e-mail: JMP100%DEOHRZ1A (BITNET) OR
JMP100%VM.HRZ.UNI-ESSEN.DE (INTERNET)
fax: 201-183-4279 (or 2787)

Universität
Gesamthochschule
Essen

Prof. Dr. Helmut Schaffrath
Chairman of the Study Group on Computer Aided Research
in the International Council for Traditional Music (ICTM)
Universität · Gesamthochschule · Essen · Postfach 103764 · 4300 Essen 1

Fachbereich 4
Gestaltung · Kunsterziehung
••MUSIK••

Eleanor Selfridge-Field
Center for Computer Assisted Research in the Humanities,
525 Middlefield Road, Suite 120,
Menlo Park, California 94025,
USA

Fernsprecher
(0201) 1831 oder
Durchwahl 183-4215/4247
Raum Nr.
Mein Zeichen scha

Essen, den 23. Juni 1991

NEW VERSIONS OF ESTAFF AND PAT

Dear Eleanor,

you have received at least ESTAFF but eventually also the first PAT-version. As you will guess from the new manual enclosed there is a new version of pat with many a new option. You can order it the usual way (License Agreement and formated discette).

At the same time we are updating ESTAFF into version 3.0:

- It will support the mouse in every function,
- staff and graphics habe become much faster,
- any screen colour is supported,
- some new "alterations" are correctly represented,
- the method of drawing notes from the menue has become more elaborate,
- you can copy and shift graphics in a more user-friendly way etc.

Ulrich Franzke is working on this and needs to know some of your criticism before you plan this year's holidays...

We cannot utter as many wishes ourselves as more then 50 ESTAFF users and therefore need your help. What we want to know is:

- Do you use ESTAFF at all? We need also to know how many "passive users" there are! If YES:

- What tasks do you need ESTAFF for?

- Which are the disadvantages of the program?

- What could be more beautiful, quicker, elaborate? (We cannot become cheaper as you know).

- Did you also use some of the remaining Essen programs like MAPPET to input your melodies?

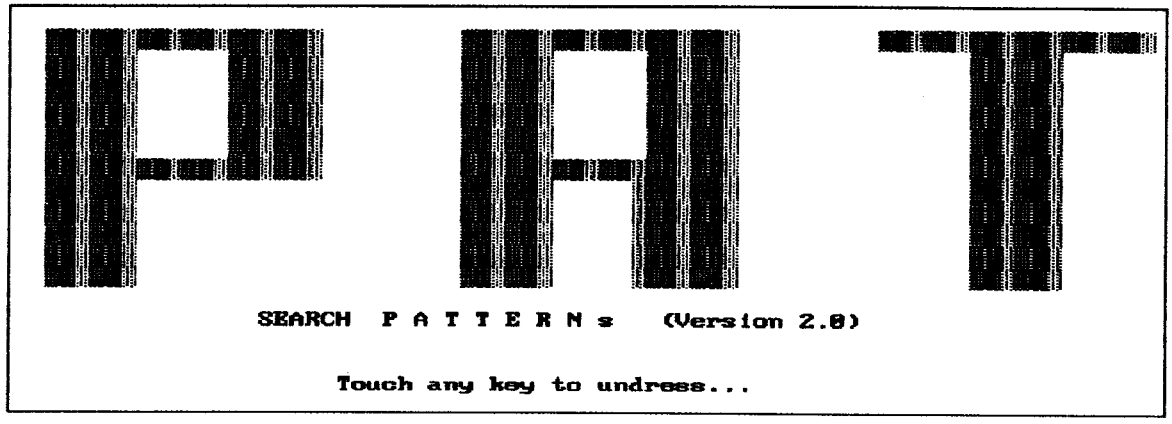
Since I shall not be in Germany until the end of September and since U. Franzke does this updating himself anyway, you should send your reply or order directly to him. Just make use of the envelope enclosed. E-mail users can reach him by all(!) user numbers of the License Agreement.

Have a good summer!
Best wishes

(Prof. Dr. H. Schaffrath)

P.S.
As announced you'll find a larger paper with many examples of our system.
Have a good time!

University of Essen, FB 4, Musik



1 Introduction

It is only five months after publishing the first Pattern Search Program (Version 1.0) that we have to update it now and switch to a larger version. This was adapted to the Essen standards so that everything you can read on the screen has been stored in an external text file and consequently can be translated into different languages. We will go on with this kind of "internationalization", which at the same time requires a responsible user: Since we can no longer be responsible for the screen texts, you will bear some kinds of "respectlessness" because every user can now change them him- or herself.

We have also added a licence agreement which you have to copy, sign and send if you wish to receive Pat.

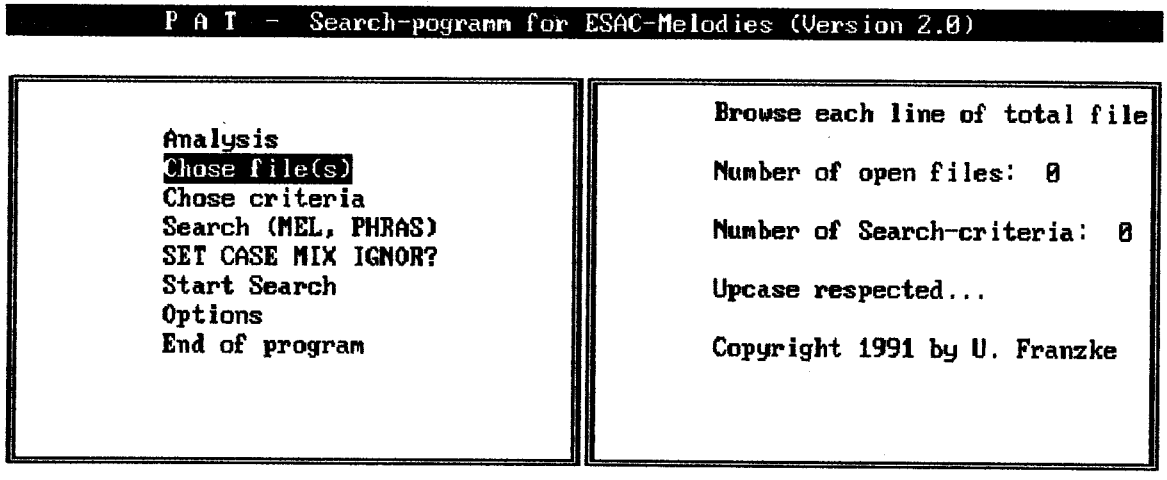
2 To Use the Program

After you have started PAT by its name and lifted it's pyjama, you will read the main menu in which the cursor is automatically placed on the *<search file(s)>* option. Hit the <Enter> key and define first how many files you wish to search and then write every single file name (the program does not react if the file does not exist). The cursor is now on *<choose criteria>* in which you also have to enter first the number of criteria and then the patterns exactly in the order in which they must occur (you may wish to look first at the example at the end of this manual). The cursor now has switched to the *<start search>* option and if you want the program to start, then hit <Enter>. These are your main activities but you will have to understand several new options:

The screen is devided in three windows. The left contains the main menu, the right displays the "status" and the lower

window is activated after the search has started. Every option of the left window can be chosen by the curser keys and the result is shown in the right window: which line(s) do you wish to search, how many files are open, how many criteria will be searched for, do you want to have the spellings with capital and small letters accepted. The lower window will be activated after the search option and displays informations about the songs, occurences and time.

2.1 More Details



Analysis: this option has been reserved for further issues. It has no function yet.

Choose files: you first enter the number and then the names of the files. The program only reacts to correct declarations. You can use the * (asterisk) in the file name as a joker, a question mark is not allowed however:

If you use, for instance, the question mark in TE?.SM then you will find any file starting with TE like TEST1.SM or TEST2.SM. The asterisk, however, will causes the program to **use** every file whose name starts with TE.. and has the type SM. So consequently if you wish to analyse all files of the type SM, then answer the question "How many files?" by 1 and write *.SM instead of the filename.

