/or night. „I can’t choose what is just right for me now“. Many test subjects expected more transparency with respect to the sonic selections of the program. As such they felt as if they were ‚groping in the dark’ - strictly dependent upon what was delivered.

### 8.1.3. Sedative and Activational Qualities of Musical Therapy Support

Essentially the present study characterizes a musical offering for patients in hospitals that can be described as treatment-supportive, encompassing both sedative as well as energizing qualities.

Patients were exposed to a reassuring, sedating program ("Owning") – not the recognition of famous hits – but rather the reanimation of an internalized, ‚stored' sound pool stands in the foregound.

Commonly used musical patterns that are (re)recognized are accepted as intimately pleasant sources. Sound implementation with an accent on well-established sound/song standards has a stabilizing and thus sedative effect.

The ‚locked down' state of a patient is taken on directly using sound – reassurance stands in the foreground. The program unfolds in two directions. It offers a state of peace and reassurance, quiet relaxation, floating off into a doze that may assist the listener in falling asleep. Intimate homey sounds lull the listener with a ‚lullaby' effect. The program in this sense takes over a mothering function, servicing infantile demands of patients in that the sonic atmosphere lulls them calmly, warmly, intimately, securely and safely into sleep.

The sedative components can however evoke other states - primarily with regard to deep, slow and lugubriously ‚thick' tonal moods, which can induce a state of melancholy in the listener and thus bring danger of triggering or accentuating feelings of depression and sadness. The patient is subject to mood deprecation and heaviness that focuses on the finality of life and nearness of death. Quiet minor keys and dark sounds are thus converted into deep feelings of hopelessness. Such a listening experience is only barely if at all tolerable for patients.

To counter this patients receive a transforming activational program ("Reorganization") and thus a treatment that offers the hope to be able to escape from too much illness-related closed in-ness. Fast, temperamental, open, affirmative, alive and cheerful tones stimulate the spirit of life. Similarly the activation program also works and transforms the hospital condition in two directions.

The fresh and lively tones have a constructive energizing effect: strengthening, empowering and stabilizing they help patients move into a health-promoting condition, one which stimulates positive development and a new beginning. The patient has the chance to activate and push forward his/her own transformation. The changing activational sounds are not only pleasant and vitalizing; they prevent the sound from being perceived as unpleasant, agitating and disturbing.

On the other hand the music can produce a feeling of disconcertment when patients find them to be (culturally) alien, ‚wild' or irritable, too strange or avant garde. The patient then does not feel motivating activation but, instead, disturbed.

The program offers the patient an effectual means to work actively against illness-induced loss of control and the process of ‚being done to' that occurs in hospital – even to turn it around. The use of the program allows a patient to have direct control over his/her state through the process of listening to something that is mood influencing. He/she takes over responsibility for the self – does ‚something for me' and uses it as self-help. The listening program becomes a personal medicament of choice ("Impact"). Such active forms of self-treatment (use of assuring and/or activating qualities) fit precisely into the program's

offering in the sense of a ‚working-in' logic as well as through active listening by ‚allowing influence'. Attentive, concentrated listening in the ‚here and now' is at the forefront.

In the sense of its passive treatment variation however, the program can also help transport patients to a state of being ‚somewhere else'; or to get to another place. In this case the patient acts less from a self-directing position. The program works to alleviate the ‚being done to' logic. The musical treatment is in the positive sense allowed to ‚pass through' the patient, who opens up to its influence and experiences a pleasant showering effect of letting go.

Primarily calming sounds and noises help the patient to let go, zone out, lose the self. They act in the background working as meditational tools ("Arrangement") and require a less concentrated listening focus.

Non-specific sound carpets gain in importance while goal oriented listening loses importance. In this form of treatment the patient not so much reaches for self-help as passes the responsibility off and allows others to help. In his/her surrendered trust in a ‚higher power' and professional competencies the patient would rather have the healing-supportive supplement ‚prescribed' by doctors and nurses.

On the side of "Equipment" the program offers a simple, stripped down and limited treatment form. Here plain and pure listening experiences and earthy elemental sounds are at the forefront. Seemingly ‚mundane' sounds and tones are structured into a form that demands or tolerates little else. The patient wants it pure and simple, foundational, intimate and uncomplicated - to remain grounded. The program serves the mental and bodily limitations of the human condition. A tonally unobtrusive reduced offering comprising true-to-nature sounds with virtually no music or very simple undemanding melodies, including familiar natural sounds, satisfies a need for more grounded earthy tonal ranges.

As a counter measure to their limited state of well-being the program also helps patients to eventually embrace more metaphysical sound-journeys ("Extension"). This provides the possibility to overcome physical limitations - to break out of a condition of being closed off or locked in. Without leaving the room they are in, patients are able to experience vast spacial dimensions and beauty. He/she undertakes positively charged ‚time-travel' or ‚travels in thought' to exotic paradises and vacation dream worlds. This form of thought-based metaphysical sound-journeying can shift a patient into a more sound, healthier, harmonious state. He/she feels liberated, light and gravity-free.

The program thus offers patients in a state of suffering – even extreme bodily limitation – a disengaging process of endless lightness up to a feeling of euphoria and oceanic vastness. The music in this regard is based on the ‚more' principle: tending to contain substantially more variation and stylistic variety, with a tendency toward the experimental, spheric or synthetically produced sound-worlds. However, though sonically a listener can be transported into beautiful, harmonious, consolatory ‚safe' inner worlds, in the negative sense the program can also become for some a barely acceptable if not unbearable artistic expression.

As seen there is thus evidence that suggests the listening offer provides valuable qualities that affect all of the psychological formation factors in the morphological hexagram. The problems regarding its effectiveness are elaborated below.

## 8.2. Problem-Solution Factors in the Treatment Program

As its main finding the present study provides evidence that a distinctive listening program within a clinical setting when used as a musical treatment opportunity encompasses both sedative as well as activational qualities.

The study also makes clearer the presence of patients who experience both active as well as passive states within the realm of hospital visitation. Thus the program generally coincides with a patient's bio-rhythmically determined activational and de-activational phases. However it was also shown that the ‚working together' of a musical program with the psychological makeup of patients does not always function.

This reciprocal polarity problem can be further explained as follows.

The effective structure of the music offering was divided. It had an effect that was both sedative as well as activational.

Sedative figurations

The program accentuates more the passive qualities of the night: peace, relaxation, meditation, sleep, as well as retreat, ‚grounding' being alone, sadness, death.

Activational figurations

The program focuses on more of the active qualities of the day: alertness, movement, action, strength, energy, liveliness, but also stress, restlessness, nervousness.

## 8.3. Limitations of Sedative vs. Activational Figurations

The program offers listeners two sonic figurations that are generally described as sedative and activational figurations.

On one side of the borderline the program accentuates more of the sedative qualities.

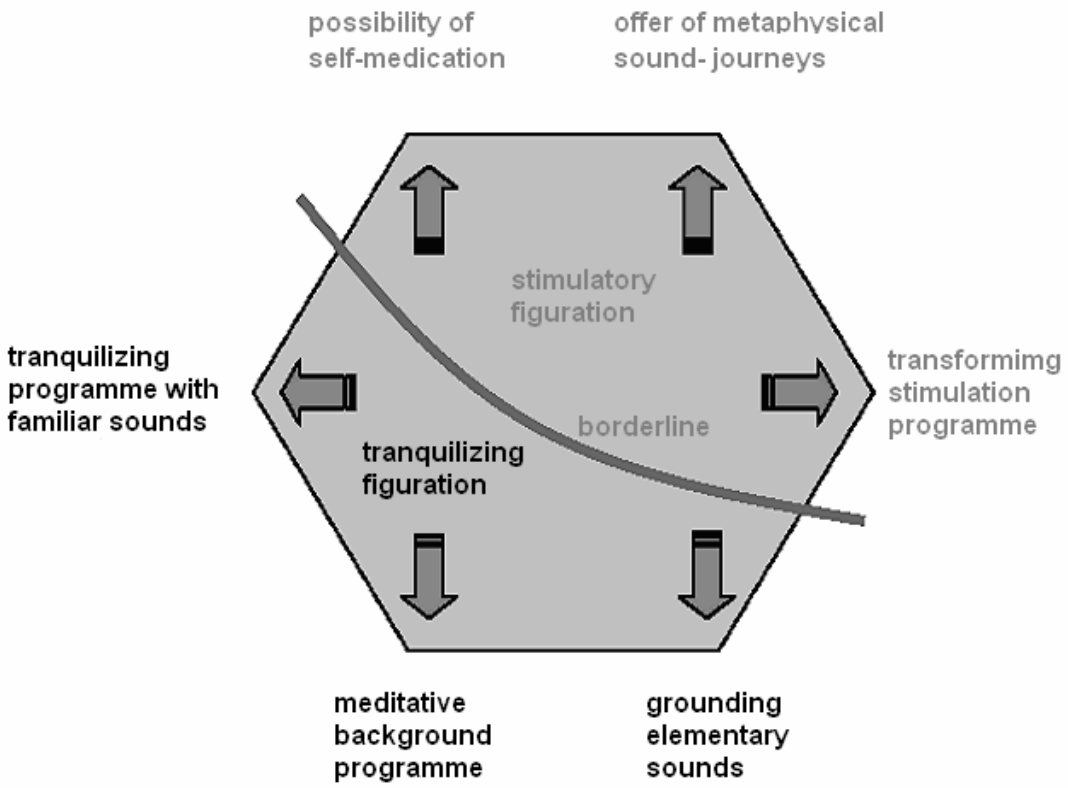
In the morphological hexagram the forming factors

"Owning" (´sonically familiar sedative program´),

"Arrangement" (´meditative background program´) and

"Equipment" (´grounding elemental sounds´)

are relevant.



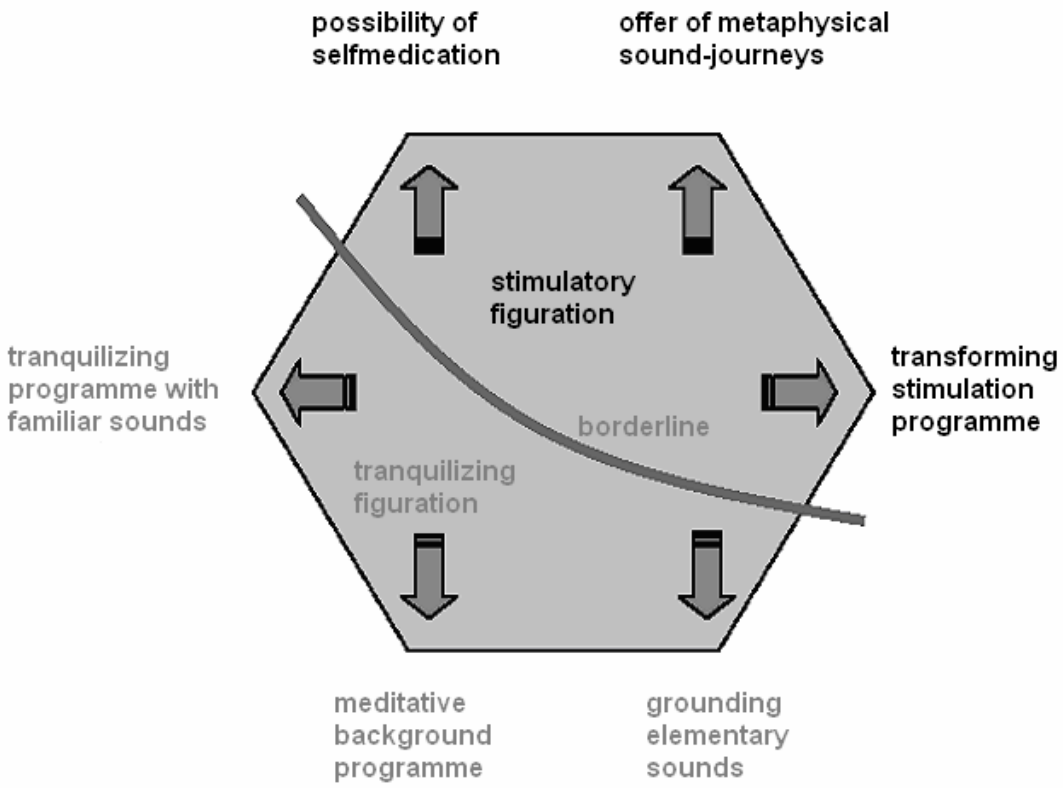

On the other side of the borderline the program accentuates more of the activational qualities

The forming factors are thus

“Impact” (´possibility for self-treatment´),

“Reorganization” (´transformational activation program´) and

“Extension” (´entices a metaphysical sound-journey´).




The effect becomes problematic on account of the psychological borderline. When sounds are not befitting the patients resist. Thus patients can end up being exposed to sedative qualities during mid-day and activational ones in the night. These qualities do not befit the acute chrono-psychological condition of the patient and are thus rejected as unsuitable.

# 9 Summary

The present study pursued the psychologically based question of how a listening program that has been specifically tuned for clinical settings is experienced, i.e. which mental effects it would have. In order to more adequately understand how such a program should best be structured for use as therapeutic treatment - directed at hospital patients – it became imperative to psychologically characterize the mental states of adult patients in advance.

This (advance) research matter could be characterized as a ‚treatment-specific disruption': a no longer self-manageable, dramatically developing illness triggers multi-faceted ‚disconcertment' and makes treatment in hospital unavoidable. The patient experiences the limits of his/her self-treatment abilities. The new, changed circumstance removes all customary routine and daily familiarities and delivers the patient into the hands of professional strangers for treatment. The admission into a specialized hospital world - one that primarily deals with illness and its treatment - in which the patient must release the self into the control of others, forces an acceptance of a reality with its own set of specific complications. However this same illness-related problem also infers – in the case of a beneficial solution – a renewed sense of assurance which can metamorphose a problem into a new set of possibilities.

The subject matter ‚illness-hospital-treatment' is thus dominated by a tension-relationship between calmness and nervousness. However a hospital-centric listening program addresses precisely this condition in a specialized manner.

A major issue of the study was to work out and explain the psychological effect such a specific listening program has. Here we can definitely claim that the audio-offering – in consideration of the psychological form factors present in the morphological hexagram – produced valuable effect qualities. Essentially the offering was characterized as a musical treatment support that has both sedative as well as activational qualities. The unique effectiveness of the program derived from out of these two polarities which in turn arose from the morphological form factors *"Owning"* and *"Reorganization"*. The offer of familiar sonic tapestries provided a reassuring sense of hold and stability and lead listeners into a relaxed sedated state or served as effective sleep assistance.

Activational sounds have the potential for transformation. They help patients emerge from an illness-imposed state of being ‚closed off'. Through their building, energizing effect they stimulate healthy regeneration. From such an offering patients can derive the ability to initiate an acoustical and/or musical form of self-treatment – with whose help they can assert influence over their present condition and ultimately transform their state of mind. The program thus offers an effective means to actively counteract the feeling of being subject to an unfamiliar influence, the feeling of ‚being acted upon' caused by their illness and being in hospital. At the same time the program helps patients also to get into a better state of mind in the case of passive influence.

Here the program can be applied to the ‚being acted upon' logic. The patient reaches a pleasant state while being ‚showered' sonically; is able to zone out and let themselves go. He/she surrenders to a passive acoustic treatment and experiences the music as a meditative background program. Since the morphological forming factors of ‚"Impact"' and ‚"Arrangement"' are clearly addressed, here the patient is – with respect to state of being in hospital – being sensibly ‚treated'.

To round off the offering, it also provides effectful sonic properties with respect to the remaining polarities ,"Equipment"' and "Extension"' in the hexagram: simple, reduced sounds – especially familiar, nature sounds – appeal to the patient's state of limitation. While not overly taxing him/her, the listener is treated with simplified ,earthy' sounds.

As a counteraction, the program helps patients overcome their limitations by transporting them to a ,completely different place' from the closed in confined space they may find themselves presently in; thus embark upon metaphysical sound-journeys. As a ,psychological media form' there is thus immediate evidence that the program provides ,overall' morphological benefits.

Disruptive and less effective aspects of the program were made subject to the application of suggestions for optimization based on psychological structural traits. It is crucial in our opinion to rework the conceptual nature itself: the study exposed a critical problem of the daily program, as it became clear that the musical offerings brought at a certain time of day didn't always coincide with the chrono-psychological state of each patient at that moment. During listening the test subjects either got exposed to the ,right' or for them ,wrong' audio offering which created a psychological borderline dividing the sedative and activational figurations of the program.

Consequently sonic qualities experienced as unbefitting received resistance. If at that moment the subject required a specific ,sonic treatment' but was instead exposed to something opposite of what was expected/desired the subject would often decline the entire selection. On the basis of this problem two concept variations are proposed as suggestions for an alternative offer:

The program remains as is in an optimized form. In this case it is imperative to explain to patients that during the day they can expect more activational selections to play, while in the evening and nights the more sedative selections are to be expected. A second option would be to split the program into the two separate offerings, where patients could select the one that best befits their acute psychological condition.

In consideration of the program's direction of healing-support, the study was able to determine that the foundational mental and bodily-challenging aspects relative to patients' psychological condition from illness and presence in hospital are addressed and ,treated' as a result of the listening program.

Patients receive an acoustic form of mental nourishment. They experience comforting provision to manage their ,unease' or activational treatment to address being ,locked down'. They can be treated or treat themselves acoustically. They can expand their hospital bed or room environment through thought-based sound-journeys into nature and thus focus on the elemental. The expansion of their horizon allows them to overcome their present limitations and reach the farthest expanses. The acoustic journey stimulates them to think beyond the present day. The artform music implants a new survival-stimulus to overcome a vulnerable condition far removed from its habitual lifestyle. Acoustical treatment for the mind stimulates treatment of the body. A new, healthy future is proclaimed.

In general it can be concluded that the program essentially functions because it contains sedative as well as activational sounds that offer patients musical treatment support for dealing with their hospital condition.