Choose criteria: write first the number of criteria and then the patterns themselves (any alphanumerical string. Do not forget however, that 112 leads to complete different results as 1 1 2 !).

Search (Mel, Phrase): you can choose here if only the first or the last melody line has to be examined or all of them or each line of the total file. If you search *<all melody lines>* then your pattern may occur in different phrases of the song, if you choose *<each*

single line›, then your pattern will be searched in any line of the file. So one can also search for the title of the song, for a signature or a remark. The options ‹*only first phrase*› or ‹*only last phrase*› might also serve as an example to enlarge those possibilities in further updates of Pat.

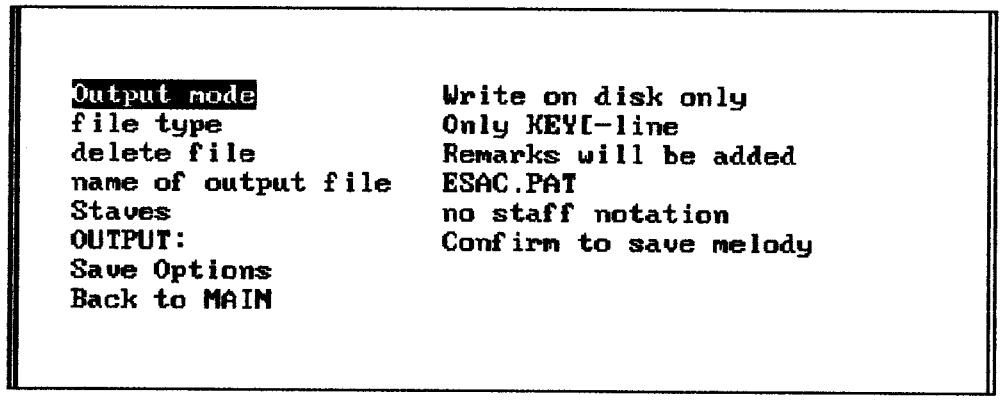
Set case mixed ignore: either respects upcase letters or ignores the correct spelling of the words. You can see in the status window that the respective mode is displayed.

Start search: ... (You got it!)

Options: PAT2 offers a few new options which shall be depicted in more detail in the next paragraph.

End of program: ... (You may drop us a letter if you don`t understand that).

3 Options



The above printed menu will be activated after you have chosen ‹options›. You should know that you can store any chosen options under the point ‹*save options*›.

Output mode: you may wish to save your results in a file, browse them on the screen or both. If you choose ‹*only internal*› then the program counts only the occurences. If you have changed "so called staff notation" under ‹*staves*› then you can also prompt the system to display the song in staff notation and play it by the computer speaker. To speed up the search when using large data collections we advise you to choose this option or let the program write any results in a new file which you then can browse again.

File type: ‹*only key-line*› will store only the signature of the melody which you then might ask in some original collection. You may also wish to store a ‹*comment-*

line> about the pattern and the filename in which it occured, and you can choose a complete *<copy of the melody>* thereby selecting every melody containing your pattern.

Delete file: if you choose *<file will be re-written>* then the existing file (ESAC.PAT) will be deleted. But you may also wish to <add> any result *<remarks will be added>* to an existing file.

Name of output file: choose the name of your output file if you do not want to use ESAC.PAT.

Staves: you have to choose here in advance if you later wish to look at the melody in staff notation or not.

OUTPUT: this option is only useful when the program does not only run on screen or internal. If it does, it automatically displays *<save without confirmation>*.

Save options: every chosen mode can be stored in the file PAT.CFG which will be evoked by every further call of PAT. You should, however, not try to delete the copyright from this file, because this would destroy the exec file. In this case you better delete the complete PAT.CFG and then start again. Any detail can be saved here including those of the further *<staves>* options.

Back to MAIN: ... (Just look what happens).

Graphic display: when the program has found a pattern and the option <staves> was switched on "staff notation", then you will be asked if you want to see the song in staff notation. The eventually stored lyrics are not displayed. If the melody is longer than the screen, you can use <PGDN> or <PGUP> to scroll or use the option <D> to have the melody displayed in 2 different windows. In this case you press <Q> to return to the normal screen.

The option <M> persuades the internal speaker to play the melody. You will see every single phrase framed in the middle of the screen and every single note will be marked during the playing process. You cannot switch this off even if you are good in sightreading.

You choose <O> for further options which later can also be saved. So you may wish to change the duration of the single tones whose default is 5000. The speed depends on the type of computer and of course on your wishes.

You also may wish to change the number of semitones per octave: the default is pythagorean 12 tones, the ideal PELOG however could be 14 semitones per octave. We have not prepared a free (not arithmetic) distribution of semitones in this version yet.

You now can choose the colour of the characters and the colour of the background. If you have a Hercules

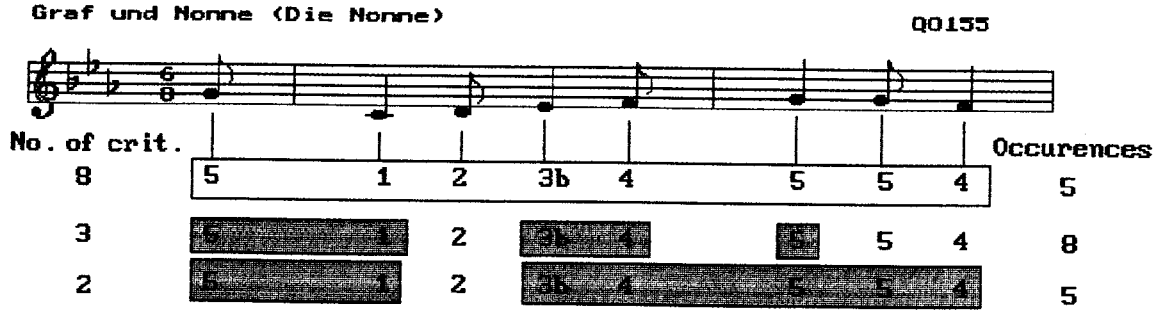
graphic-card you have to choose number 1; for colour cards numbers between 0 and 15 are possible. In the case of Hercules you should choose number 15 for the background.

If you like your changes, don`t forget to save them later under *<save options>*. While in graphic display you can return to the main menu or to your search by pressing <ESC>.

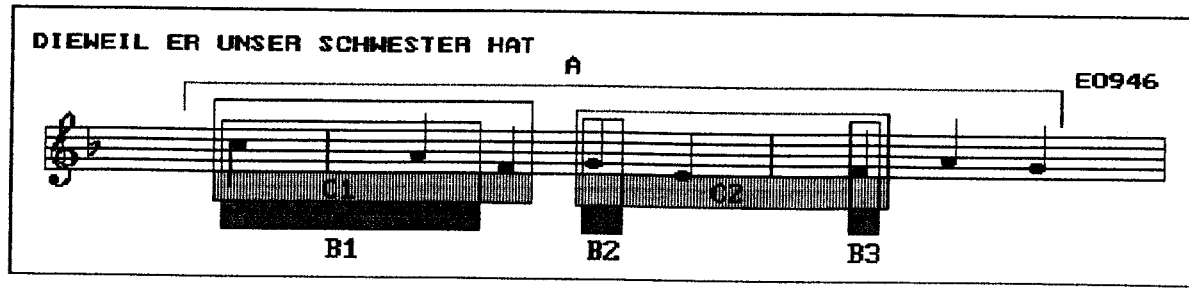
4 Examples

A:

One cannot only find melodies with PAT but also many variants. The following example contains of the first phrase of a song. If every pitch is equally important then the example contains of 8 different criteria. In this case we found 5 songs in more than 6.000, one of which was a double and the rest is very closely related to our example. But you could also have saved some time and numbers because the result with only 2 criteria is identical. This is different with 2 criteria: there are especially some melodies with different endings as is for instance the auxiliary note (5 **6b** 5), but they are all closely related to the "original".