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# Progress Report Summary:

# Musico Cause & Effect Study

# Basic Study

**(04.11.2004 – 14.12.2004)**

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In Cooperation with

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# Content

# 1 Goal of the Study

The goal of this study is to verify a correlation between regulatory processes that occur within music and biological regulatory processes governing those listening to it. It is based upon the hypothesis that bio-rhythmical changes brought into music unconsciously by composers and performers have a synchronizing effect upon the present bio-rhythmical processes within listeners. It is further asserted that music – as a premise – becomes pleasing to the listener at that point when the bio-rhythmical processes within music and listener begin to synchronize. The level of concentration (level, duration) depends upon the level of activation, bodily reserves, degree of attention and certain other factors. It is further proposed that a greater degree of relaxation (relaxation level, relaxation ability) before a period of concentration results in a subsequently greater level of concentration. The difference between relaxation without any particular method as opposed to relaxation using music will be examined. To reduce stress load no particular relaxation techniques will be deployed. Also examined is the hypothesis that relaxation exercises, repeated many times, leads to a stabilization of the immune system.

# 2 Tasks Executed

Researched will be the effect that music has upon the relaxation state, concentration ability, subjective assessment of music and the direct correlation between music and psycho-physiological and immunological changes in an organism[1] in order to find a link that accounts for the individual effects that music has. Goal of the study is to also test to what degree of precision the chosen method of music analysis is in principle able to predict the potential effect the music has upon its listener. This study is one of methodology.

To reach conclusions as to the reactive ability of an organism with respect to selective exposure to various stresses, times-series analyses of physiological and musical parameters - electromyogramm (EMG), skin potential (SP), skin resistance (SR), changes in volume (VC), frequency spectrum (FS), tone interval density (TD) – shall be made. Thereby we shall study the dynamics of vital regulatory possibilities in the body and music using chronobiological regulatory diagnostic tools. Individual determinations shall be made for vital function, state function (benevolence, activation), state dispersion and the correlational relationship between the physiological, musical, psychological, immunological and behavioural parameters (concentration, endurance).

[1] In cooperation with Univ.-Prof. Dr. Gerhard Hacker (SALK: Salzburger Landesklinik; St. Johanns-Spital, Forschungsinstitut für Grund und Grenzfragen der Medizin und Biotechnologie) and Prof. Dr. Günter Schwamberger (NAWI: Naturwissenschaftliche Fakultät der Paris-Lodron-Universität Salzburg, Institut für Chemie und Biochemie).

# 3 Methodology

## 3.1 Execution Methodology

### 3.1.1 Selection of Test Subjects, Selection Criteria and Testing Conditions

24 subject persons in all took part if the music effect study – 12 in a music listening group, and 12 in a control group – and were made up of males and females between the ages of 18 and 34.

As inclusion- exclusion criteria the following conditions were set[2]:

| | |
|---|---|
| Gender: | male, female |
| Age: | between 18 and 40 years |
| Medical history: | no long-term medication |
| | no existing illnesses |
| Linguistic capabilities: | competency in German |
| Additional requirements[3]: | no coffee, no black tea (exception: hypotension-afflicted subjects were allowed 1 cup of tea or coffee), no energy drinks |

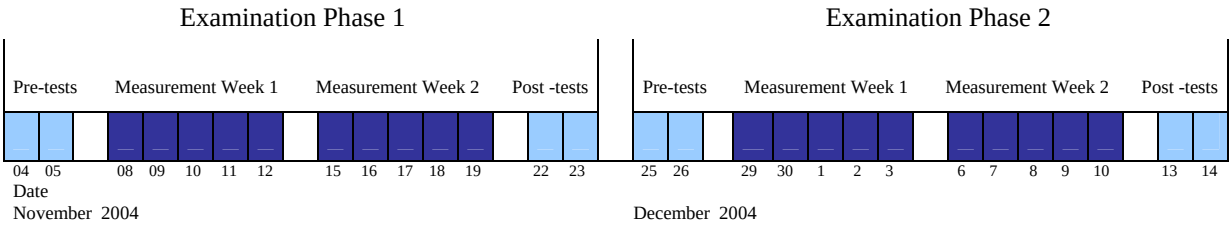
### 3.1.2 Process

The entire study consisted of two measurement phases, each of which was carried out over a period of ten (Monday to Friday) days. (Figure 1).

The subjects took a series of diverse tests over two days before and at completion of each of the measurement phases. This included questionnaires, blood pressure relaxation tests, stress-relaxation tests, as well as concentration tests. Additionally, physiological parameters were measured and saliva samples taken. Fully detailed descriptions of each of the tests carried out are found in the complete interim study. The second examination phase commenced after a one day pause subsequent to the first phase.

[2] Pursuant to the study concept dated 01.01.2003 regarding Music Cause-and-Effect Study.
[3] These conditions were required only 2 hours prior to each measurement.

FIGURE 1

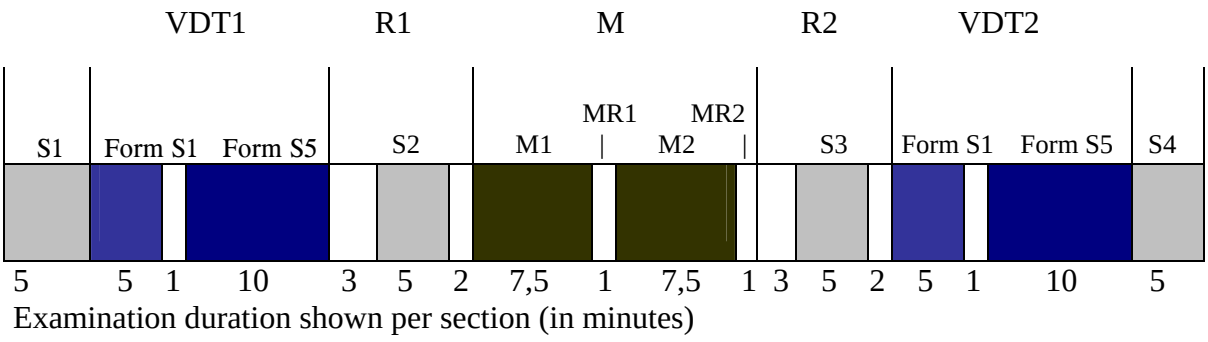



Timing Schedule of the Study

Each day session of testing was structured on the same principle (Figure 2). The test subjects were given a SMARD-Watch to wear. Then they were given psychological questionnaires to answer. After this a saliva sample was taken. Upon completion the subjects were asked to complete two *Viennese Determination Tests* (test forms S1 and S5, separated by a one minute pause). This was followed with a ten-minute resting pause during which a second saliva sample was taken. Then the music listening phase followed with two selections each of circa 7 ½ minutes duration, followed with a one minute break in which subjects were asked to rate the piece just heard on basis of a given scale. Detailed specifications as to each of the musical selections are found in chapter 3.1.3. Following the music listening phase was a further ten minute break during which a third saliva sample was taken. Once again there followed as at the start of the session a *Viennese Determination Test* (S1 and S5). Finally a fourth saliva sample was taken.

The session sequence of the control group was different only in that during the 7 ½ minute hearing sessions while subjects also wore headphones and sat in reclinable chairs, they heard no music and were thus asked to relax without the assistance of any external stimulation.

FIGURE 2

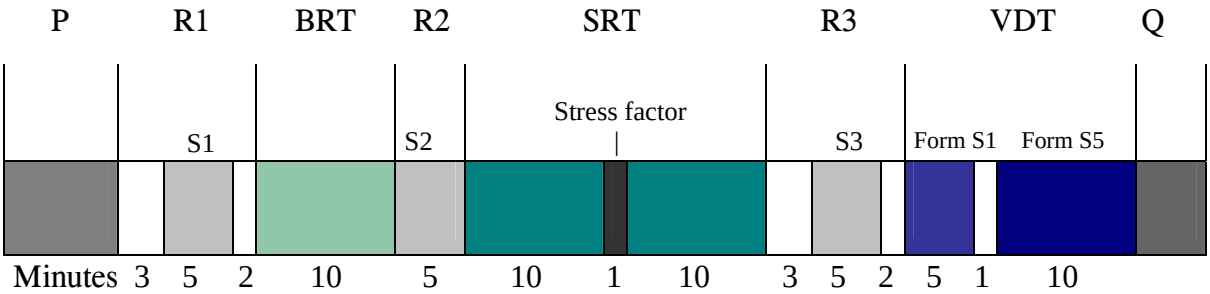



Timing sequence of one day of testing: S1,2,3,4 – Saliva, VDT1,2 – Viennese Determination Test, R1,2 – Rest phase, M1,2 – Music Listening Phase, MR1,2 – Music Rating Phase

The sessions during testing days (pre-test and post-test) ran as follows (see Figure 3): Test subjects were seated into comfortable chairs, in which they could select between sitting and lying positions. An initial saliva sample was taken, followed with a blood pressure

relaxation test. Then a second saliva sample was taken. Next came the stress-relaxation test followed by the taking of a third saliva sample. This was followed by subjects' performing of the *Viennese Determination Tests* S1 and S5. Finally subjects were asked to complete the psychological questionnaires provided. The exact test and questionnaire descriptions can be found in chapter 2.1.4. Due to time and place constraints half of the subjects went through a slightly different timing sequence during the examinations. They began by putting on the SMARD-Watch and filling out of the psychological questionnaires, followed by the *Viennese Determination Tests* S1 and S5. This in turn was followed by the taking of the above described initial saliva sample, the stress-relaxation test, and, finally, a third saliva sample. Through this splitting up of the timing sequence it was possible to carry out testing on two subjects simultaneously.