B:



If you take the whole melody line as a single criterium A and search for the pitches (5312-7132) in every first phrase, then you will find only the original among more than

6000 melodies. If you define your own contour by the criteria B1 to B3, you will find 183 phrases. If you only define the 2 criteria represented by C1 and C2, then you will find 9 melodies which you might wish to examine by conventional methods[1]. You will then see that the 9 lines consists of 6 very closely related variants and 3 more distant relatives.

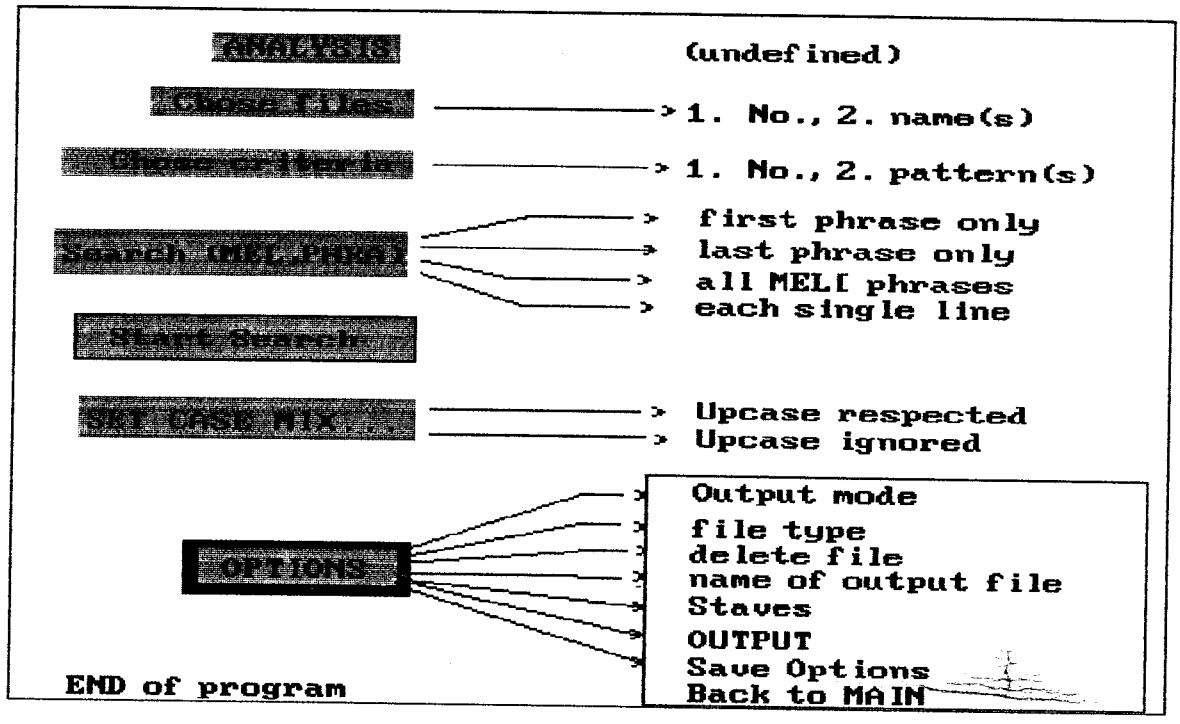
5 Old Mistakes

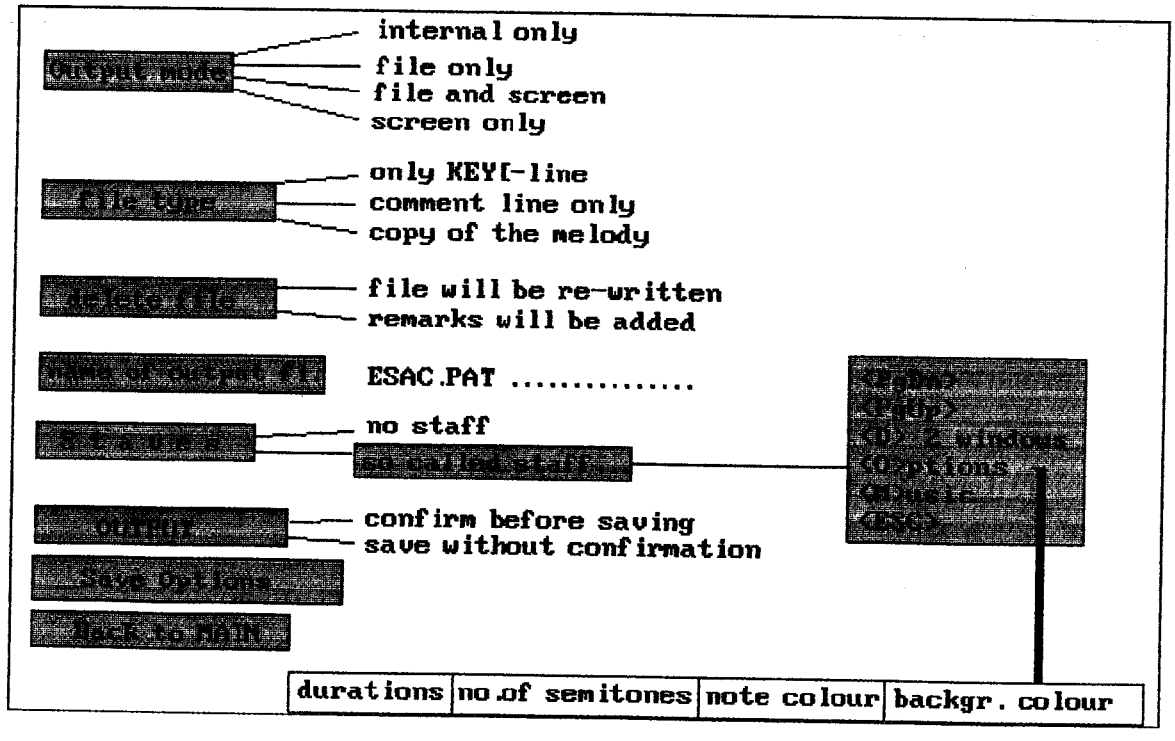
The new Pat doesn`t only know the difference between the tones 3 and 3b or 6 and 6b but also between the notes 1 and +1 as well as between ++1, -1, --1 (++1 is 2 octaves above 1).

We have prepared the following graph for everyone who does not wish to turn these pages over and over in order to use Pat:

---

[1] for the results of this example you would only have to wait for 30 seconds, if you use a file that was reduced to pitches by STRIP5 and an 80 3/86 with 33 MHz.


(undefined)
1. No., 2. name(s)
1. No., 2. pattern(s)
first phrase only
last phrase only
all MELI phrases
each single line
Upcase respected
Upcase ignored
OPTIONS
Output mode
file type
delete file
name of output file
Staves
OUTPUT
Save Options
Back to MAIN
END of program


internal only
file only
file and screen
screen only
only KEYI-line
comment line only
copy of the melody
file will be re-written
remarks will be added
ESAC.PAT .....
no staff
confirm before saving
save without confirmation
durations
no.of semitones
note colour
backgr. colour

Universität Essen, FB 4 - Musik, Henri Dunant Str. 65, 4300 Essen
Prof. Dr. Helmut Schaffrath (Tel. 0201/183-4247; 4215)
e-mail: JMP100@DE0HRZ1A (BITNET)

COPY, FILL IN, SIGN and RETURN TO RECEIVE A COPY OF PAT
KOPIEREN, AUSFÜLLEN, UNTERSCHREIBEN und ABSCHICKEN

PAT: LICENCE AGREEMENT:

Please send at least one (360K etc.) formatted Discette!
Bitte schicken Sie wenigstens eine (360K) formatierte Diskette!