Figure 3




Timing sequence of one day of testing: P – Preparation, S1,2,3,4 – Saliva, BRT – Blood pressure Relaxation Test, SRT – Stress-Relaxation Test, VDT1,2 – Viennese Determination Test, R1,2 – Rest Phases, Q – Questionnaires

## 3.1.3 Musical Selections

In the first week of testing each of two musical selections were played Monday to Friday (see Table 1) and these exact music „programs" were then repeated in the second week.

In the music listening group sessions the music was played to the subjects through headphones[4]. Each of the respective three music listener subjects heard the music selections over a stereo system whose output consisted of three parallel wired headphone jacks[5].

The selections of music played is listed in the following table.

[4] SE-DJ5000 Pioneer.

[5] At the start of the first measurement week the music was played using three laptop computers. As of the afternoon of the second day (09.11.2004) and in order to benefit from improved sound quality and synchronisation of playback of the musical selections, the laptops were replaced with music played through the stereo system Technics SU-700 with amplifier harman/kardon HD 730 and speakers Infinity Reference 10's.

FIGURE 1

| Day | Nr. | Composer | Title | Duration | Musical Character |
|---|---|---|---|---|---|
| Monday | 1 | Dvořák, Antonín | Streichquartett Nr. 12, op. 96, 2. Satz | 07:15 | quiet |
| Monday | 2 | Gluck, Christoph Willibald | Orfeo. Reigen seliger Geister | 06:49 | quiet |
| Tuesday | 3 | Kalinnikov, Vasily Sergeyevich | Symphonie Nr. 1, 3. Satz | 07:41 | activating |
| Tuesday | 4 | Mozart, Wolfgang Amadeus | Klavierkonzert Nr. 17, KV 453, 3. Satz | 07:52 | activating |
| Wednesday | 5 | Sibelius, Jean | Der Schwan von Tuonela | 07:57 | sad |
| Wednesday | 6 | Fauré, Gabriel | Elegie für Cello, op. 24 | 07:11 | sad |
| Thursday | 7 | Bachmann, Kai | Streichquartett Nr. 4, op. 109, 2. Satz | 07:00 | quiet |
| Thursday | 8 | Fauré, Gabriel | Klavierquartett Nr.1, op. 15, 4. Satz | 07:47 | activating |
| Friday | 9 | Glass, Philipp | Violinkonzert, 3. Satz (ohne Coda) | 06:44 | irritating |
| Friday | 10 | Holst, Gustav | Die Planeten. Mars | 07:39 | irritating |

Musical selections used for the testing sessions, weeks 1 to 4

The musical selections were chosen using four criteria: quiet, activating, sad, and irritating and were required to be circa 7 ½ minutes in duration. Out of a substantial number of selections five individuals eventually reduced the number of qualifying music pieces to those shown in the above table.

### 3.1.4 Testing Procedure

On testing days 1 and 2 the following procedures were employed (not all tests were performed on every day):

- SNMM Questionaire (Science Network Man and Music) to establish general conditions and use of medicaments
    - General Questionnaire (pre)
    - Medication Questionnaire (pre)
    - Medication Questionnaire (daily)
- Short Scale mood/activation to establish the momentary subjective state
- NEO Five-Factor Inventory to measure the degree of neuroticism, extraversion, openness, tolerance and self-consciousness
- *Viennese Determination Test* to establish concentration ability
- Stress-Relaxation Test to categorize the type of stress regulation
- Blood Pressure Relaxation Test (ISF – Institute for Stress Research, Berlin) to determine blood pressure type (normotonic, hypertonic, hypotonic) cardiac type (tachycardiac, normocardiac, bradycardiac) relaxation level and relaxation ability
- saliva sample testing to determine the proportion of alpha-amylase and immunoglobulin A in the saliva
- measurements of the psycho-physiological parameters were taken at the underarm of the subjects to ascertain changes in the vegetative nervous- and vegetative emotional states as well as motor function activity (Science Network Man and Music). Pulse frequency and heart frequency were taken in intervals of ten seconds, while EMG, skin potential, skin resistance, skin temperature and convection temperatures were registered in intervals of one second.
- on each day during the sessions the activities and external influences that took place were continually documented

During days of measurement the following was carried out:

- the registration of psycho-physiological parameters as on testing days
- SNMM Questionaire to ascertain subjective states, medication and assessment of the music (only in the listening group)
    - Medication Questionnaires (daily)
    - Music Assessment Questionnaires (daily) (only music listeners)
    - Musical Familiarity Questionnaires (daily) (only music listeners)
    - Stress Questionnaires (weekly) (only on the 5th and 10th measurement days)
- Short Scale Mood-Activation
- Viennese Determination Test
- saliva samples
- during the sessions on measurement days activities and external influences were recorded in detail

## 3.2 Methodology of the Analysis

### General Remarks on the Analysis and Statistics

Based on the small number of test subjects (24) on which examinations and tests carried out it is not possible to come to any statistically definitive conclusions. Therefore any conclusions made are best characterized as trends or of an informational nature.

The use of times-series analysis methodology (program ANLyyy) allowed dynamic analyses[6] to be made, which derived from the original times-series of physiological and musical regulatory states.

From these it is presumed that essential information about processes in biological systems exists in the periodicities that are evident in the times-series. The foundation for this is the existence of control processes found in biological systems. To determine regulatory functions a times-series needs to contain the following three elements:

- quasi-stationary elements (slowly changing)
- stochastic elements
- periodic elements

In the dynamic analysis the quasi-stationary elements are separated from the stochastic and cyclical elements via the elimination of trends, while cycles with the highest probability are calculated inside a window (20 data) using the auto-correlation and production-density spectrum. By realigning the window within the times-series a new times-series is formed which reveals the change in a cycle (regulatory function) over time. With this method a simultaneous separation of the stochastic and cyclical elements occurs. This analytical process is then applied to the other physiological parameters (here it is skin potential, skin resistance and EMG).

To verify the correlation between two regulatory processes the correlational function is calculated within a data window. By passing the data window through the two regulatory functions f(x,t) and f(y,t) the change of the correlational coefficient over time is revealed as a dynamic cross-correlation function. Within the present study the dynamic analysis was carried out in one second-intervals, from which an analytical scope from two to thirteen seconds developed[7].

From the distribution frequency of the dynamic function, windows (20 data units) representing the regulatory states[8] as times-series were depicted[9] which display a two-dimensional cyclical system of regulatory states in second-intervals.

In this cyclical system the x-axis shows the change-over from an active state to a non-active state as numerical values ranging from 1 to 7, while the y-axis depicts the regulatory performance with the numerals 0 to 7. In the case of the regulatory performance smaller

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6 Hecht, Karl, Balzer, Hans-Ullrich (1999): Psychobiologisch-regulatorische Aspekte der Stressdiagnostik als Evaluierungsmethodik wissenschaftlicher Arbeitsprojekte – eine Quasimodelluntersuchung, In: St. Dauer, Hennig, H. (Hrsg.): Arbeitslosigkeit und Gesundheit: Beiträge zur Medizinischen Psychologie und Grenzgebiete (Bd. 1) Mitteldeutscher Verlag, Halle/Saale, S. 194-216.