Name:.....

Institution:.....

PAT ist eine kostenlose Software, wenn auch nicht so ganz "public domain". Sie ist urheberrechtlich geschützt und darf ausschließlich entsprechend dieser Lizenz und nach Erhalt einer Genehmigung benutzt werden. Der Quellkode von PAT wird nicht weitergegeben.

Jede Veränderung, Kopie und Verkauf sind verboten, es sei denn, es liegt eine schriftliche Genehmigung des Autoren vor.

Nutzer und Nutzerinnen sollten PAT, ESAC und die Autoren zitieren, wenn sie es für Publikationen benutzen.

:::::::::::::::::::: engl. ::::::::::::::::::::::::::::

PAT is free but not completely public domain. It is copyrighted and may only be used according to this license and under the author's permission. The source code is not available.

Any change, copy or purchase is prohibited without express, written permission in advance.

Users should mention PAT, ESAC and the authors when the software is used for publications.

Date: .....

Signature:.....

RETURN TO:

Prof. Dr. Helmut Schaffrath
University of Essen, FRG
Postfach
4300 Essen 1
Germany
phone: (201) 183-4214 (4247)
JMP100@DE0HRZ1A (BitNet/EarnNet)

OR TO:

Ulrich Franzke,
Am Eschenbruch 10
4630 Bochum
Germany
(0234/ 59 37 29
e-mail:
DE0HRZ1A@JMP120, HNR00R

H. Schaffrath
University of Essen, FRG

Representation of one part melodies, computer aided analysis and music databases in Essen

1 Introduction

1.1 General aspects

If you ask our electronic bibliography about the topic "Music and Computers", you will find more than 1300 entries. As a next step you might wish to ask for the keyword "analysis" under which you will find 303 articles or books. Some of them are not related to computers because you should know something about traditional methods, before you teach a machine to analyze music. Apart from this one also has to consider the "semantic field" or the connotations evoked by the word *analysis* at the present state of our database (which is an empirical view rather than a theoretical concept):

ANALYSIS

Procedures	Examples / Objects
Representation	DARMS, MIDI etc. Procedures of Transcriptions Sound analysis (s.b.)
Acoustics	Sound analysis and synthesis Composition
Statistics	Sorting, Selecting, Correlations Typologies, Classification Analysis of Style
Structural Studies and Theories	Grammar of musical Parameters (MEL, RH, HARM, ...) Formal analysis Analysis of Style Musical Grammars Cognitive Science "Artificial Intelligence"
Psychology	Perception vs. "objective" phenomena
Pedagogy	Theory (Counterpoint etc.) Programming/Mathematics

Some procedures analyze how music is **represented**, which might be a transcription or any representation in graphics or machine readable form. Generally spoken one would analyze the relation between sound and notation. One should not forget that also Staff notation is a code which represents music in a more or less unsufficient way.

Other procedures examine the **sound** especially with respect to it's physical properties. The researcher looks at a complete physical representation of music - at any time more complete than music can ever be represented in notation. This angle of looking at analysis could also consider compositional aspects especially when composers try to change acoustic parameters in order to synthesize new sounds.

Statistical methods could be called a standard repetory of any computer-aided analysis, because no human beeing can count, sort and test numbers in such a reliable and stupid manner as this machine. I will later give quite a few examples about this method.

Structural procedures are mostly based on theoretical concepts about the computation of music. They postulate attributes that are much more complex than those which can be examined by statistical methods. "Grammers of music" in the broadest sense belong to these procedures, but also questions of musical style and typology. As you can see from the table we were unable to make differences between theoretical concepts and structural methods at this stage of reflecting the analytical field.

Also music **psychology** is concerned with many new and special aspects. The psychologist could examine many conjectures of other methods with respect to the individual human beeing. This is especially evident when you look at statements concerning similarities of melodies, motifs and similar musical components, because one has, for instance, to examine which social and cultural influences and ways of learning are necessary to agree with those assumptions. It might be possible for instance, that the European expert for "Opus music" can hear and depict a certain motif, a particle or whatever you would call it immediatly whereas the blue collar worker would not perceive this formula at all. It is, of course, difficult to examine such problems without sociological, ethnological and anthropological aspects.

Some other interests can easily be identified as **padagogy**. It is not the analysis of counterpoint itself, for instance, but also the analysis of culturebound learning that even a drill and practice program has to be based on.

There will be examples of any quoted aspect in this paper (except of the acoustics). But first some general remarks about the correlation between analysis and *databases*. The word "database" is used as a term which does not signify any collection of data but *retrieval systems* containing further tools to handle those collections.

1.2 Databases and Theories

If you ask our bibliographical database for the number of correlations between the words *analysis* and *database* then you will find only six examples, just four of which prove that the project is really based on large data collections[1].

Although this bibliography is not complete (and never will be), I guarantee it's representativity: you would not find larger analytical projects very often that are supported by large data collections.

One may speculate about the reasons:

1. It is still hard work to produce those data in a machine readable form.

2. Even profound theories must be verified by quantities and the results might be unsatisfactory for the theory.

3. The sound (or taste) of user oriented practical sulutions is too much connotated to engineering, and this is not intellectual enough for questions of analysis.

Also well sounding papers on grammars are still expecting quantitive verification. Even when Baroni and others publish a "grammar of the melody", one will find out that this group naturally has based it's studies on a selection(!) of songs of the Italian Renaissance or of old French Canzones[2]. Maybe this is a result of the fatal comparison between music and language. One should for once consider that there are no linguists who dare to write a "grammer of the language", because we know that there are many different languages and many, many different dialects. One consequently would have to examine hundreds of musical languages and dialects of different places and different historical periods. When somebody writes an article like *"Music: the universal language"*[3] I can only advise the reader to prefer titles like *"From the Ivory Tower to the Tower of Babel"*[4].

Also the field of artificial intelligence remains very theoretical at the moment. Titles often contain words like "approach" obviously signifying that one is still approaching music instead of working with it.

I must point out that theories are principally unavoidable and very necessary, but I would like to see them verified on

---

[1] Becker & Becker 1979
Dillon, M., Hunter, M. 1982
Steinbeck, W.1982
Grijp, L. P. 1984

[2] Baroni, M. (et al.) 1984a, 1984b, 1984c

[3] first workshop on artificial intelligence and music, Minneapolis 1988

[4] Lombardi, L. 1988

a larger data collection at least for once. There are not so few authors who know that we have stored more than 10.000 melodies in Essen, two thirds of which are in public domain. But we are still waiting for empirical proofs of those theories with our simple, one-part melodies before one discusses much more complicated constructions (such as Bach's polyphony) just on paper.

However, I do not wish to report on numerous theoretical dispositions before they have further grown. Quite few years ago we have started to develop simpler methods in Essen which certainly can also be criticized. We concentrated on storage and retrieval of melodies and at the same time on the problems of musical *identity, similarity and difference* in the perception of listeners. It sometimes is still quite a burden and we actually expect some help from our theory producing opponents.

Many methods developed in Essen may support or falsify theories but simply all of them solve very practical problems. This paper will therefore focus on a description of recording, analysis, retrieval and representation of one-part melodies as they were developed accompanied by other data. One consequently may examine promises and findings by comparing them to a large number of examples.

1.3 Encoding melodies with ESAC

It is unavoidable to begin with some information about the encoding method. The "**Ess**ener **A**ssoziative **C**ode" was developed to store melodies in the shortest and simplest way which also may allow the user to sightread it from the screen. If you need some motivation to learn the code, then the following example may serve:

Only 6 melody lines of the well known Mexican song *La Cucaracha* cost at least 42.000 bytes when you store it in staff notation. A "one-to-one-transformation" of this song containing 8 melody lines and another 5 lines of documentation needs only 330 Bytes, i.e. the common staff notation is 127 times as greedy.