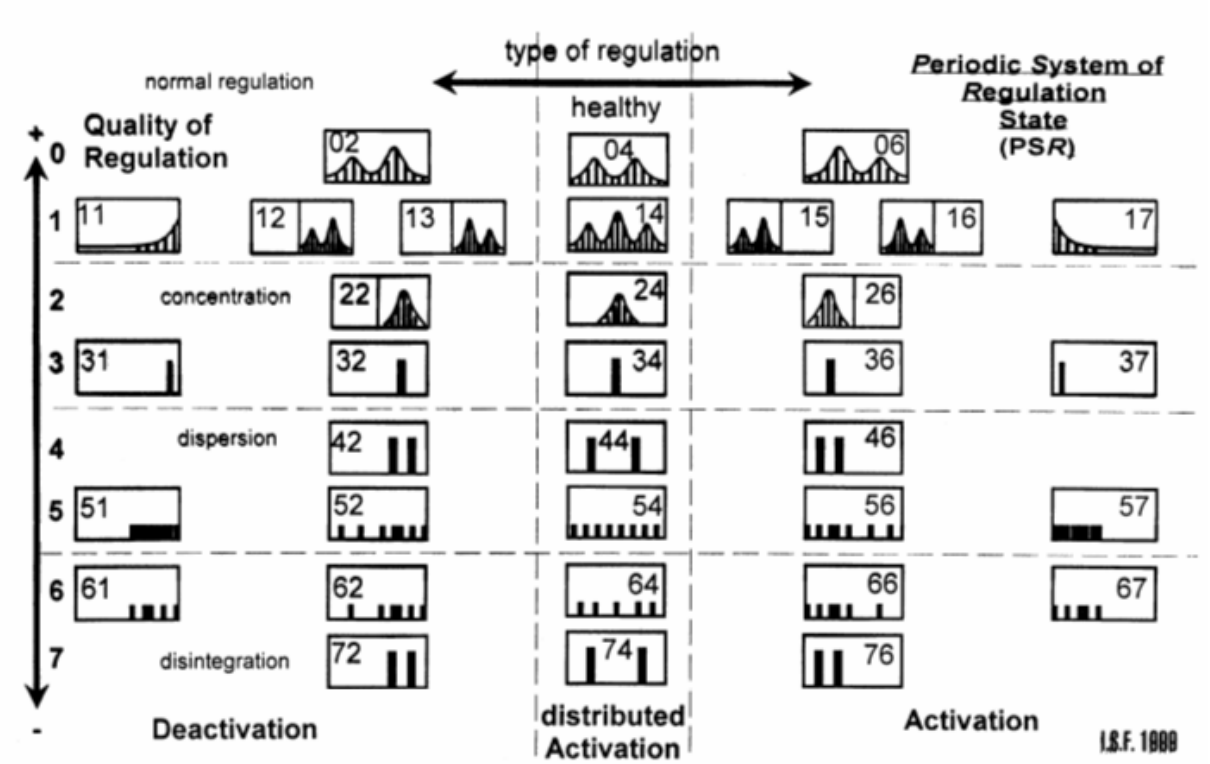
7 Balzer, Hans-Ullrich, Hecht, Karl (1988): Dynamic of processes — a possibility to analysis physiological parameters, Supplement to "The Physiologist", Vol.31, Number 1, Febr.88. Proceedings of the Ninth Annual Meeting of the IUPS Commission on Gravitational Physiology.
Schrüfer, Elmar (1992): Signalverarbeitung: numerische Verarbeitung digitaler Signale. Carl Hanser Verlag. München, Wien.

8 The expression *regulatory state* means the steady time interval frequency of verified regulatory periodicity.

9 For further details see also: Hecht, Karl; Balzer, Hans-Ullrich (2000): Stressmanagement – Katastrophenmedizin - Regulationsmedizin - Prävention. Pabst, Lengerich. Sowie: Hesse, Horst-Peter; Balzer, Hans-Ullrich u.a. (2002): Zwischenbericht der Tomatis-Hörkur-Studie (unpublished).

numerical values represent better performance, while larger numerical values represent worse performance.

FIGURE 4

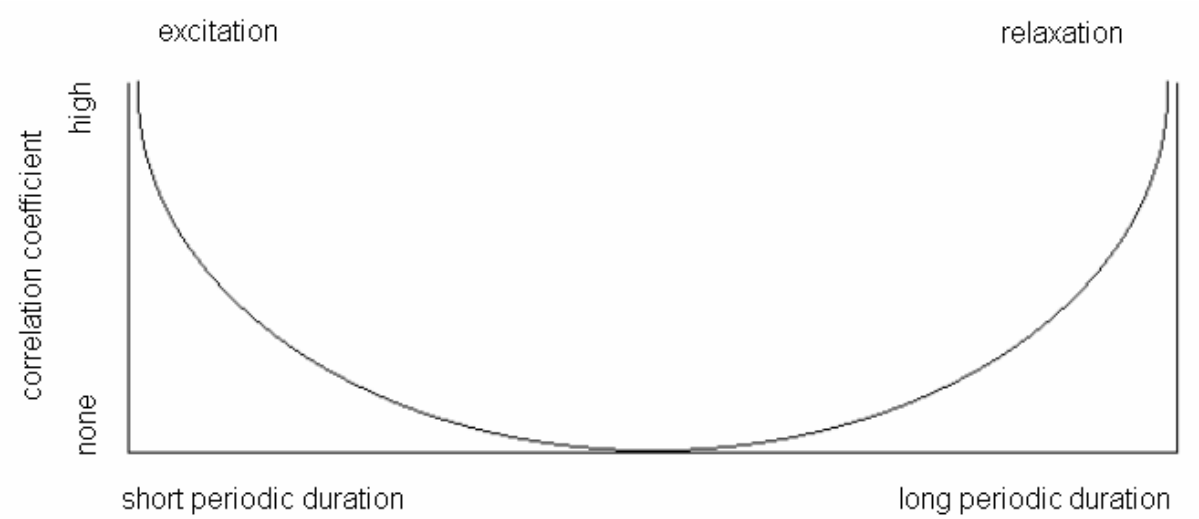



Cyclical system of the regulatory states

Because these states contains both the regulatory performance (multiple-of-ten digit positions, vertical axis) as well as the activation and/or de-activation (single-digit positions, horizontal axis) they were examined separately in the subsequent data analysis.

The synchronization of regulatory processes is calculated via the dynamic cross-correlation of vital function and/or regulatory state function (separated into performance and activation/de-activation) through a sliding window (size 20 data units) for two parameters respectively. The following basic assumption is applicable:

Figure 5




Relationship between regulation and synchronization (correlation)

In the so-called normal state (homeostasis – pictured in middle) the governing principle is regulation and counter-regulation. This means physical stress leads to mental relaxation and vice versa.

Afterward averages of three parameters (EMG, SP, SR or FS, VC, TD respectively) were calculated to chart an *entire physiological state process* for one subject and/or musical selection.

# 3 Results

## 3.1 Individual Results of the Music Analysis

Regarding the analysis of the musical parameters:

The musical parameters volume change (VC), change of frequency spectrum (FS) and change of tone interval density (TD) could be ordered into the picture made by the regulatory diagnostic, psycho-physiological states (cyclical system of regulatory states). Thus several aspects of the musico cause and effect became visible with respect to the distribution frequency of times-series regulatory states.

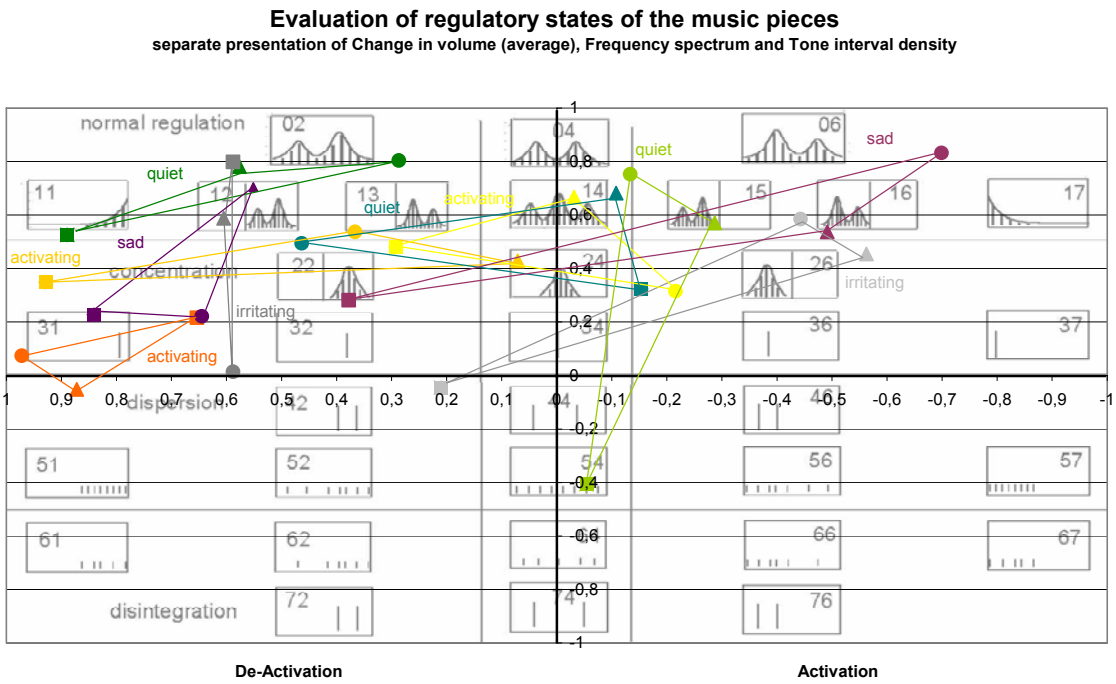
In the **frequency spectrum** of musical selections 01, 02, 05, 08 and 09, a calculation of the frequency (occurrence) of the regulatory activation levels primarily shows de-activating regulatory levels (0 to 3). In the symphony from Kalinnikov (selection 03) *only* de-activating regulatory levels occur. These results stand in contrast to those for musical selections 04, 06, 07, and 10, in which activating regulatory levels (5 to 7) outweigh de-activating levels, though in selection 06 *only* activating regulatory levels occur.

In the parameter **volume change** of the musical selections 01, 05, 08, 09 – and primarily in 03 – we find almost exclusively de-activating activation levels. In „Orfeo“ (selection 02) and in the piano concerto from Mozart (selection 04) this relationship is relatively to very well balanced. Activating regulatory levels occur most prevalently in selections 06, 07 and 10.

With respect to **tone interval density** the majority of the selections show low levels of activation (selections 03, to 07 and 19). In the piano quartet from Fauré (selection 08) there occur almost exclusively low activating levels and in the string quartet from Dvořák (selection 08) as well as in the violin concerto from Glass (selection 09) they are purely deactivating. An overwhelmingly activating regulatory level is found only in „Orfeo“ (selection 02).

The following Figure 6 shows in essence an overall unity in the subjective assessments of the musical selections with respect to the cyclical system of regulatory states, depicted in the background and up to now having only been applied in psycho-physiological, bio-chemical or behavioural parameters. To allow us to depict the possible reasons for any differences in assessments, several musical selections were used to create more area over which to spread the calculated states of FS, VC, and TD.

FIGURE 6




Graphical depiction of the calculated regulatory states of all musical selections

TABLE 2

| | | | |
|---|---|---|---|
| ● | 01: Dvořák | ● | 06: Fauré (Elegie) |
| ● | 02: Gluck | ● | 07: Bachmann |
| ● | 03: Kalinnikov | ● | 08: Fauré (Klavierquartett) |
| ● | 04: Mozart | ● | 09: Glass |
| ● | 05: Sibelius | ● | 10: Holst |
| △ | Change in volume | ○ | Frequency spectrum |
| □ | Tone interval density | | |

Legend Figure 6

The selection from Dvořák (deep green) is categorized in all three parameters as de-activating and thus quiet. The piece from Gluck (turquese), also assessed as quiet, lies in the centre of the regulatory spectrum, touching into de-activating with the parameter FS. Here this parameter is obviously the critical factor in assessing the piece as „quiet“. The piece from Kalinnikov (dark orange) is assessed as activating, although in all three parameters it approaches the boundaries leading into inhibition through overload. It thus needs to be verified whether the dynamics of the piece are actually so extensive relative to the other pieces or whether the scope of the analysis was not sufficient to properly analyse this dynamic. The selection by Mozart (yellow) was also assessed as activating and is shown here as balanced. The piece by Sibelius (dark violet) is assessed as sad. All three parameters show values that appear in the area of de-activating, whereas it becomes apparent that parameters FS and TD show very low values on the y-axis, thereby indicating disturbed regulatory states (borderline). A similarly low value of parameter TD is also indicated by the second piece assessed to be „sad“, the Elegie from Fauré (violet). This assessment follows despite showing strong activating values for parameter FS. Thus we see the first indication that, with regard to the assessment of „sad“, the parameter tone interval density (TD) plays an important role. The piece from Bachmann (olive green) is assessed as quiet. All three parameters however find themselves in the activation spectrum, whereas it is evident that tone interval density is subject to whether or not many short and irregular fluctuations occur in a piece. That element of the assessment considered „quiet“ apparently arose out of the parameter TD (relatively many small stochastical fluctuations). The quartet from Fauré (orange) is rated as activating. For parameter TD monotony is indicated, which implies „quiet“, while the other parameters (FS and VC) also appear in the area of de-activation - by comparison to Dvořák and Sibelius however already in the direction of activating. The selection by Glass (dark blue) is rated as irritating. Noticeable here is that all three parameters are found in the de-activating area, due to almost non-existent variation relative to activating/de-activating. The variation appears solely in the performance parameter (y-axis), which is considered as irritating. The piece from Holst (light grey) shows a normal variability in the parameters, however solely noticeable is a rigidity in the tone interval density (TD). Thus this piece is rated as „irritating“.

In essence we see an overall uniformity in the regulatory diagnostic assessments relative to subjective assessment. Viewed individually, however, the requirement for further analysis is indicated. Thus in order to come to a more uniform conclusion with respect to

subjective assessment of music, additional musical parameters would have to be considered (e.g. harmonic intervals or dissonance).

**The horizontal position of the TD parameter seems to be a key factor with respect to the terms *sad* and *irritating*. From the analyses it can logically be deduced that *sad* music - primarily through monotony (rigid regulatory) - is *de-activating* (states 31, 32) and characteristic for the parameters FS and TD. Music is categorized as *irritating* when there is no or little activating/de-activating variance in the transition to stochastic regulatory processes (also the area of neurotic behaviour). Music is considered *activating* when its regulatory states are found in the top right quadrant, while music can be categorized as *quiet* when all of its regulatory states appear in the top left quadrant.**

## 3.2 Results of the Examinations Compared

Overall it is apparent that the majority of the test subjects in the listener group exhibits a lesser performance rating as the music does itself with respect to String Quartet Nr. 12 from Dvořák (selection 01). However after minute four of the piece a third of the subjects reach improved levels, which could be an indication that mid-level performance rating in the subjects is positively influenced by the more positive levels in the music here. With regard to the mid-level regulatory activation we see that in the majority of the cases there are higher values in the physiological activation levels as are in the music.

In „Orfeo“ from Gluck (selection 02) it is indicated that, with respect to the mid-level activation ratings, the performance-curve levels appear in the same range for both the music and test subjects. In regard to mid-level activation it is shown that 50% of the test subjects have similar activation levels as the music has, while after minute 3:00 the other 50% reach higher activation levels as those found in the music.

The performance-curve progression displayed for the Kalinnikov Symphony Nr. 1 (selection 03) shows that the curves progress very similar to those of the music in almost all of the test subjects. However in the end in 50% of the cases the physiological performance curve doesn’t follow that of the music into the „worse“ regulatory performance. In mid-level regulatory activation almost all test subjects show a higher level of activation as the music. In the end the level of regulatory activation in music rises while this rise in level is observable in only half of the subjects.

With Piano Concerto Nr. 17 from Mozart (selection 04) a typical mid-level regulatory activation is observed in the majority of the subjects in comparison to the performance curve of the music. In two thirds of all cases the physiological curves increasingly approach the musical ones; however at the end many (curves) remain distinctly different from those of the music. Over half of the physiological curves move into worse performance curves between minutes 2:00 and 3:00, even though the regulatory activation performance in the music at that point shows itself to be at a very good level. The physiological activation follows similar levels as those of the music in most cases, however many subjects show deactivation occuring in minute 2:45 to 3:45 - right at a point in the music where a strong activation level increase is happening.

As in the piano concerto by Mozart, in the case of Sibelius' „Schwan von Tuonela" (selection 05), most physiological performance curves indicate an increasingly similar performance level to those found in the music. With regard to activation the physiological curves repeatedly show high levels, which are not however very often reflected in the activation curves of the music. Of note is that several of the subjects (at approximately minute 3:45) almost simultaneously register a short term activation increase. This could be caused by the short – but by far not such a strong – activation increase which occurs in the music one minute earlier.

The majority of subjects during „Elegie for Cello" by Fauré (selection 06) indicated a worse performance as that found in the music. During the process of activation at the start in many cases a strong increase was read, followed by deactivation, while the music exhibits an activation here. Then physiological and musical curves remain for the most part parallel in mid-level activation until the end.

In String Quartet Nr. 4 by Bachmann (selection 07) and in the piano quartet by Fauré (music selection 08) the progression of the physiological performance curves in most cases follows this pattern: subjects, who at the start of the piece experience a good regulatory performance show a worsening quality as the piece progresses. In the case of subjects who at the start show a poor regulatory performance it works in the opposite way. Subjects with a mid-level performance quality tend to stay with such. It becomes apparent in the two musical performance curves that in both cases in the second half the curves move higher into worsening performance levels, then however sink again to better performance grades. With respect to musical piece 07 the music is deactivating, however this is not reflected in the physiological curves. Over the course of the piece the physiological activation curves become more like those of the music in the range of mid-level activation. In musical selection 08, after the initial deactivation levels, most subjects tend to a mid- to high-level activation, while in the music a continuous switching between deactivation and mid-level activation occurs.