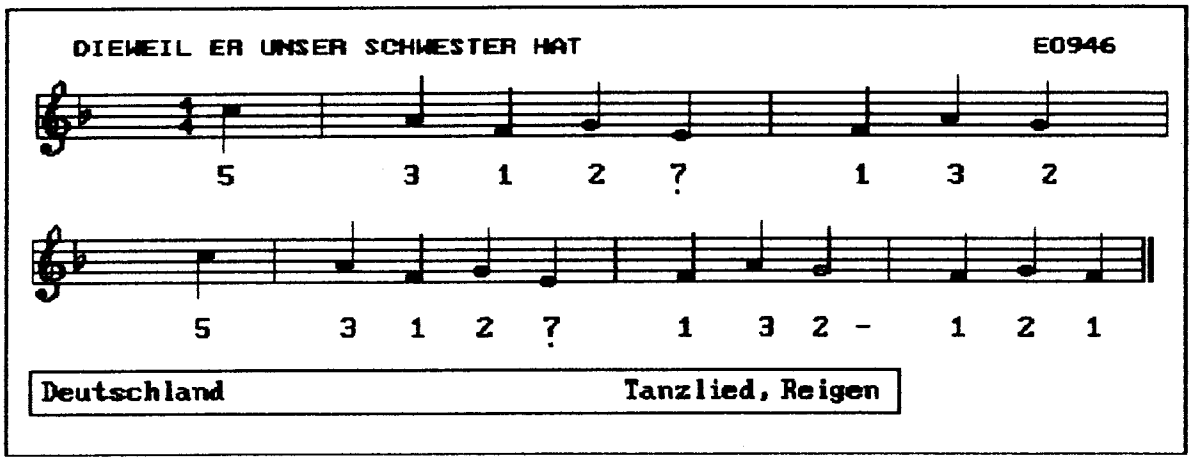
One can in this manner store 10.000 songs readable by any hardware on little more than three discettes.

ESAC is based on a cypher notation as it probably came from Europe to Asia during the last century. Every pitch is relative to the tonic represented by cypher "1". We have developed this code in so far as also every duration is relative to the shortest duration of the song so that you do not see any changes when you represent the same melody in 4/4 or in 4/2 meter for example. Only the input of the shortest duration has to be changed.

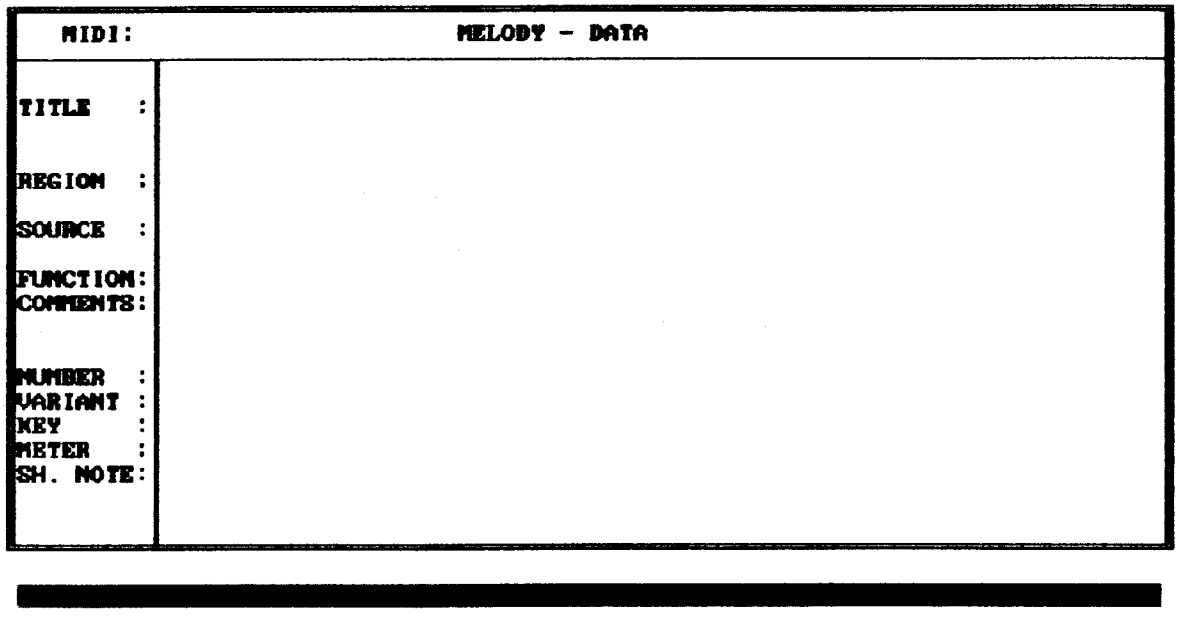
We naturally have discussed this code over and over especially concerning the aspect of representation: which musi-

cal elements does it "mirror" and which not? But this is not the place to propagate such questions.

First look at a very simple example in which the Chinese *Jianpu* notation was placed under our "genuine notes", because this notation combines some of the essentials of ESAC:



More than 3000 of these melodies were translated from another code (Steinbeck 1982). Then we developed our own automatic input method and the most important verbal remarks were standardized:



Since a European musician might prefer not to type numbers on the computer keyboard, we developed a kind of "sequenzer" which translates songs or pieces directly into ESAC from the Midi code. We thereby had to study some habits of musicians, because the usual quantization of commercial software is comparatively strange and not very "musical". We tested the playing habits of some typical Jazz- and Rock musicians in some experiments on the one hand and - as we found out - the

agogic mannerism of typical "classic players" on the other. We thereby touched at least the former mentioned area of music psychology. But also this cannot be expanded in this paper[5].

When you have played the melody you can listen to it by the internal speaker, thereby proofread and define the phrases.

Instead of the following worm:

```
MEL[1_.1  5__.+1_5_.4   5___ +1_+1_   7b__.+1_  5__4___   3b_1_3b__.
3b_.13b___ 5__.(454)3b_1_  4_.3b1_.-7b  1___ //]
```

everyone would prefer the precise structure of the complete document shown in the following picture:

```
TEST2
TTR[B0055] TT[TB]
CUT[Farewell to the Warriors]
REG[Amerika, USA]
ETH[Indianer, Chippewa]
TRD[Densmore, Fr.: Chippewa Music, Washington 1910]
KEY[C0000  16  D 3/4 2/4]
MEL[1_.1  5__.+1_5_.4  5___
    +1_+1_  7b__.+1_  5__4___
    3b_1_3b__.5_  3b_.13b___
    5__.(454)3b_1_  4_.3b1_.-7b  1___ //]
TXT[Um- be a- ni ma - djag        *
    wa- si- gi- di- ja- min       *
    ya wi a ya wi - a             *
    ya ya   wi a ya wi a - a. ]
FKT[Abschiedslied]
BEM[Zum Vergleich mit der Komposition von Griffes.Grundton
    geändert. Die Tonbandangabe bezieht sich auf Griffes.
    Weitere Chippewa-Lieder sind auf Band B0059.]
```

Maybe you wsih to listen to this song of farwell of the Chippewa Indians played by a blissless syntheziser? The remarks under "TTR" etc. are also interesting because they contain the signature (B0055) and the sound medium (TP for Tape) of the same example stored in our sound database. As you can see in BEM (=remark) at the end there is another sound example by an the American composer George Thomlinson Griffes[6].

Also some controlling methods were programmed. PLAY displays the melodies in ESAC and the generator then beeps it or transfers it to the syntheziser so that one can "proofread" and "prooflisten". SYNTAX finds any syntactical error which you could - especially by typing - have produced. The sum of

---

[5] You will find examples in Jesser 1991 and Schaffrath 1988, 1991.