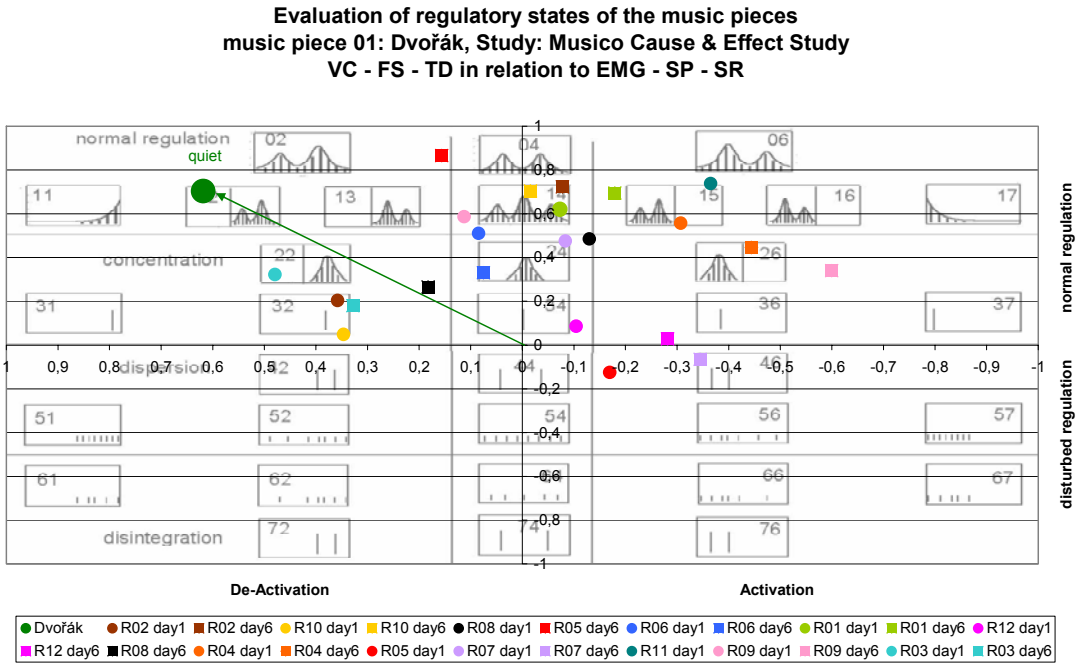
In the case of the violin concert by Glass (musical selection 09) we see that the physiological performance curves have a relatively large similarity to the musical performance curves. In total the physiological activation progressions show a higher activation than the musical ones. Some of the curves sink to lower activation levels in the last third, then rise again to elevated levels. As opposed to the musical pieces by Mozart (selection 04) and Sibelius (selection 05), at the beginning of the piece „Mars" by Holst (selection 10) in most cases there is a great similarity between the physiological and musical performance curves whereas all test subjects display increasing variation in their curves compared to the music as the piece progresses. With regard to the activation we see on the one hand progressions that in respect to physiology are similar to the ones found in music while on the other hand they have little in common with it. Striking is how in many test subjects large fluctuations in activation occur at minute 2:15. Remarkable also is that the musical activation curves in pieces 04 and 10 are so very different from one another with respect to the broadness in their fluctuation. While the musical selection 04 (Mozart) indicates a very large range of activation levels, jumps between activation levels in piece 10 never exceed two levels.

It becomes evident in many cases that during the musical pieces an increasing adaptation in performance and activation of the physiological regulatory processes to those regulatory processes found in the music takes place. This is considered to be the synchronization process. However the physiological regulatory functions require 30 to 60 seconds to adapt

to the performance progression of the music. Through this time difference there arose a predominantly negative correlation. To reduce the delay in physiology relative to the music, the physiology curve in mid-level performance and mid-level activation were exemplarily shifted to the left with an especially clear but delayed synchronization (subject R02, day 07, music selection 04) of 45 units (seconds) and the correlation between physiology and music calculated anew. Thereby, in comparison to the analysis without the shift, an opposite relationship between positive and negative correlation and thus a predominantly positive correlation value resulted.

In the following an example of a differentiated evaluation of the regulatory-diagnostic analysis of the musical selection 01 is depicted.

FIGURE 7



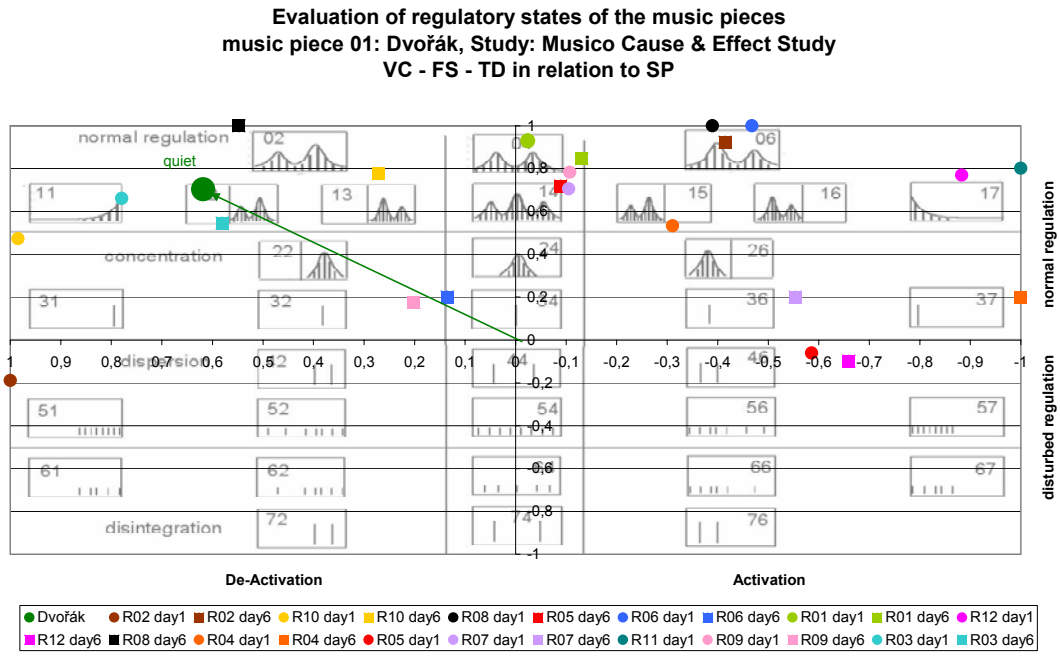

Regulatory diagnostic assessment of music selection 01

In Figure 7 the differences between the regulatory diagnostical evaluation of the music selection by Dvořák and the psycho-physiological reaction of the test subject, with respect to frequency (occurrence) dispersion of performance parameters and activating and/or deactivating bodily functions EMG, SP and SR, is averaged, normalized and depicted. As a rule every test subject heard the music twice. The reaction at first listen (day 1) is shown with a circle, while the reaction to the second time listening is shown with a rectangle (day 2). In the overall view - or averaging - of all three bodily functions, a prevalence toward the activation side is shown. In nine measurements a complete de-activation state in all three bodily functions was reached; in contrast by 14 measurements not. The cause of this appears among others to be a high degree of activation in the test subject prior to commencement of the examinations. This in turn is contradicted by the on average positive assessment of the music of Dvořák, which was found to be very enjoyable. Conspicuous is also that there evidently was a difference between day one and day six. This difference is noticeable in that, in many cases, measurements taken on day one were nearer

to the values resulting from analysis of the regulatory diagnostics of music (state 12 – quiet) as those taken on day six (7 times = 14 of 23 examinations). A correlation to the examination date/weekday is not discernable, since the music of Dvořák was only heard on Mondays. One can only assume therefore a conditioned reaction or influence from the previous activation.

To investigate these differences more closely, connections to individual reactions (vegetative-emotional, vegetative-nervous, muscular reaction) were examined separately. It is to be expected that an assessment as „enjoyable“ shall likely have a correlation to the sympathetic nervous reaction (measured via skin resistance) of the subjects tested.

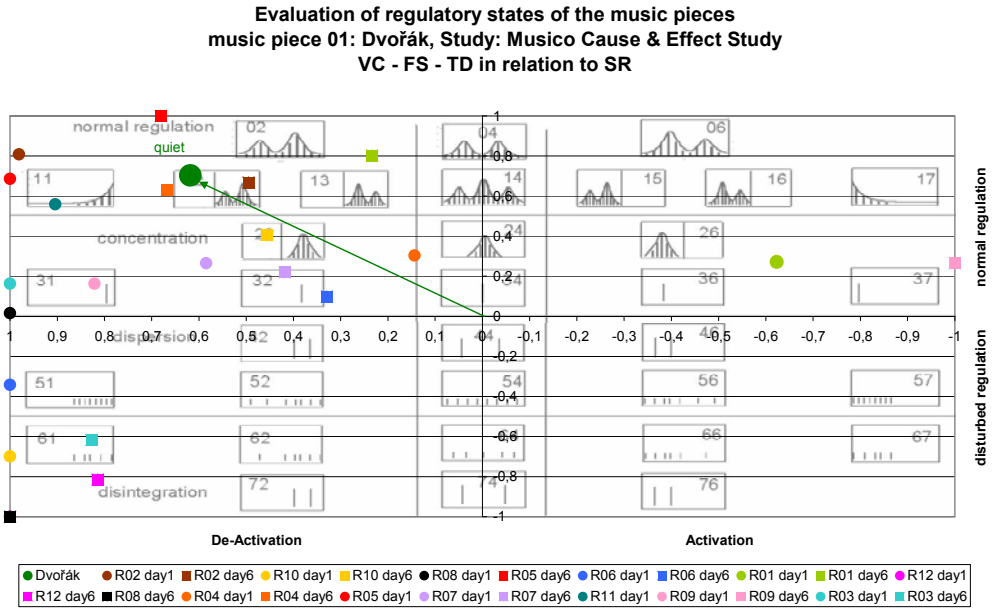
FIGURE 8




Regulatory diagnostic assessment of musical selection 01 (VC-FS-TD compared to SP)

The depiction of the vegetative-nervous reaction of the test subject while listening to the music of Dvořák shows that only one subject in both examinations is close to the same regulatory state that the music is in (subject R03). This was also true for four subjects on the second day and two on the first day. All other fifteen find themselves in an activated state with regard to the vegetative-nervous reaction which indicates that, under the conditions presented, this piece by Dvořák triggers fewer cognitive processes.