[6] There is, by the way, a program which automatically changes the German mnemonics into English ones.

every bar will later be checked by ANAlysis, and the mnemonics can be changed by TRANS into other languages.

There is no time to comment on many such options but give information about the analysis programs by as many examples as possible.

2 Analysis in MAPPET

The program package "**M**usic input, **A**nalysis and **P**layback **P**rogram for **E**SAC **T**ranscriptions", called MAPPET, has been principally depicted already. ANA can perform 12 different analyses for every song.

A N A L Y S I S P A R A M E T E R S

(1) Inventory of intervals
(2) Inventory of durations
(3) Inventory of pitches
(4) Rhythmic Incipit
(5) Scale and Mode
(6) Range
(7) Stressed Tones
(8) Cadential Tones
(9) FORM (pitch)
(10) FORM (rhythm)
(11) FORM (countour)
(12) Up/Downbeat of phrases

2.1 Analysis from the Statistical Repertory

The repertory of intervals counts the total number of tones of a melody as 100% and then computes the relative contribution in every ascending and decending interval. It contains also a kind of summary by step- and leap-definitions and even a larger summary which subtracts the ascending from the descending intervals: from this measure you can read if the song in it's central tendency is descending, balanced or ascending. The previously shown Chippewa song for instance deviates from a balanced interval distribution by -13%, i.e. it is descendent.

According to the rules of mathematical logic one can compute an unlimited number of songs from such statistics because they only count the intervals irrespective of their places within the melody. But these mathematical rules remain theoretical because you would not find a single pair of songs with identical statistics among more than 6.000 melodies unless it is a "double".

This kind of statistics is very sensitive to any change such as the addition of a grace note. One can call it a kind of fingerprint of the melody. If you do not enlarge the range of percentages for your search, then there is no chance to find variants or similar melodies. But you can define cha-

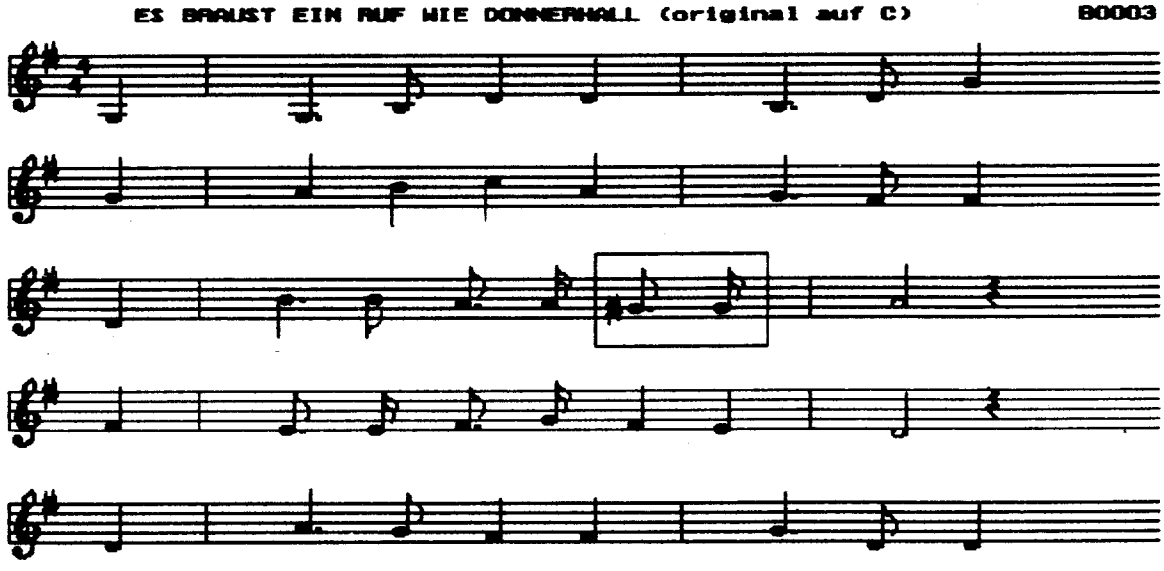
racteristics of certain groups. Children songs (and some kind of church songs), for instance, have the largest number of unisons.

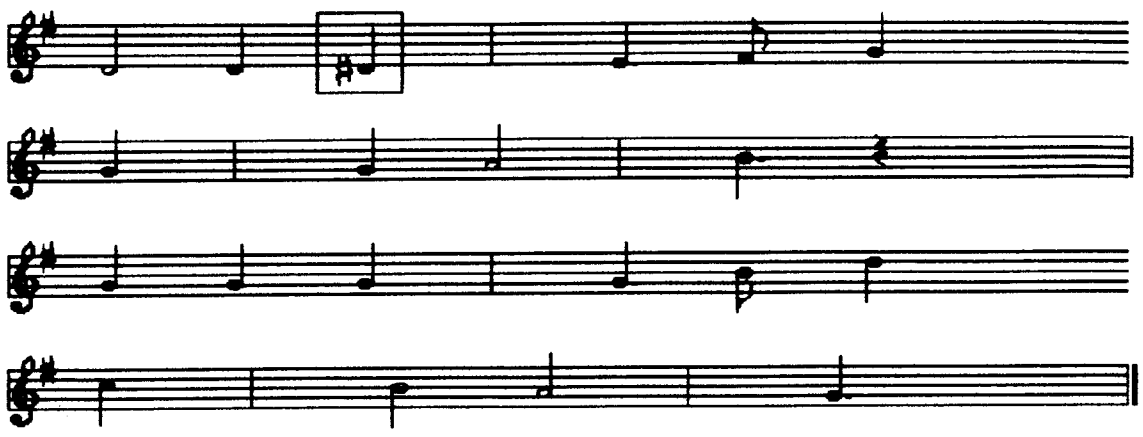
Generally spoken simple statistics don't produce cognition. One has to evaluate them with other details. But they turned out to be very useful as can be proved by the solution of a small problem of a trumpet teacher:

She was looking for "easy melodies" for beginners consisting of the first five tones of our major scale only. This would be the attribute *"pentatony major"* in our analysis of scales and modes. The teacher had to look at 375 two-phrased songs (another criterion) and certainly was in despair to reduce this number. Even this could be done by pedagogical principles because the young pupils should only play 4/4-measures and the melodies should be easy in the rythmical aspect. Consequently the retrieval conditions were enlarged to 4/4 time and 2 different durations per song only. Now 23 songs were found of which the tonic had to be changed to B- flat according to the abilities of the pupils. The songs were automatically translated by another software into staff notation and the teacher decided to make use of 9 of them which were far more interesting than the ones you usually find in trumpet schools.