FIGURE 9




Regulatory diagnostic assessment of musical selection 01 (VC-FS-TD compared to SR)

The representation of the vegetative-emotional reaction of the test subject while listening to the music of Dvořák shows a contrary picture to that of the vegetative-nervous reaction. With the two exceptions all reactions are in the area near to the regulatory state of the music sample (state 12). Furthermore more second measurements than first measurements are shown to be in this state. This could potentially indicate a familiarization effect. Particular concurrence is shown by subjects R02 (day 6) and R04 (day 6). These results confirm the above assumption that an especially strong consistency in assessment of the music by the subjects occurred with respect to „enjoyable“ and their sympathetic nervous reaction.

The musical selection was assessed as „quiet“.

Over and above that, through differentiated observation of the psycho-physiological states it was possible to distinguish several other characteristics with regard to the assessment of music.

The assessment „the music is enjoyable“ is represented primarily through the parameter SR – vegetative-emotional reaction. Activating music (Mozart) contributes to an increasing occurrence of activated SP regulatory states, which is evidence to show vegetative-nervous reaction with increasing occurrence of cognitive processes. Large fluctuations in parameters FS and VC in music (Kalinnikov) bring an increase in occurrence of de-activating states in the parameter SP as a result of overload inhibitions. Balanced, quiet music leads in the best case to de-activating states in all psycho-physiological parameters. In the typical case (Dvořák, Gluck) the principle of regulatory and counter-regulatory states is true, which is to say that activating states in the vegetative-nervous reaction lead to strong mental relaxation states. Monotonous music with only slight changes (Glass) is shown mathematically in its structure as „de-activating“. Physiologically it triggers a counter-reaction in the sense of activation, which in certain circumstances can also be classified as „irritating“. „Stochastically“ structured music, or music with large variations in its distribution of the states (Holst) of the three base-parameters is also classified as disturbing. The psycho-physiological reactions lie in the area „chronically

stressed“. Sad music (Sibelius, Fauré-Elegie) is characterized with lesser performance due to its extremely de-activating SR regulatory states.

As a rule, it takes about 1 –2 minutes for the synchronization between music and psycho-physiology to happen. At the same time the setting in of the synchronization is dependent upon the initial state of the listener (activated or de-activated) and from the music’s commencing state (activating or de-activating).

**Analysis of the Correlation between Music and Vegetative Regulatory State:**

To arrive at a picture of the various effects the music had upon the subjects tested, all regulatory parameters were compiled independent from test subjects:

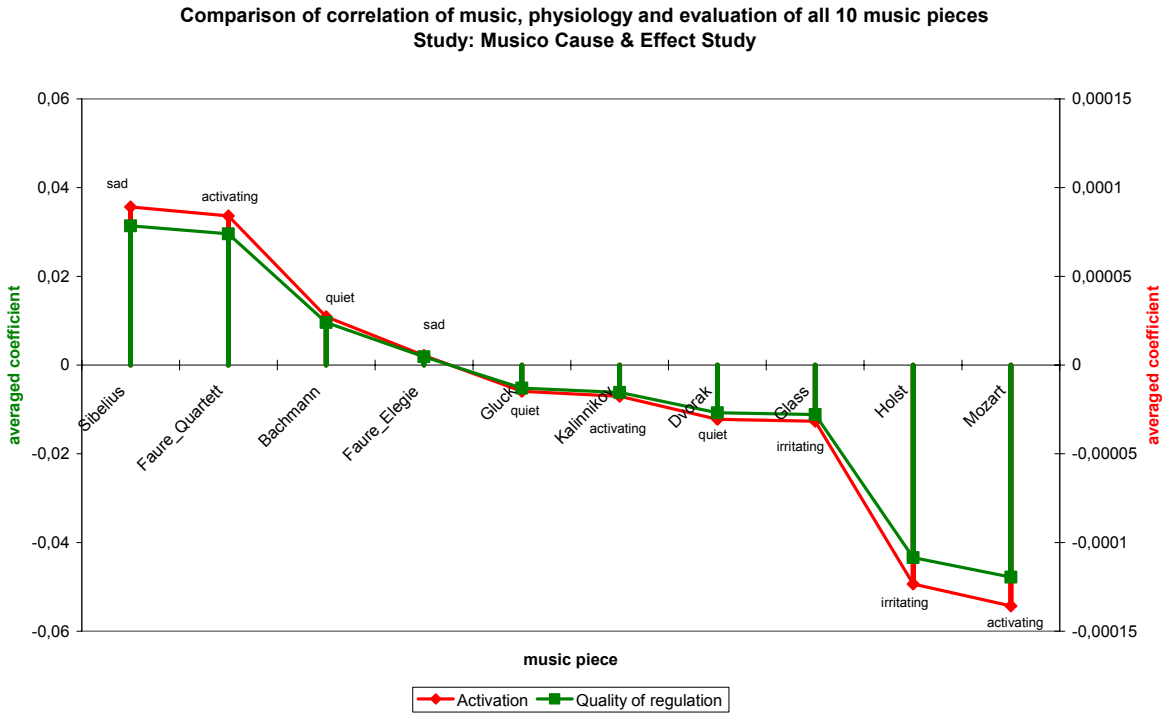
TABLE 3

| | Musical Selection | Performance Averages | Activation Averages |
|---|---|---|---|
| Dvořák | 1 | -0,01074605 | -3,05285E-05 |
| Gluck | 2 | -0,00518775 | -1,47379E-05 |
| Kalinnikov | 3 | -0,00617589 | -1,75451E-05 |
| Mozart | 4 | -0,04780138 | -0,000135799 |
| Sibelius | 5 | 0,03136837 | 8,91147E-05 |
| Fauré_Elegie | 6 | 0,00189394 | 5,38051E-06 |
| Bachmann | 7 | 0,00958807 | 2,72388E-05 |
| Fauré_Quartett | 8 | 0,0295928 | 8,40705E-05 |
| Glass | 9 | -0,0111451 | -3,16622E-05 |
| Holst | 10 | -0,04344223 | -0,000123415 |

Overview of all 10 musical selections

Calculated were differences in function distribution of positive and negative proportions of synchronization and regulatory function performance and activation between the music parameters FS, VC and TD as well as the physiological parameters EMG, SP and SR. These were normalized and displayed separately for performance and activation for each musical selection independent of test subject and/or measurement taken. Negative values indicate an overcompensation of negative and/or counter-phased correlation of the regulatory state function between parameters. Positive values indicate a compensation through like-phased synchronization functions between the parameters. After assessing the values the following picture materializes:

FIGURE 10




Correlation of music, physiology, and assessment for all 10 musical selections compared

Interestingly this depiction (Figure 10) remains consistent for both an assessment based on performance as well as one based on activation. **Thus, regardles of the listener, the best correlations between music and physiology are reached in the piece by Sibelius (sad), the least correlations for the piece by Mozart (activating). Overall there is a tendency toward reduction in correlation from sad/quiet to activating/irritating. The cause for this is evidently the problem of the contrived nature of a situation where test subjects are asked to relax to the effect of music which apparently and logically works better with de-activating music as it does with irritating or activating music. Over and above this the assertion can be made that the correlation between the performance values of music parameters and physiological parameters is essentially higher as the correlation between the activation values** (recognizable from the large differences in the averaged correlational coefficients factored by $10^2$)**. This means that music has a greater influence on the regulatory performance as it does upon the type of regulation (activating or de-activating). Said in another way: the activation state of a person is more difficult to influence as the quality of the regulation.**

# 4 Software Used

**Existing:**

- **Jumi01 (Balzer)**
- **Jukor09 (Balzer)**
  Program to calculate the dynamic cross-correlation of two times-series
- **Aiko02 (Balzer)**
- **Screen Manager**
- **SET analysis program (Balzer)**
- **WDTprogram**
- **ANLyyy (Balzer)**
  Program to calculate the performance- and activation states of one times-series
- **CDEx 1.51**
  Program to read CD tracks and save them as wave files.

**Newly programmed:**

- **AlisOnda136 (Bachmann)**
  Program to analyse volume, frequency and density of sound from wave files using times-series analysis
- **Wiener133 (Bachmann)**
  Program to make visible the individual results of the Viennese Determination Test
- **Wiener Kontrolle-Programm (Bachmann)**
  Program to backup the data from the Wiener133 program
- **Kompu110 (Bachmann)**
  Program to convert commas to (binary data modus) dot.
- **MalTau (Bachmann)**
  Program to shift the decimal point by four places to the right
- **HW-Korrekturprogramm (Balzer)**
  Program to correct original times-series of the parameter skin resistance, should they be affected
- **Jukor10 (Balzer)**
  Program to calculate the dynamic cross-correlation between two times-series.

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