The pricipally boring statistics consequently offer a large number of selections, and I wish to prove that this is not a question of *making* music only:

"Die Wacht am Rhein" is a German national chauvinist song of the last century which was taken as an example for a seminar on German folksongs. The usual student only knows that he or she does not like this melody. But for a comparison you must first describe what is special or usual about it. We were lucky:





Exceptionally the first and the fifth tonal degree of the song are sharpened. We consequently used the inventory of pitches to search the number of songs containing these attributes. 36 out of more than 6.000 were selected of which we asked the computer to display only the remarks stored in the paragraph "function":

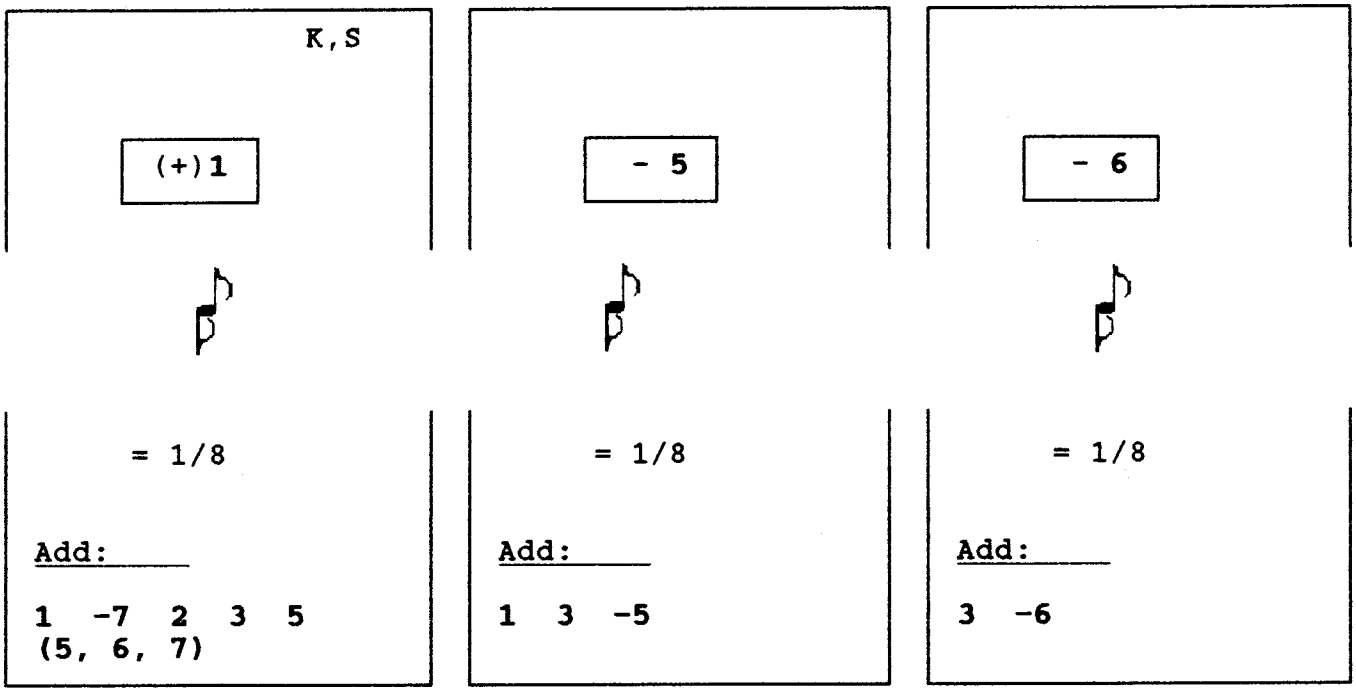
Anzahl	Funktion
14	**geistlich** (davon 1 "Moral")
6	Romanze, Ballade
5	**politisch, Krieg, Vaterland**
5	**Stimmungs-, Zech-, Trink-, Scherzlied**
2	Liebe
2	??? (ohne Bezeichnung)
1	Jahrezeiten
1	Entführung

19 out of 36 (which is more than half of the songs) either refer to religious functions or correlate with our chauvinist topic. One consequently could examine the question whether the "Vaterland" makes use of religious "attitudes" or the church of chauvinist musical "manners". If you consider that the functional remarks of collectors and musicologists are often adventurous but never systematic, then one might find similar topics among the category of "Stimmungslied" etc. But we have no time to verify this hypothesis. The example shows, however, that one can try to interpret correlations of function, esthetics and musical parameters, and I strongly believe that one can find quite a few newer songs containing these attributes which have been sung during the so called "Third Reich".

I wish to repeat that statistical repertories on there own do not give very much information. But we have just used them to examine and select criteria from a number of songs containing only two phrases. We thereby tried to base some rules for the composition of a melody on a number of statistics, such as

- the average number of tones
- the most frequent cadential tones (2-1),
- the relative contribution of pitches and durations and
- some combinatory rules which examine the probability with which a tone z follows a tone y.

The last rule considers only combinations of two tones (so no pitch chaines). The whole set of rules resulted in game of 30 cards which you can use to compose your own melodies according to different games (for instance "Patience").



In playing this game we have "composed" quite a few interesting melodies none of which completely fullfill the esthetics of the original. But the students in a seminar on analysis are quite motivated to use this communicative game in order to find further melodic rules. New questions occur like "What would a melody of a certain repertory have to look like?" "How can one enlarge the system of rules?" etc. With one word: we are also looking for some kind of grammar of the melody but use a rather padagogical and inductive method.

2.2 Analysis of scales and modes

The example of the trumpet teacher indicated that we can analyze quite a few scales used in many places of the world. We have ordered them according to the most familiar terms, i.e. if the structure of a maquam coincides with the definition of our "aeolian", the analysis would write *aeolian* rather than "ussak" or whatever the emic term would be. In

other cases we have to use the terms of the respective culture:

For your entertainment I have copied a number of scales consisting of ahemitonc and mixed-pentatony which you can listen to while looking at their structures. At the same time you hopefully will hear why I call the phrase "music as an universal language" simple nonsense: this world of sounds is no longer European although we are still using equal temperament for this demonstration.

Scale **structures** in ESAC-Representation

PENTATONIC - Ahemitonic Modes

GONG	1....2....3....5....6....1
SHANG	2....3....5....6....1...+2
JIAO	3....5....6...+1...+2...+3
ZHI	-5...-6....1....2....3....5
YU	-6....1....2....3....5....6

PENTATONIC - Hemitonic Modes

HIRAJOSHI	-6...-7....1....3....4....6
IWATO	-7....1....3....4....6....7
HINDOLA	1....3....4....6....7...+1
KUMOIJOSHI	3....4....6....7...+1...+3

Mixed PENTATONIC - Modes

AKEBOWO	2...3...4...6...7..+2
HAN IWATO	3...4...6...7..+2..+3
HAN KUMOI	2...3...5...6...7b.+2
RYUKU ONKAI	1...3...4...5...7..+1

HEPTATONIC SCALES:

rast/bilaval	**IONIAN**	1....2....3....4....5....6....7....1
hüseni/kafi	**DORIAN**	1....2....3b...4....5....6....7b...1
kürdi/bhairavi	**PHRYGIAN**	1....2b...3b...4....5....6b...7b...1
- /kalyana	**LYDIAN**	1....2....3....4#...5....6....7....1
yegah/khamaja	**MIXOLYDIAN**	1....2....3....4....5....6....7b...1
ussak/asavari	**AEOLIAN**	1....2....3b...4....5....6b...7b...1
irac evic/ -	**HYPOPHRYGIAN**	1....2b...3b...4....5b...6b...7b...1
	HICAZ 1	-5...-6...-7....1....2....3b...4....5
	EVICPUSILIK	-7....1....2....3....4....5....6#...7
	HOMAYUN	3....4....5#...6....7...+1...+2...+3
	HICAZ 2	3....4....5#...6....7...+1#..+2...+3
	KARCIGAR	2....3....4....5....6b...7...+1...+2
	MARVA THAT	1....2b...3....4#...5....6....7...+1
	SEGAH 1	-7....1....2....3....4....5....6#...7
	SEGAH 2	-7....1....2....3....4#...5....6#...7
	SABA	2....3....4....5b...6....7b..+1...+2
sedaraban	**KALINGADA**	-7....1....2#...3....4#...5....6#...7
Zigeuner-Moll	**NEVESIR**	1....2....3b...4#...5....6b...7...+1
	SHRI	-7....1....3b...4....4#...5....6#...7
	TODI	-7....1....2....4....4#...5....6#...7

MINOR-SCALES:

MELODIC WITHOUT 6	1...2...3b...4...5...6b...7b...7...
MELODIC WITHOUT 7b	1...2...3b...4...5...6b...6....7...
MELODIC WITHOUT 7	1...2...3b...4...5...6b...6....7b..
MELODIC WITHOUT 6b	1...2...3b...4...5...6....7b...7...
MELODIC MINOR	1...2...3b...4...5...6b...6...7b...7.
HARMONIC MINOR	1....2....3b...4....5....6b...7....

SCALE Segments:

MINOR ?	1....2....3b...4....5....
MAJOR ?	1....2....3....4....5....

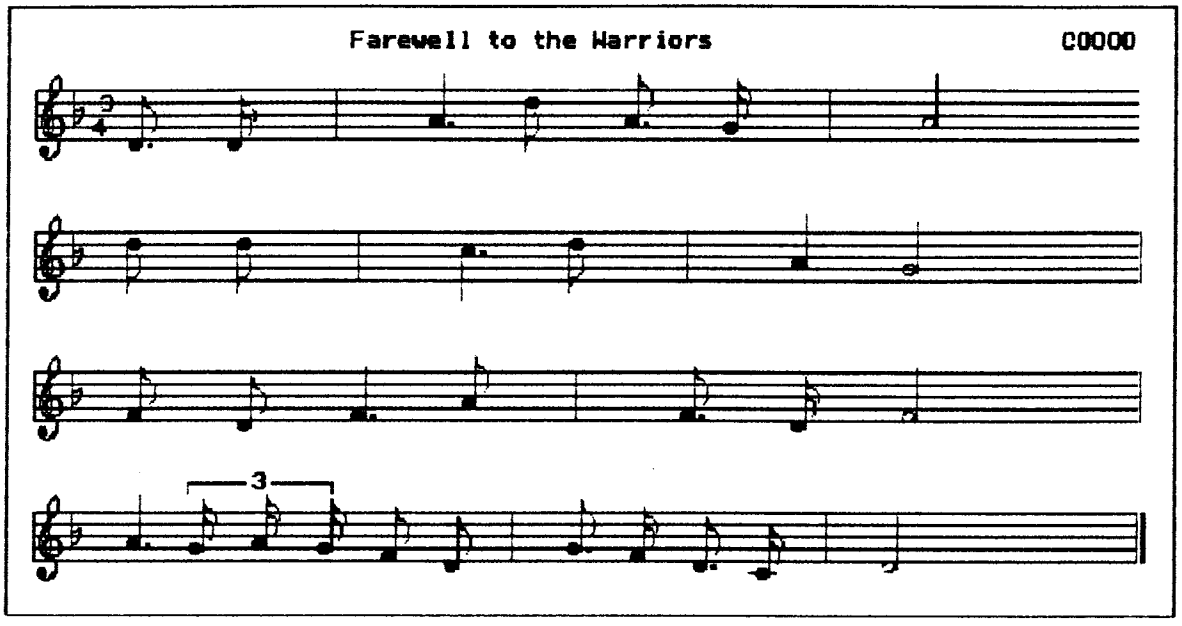
uncomplete Definition

TWO-TONE-SKALE
THREE-TONE-SKALE
FOUR-TONE-SKALE
SIX-TONE-SKALE
EIGHT-TONE-SKALE
NINE-TONE-SKALE
TEN-TONE-SKALE
ELEVEN-TONE-SKALE
TWELVE-TONE-SKALE

The computer analyzes the material structure of such scales but not the rules of their uses if they are more complicated as we still know from the European melodic minor. The re-

spective temperament, however, can be adapted to the respective culture. You can say that it is only a question of definition if the harmonic sixth would be played with 440 or any other number of herz. Our program PLAY can demonstrate this with 5 options, and we are preparing another program in which the user can define his or her specific "temperament".

The very beautiful and already played melody of the Chippewa Indians contains a Chinese mode, by the way, which we have identified as Zhi[7]:



In certain cases this attribute operates perfectly for classification but one can hardly use it as a measure of similarity. We can, for instance, say that 30 out of 31 songs of a genre called *mengjiangnü* in Chinese folksongs are in Zhi mode, but this is also true for about half of the remaining songs of this collection. One consequently would have to analyze further correlations first.

2.3 Stressed and Cadenciale Tones

In most of the European songs of the last three centuries the repertory of *stressed tones* is a very powerful attribute of similarity. The analysis writes down the stressed notes within every meter. One can say that phrases containing the same sequence of accented tones are boringly similar. I have selected some first phrases from only one collection (ERK) for an acoustical demonstration which all start with the accented tones 1, 3 and 5. There were 87 songs in just one collection which had to be reduced by the question that they

---

[7] According to present rules which are used for Chinese melodies only, however, the analysis would display GONG mode. To avoid many discussions among Chines specialists we have only taken the most simple way which defines the mode according to the last tone of a melody.

should begin with the ascending fourth: -5 1. This resulted in 47 songs. I have then filtered out the doubles and prepared some for this paper. The first phrases are copied in a relatively arbitrary order just respecting 4/4 and 6/8 meter. The result is the following:

```
/TB 5/

F[ERK1
CUT[ES BLIES EIN JAEGER und andere Varianten: AKZ[135* + 4/4]
REG[Europa, Mitteleuropa, Deutschland,...]
KEY[E0019C 08  F 4/4]
MEL[-5_  1_1_3_34  5_543_
    -5_  1_1_3_3_  5_5_3_
    -5_  1_.23234  5_.65_
    -5_  1_2_3234  56543_
    -5_  1_113_21  522_0_
    -5_  1_.23_46  5__0_
    -5_  1_.23_4_  5_.65_
    -5_  1_1_3_3_  5__3_
    -5  1_1_3_3_  5_+153_0_
    -5_  1_.23_4_  5__0_
    -5_  1_2_3_4_  5_565_
    -5_  1_2_3_4_  5_4_3_0_
    -5_  1_2_3_42  5_432_ //]
FKT[DEMO]

F[ERK1
CUT[EIN SCHAEFER WOL... und andere Varianten: AKZ[135* + 6/8]
REG[Europa, Mitteleuropa, Deutschland, ...]
KEY[E0043E 16  G 6/8]
MEL[-5_  1_-5_1_3_1_3_  5_6_5_3__.
    -5_  1_-5_1_3_1_3_  5_.6543_0_
    -5_  1_-5_1_3_1_3_  5__.3__
    -5_  1_1_1_3_1_3_  5__5_3__5_  4__2_3__
    -5_  1__1_3__3_  5__5_3__
    -5_  1__2_3__4_  5__3_1__
    -5_  1_-5_1_3_1_3_  5__+1_6_4_
    -5  1_13_3  5_53_
    -5_  1_.-71_3_.21_  5_.65_3_.2
    -5_  1__2_3__4_  5__.3__
    -5_  1_1_1_3_1_3_  5__5_3__
    -5_  1_-5_1_3_1_3_  5_6_5_3_1_ //]
FKT[DEMO]
```

You can evaluate and use such examples in different ways: Within a study of European folksongs a comparitive musicologist may point out that a typical attribute of German songs is the upbeat "-5 1". The historical musicologist, however, might wish to stress how dull folk has composed in comparison to professionals and the teacher may take the same examples to demonstrate "Variations on only 3 given tones" etc. etc.

The sequence of *cadential tones* is a very commonly used archiving attribute. Melodies based on the same cadential tones are mostly comparitively (in many cases even very) similar. Instead of further sound or notational examples I would like to present a statistic from which you can take

number and place of cadential tones in 259 two-phrase songs (out of 7.166):

Ranges	**total:**	1	3	2	5	4	6	7	3b	7b
Ranges	**first line**	2	5	3	1	4	6	7	6b	7b
Ranges	**2nd line**	1	3	5	2	4	-	-	-	-

LINE: ESAC	1	2	TOTAL (without #/b)
1	**44**	**200**	244 of
1#			0 #
2	**72**	7	79 of
2b			0 b
3	54	34	88 of
3b	2	0	2 b
4	12	1	13 of
4#			0 #
5	**59**	17	76
6	9	0	9 of
6b	2	0	2 b
7	9	0	9 of
7b	2	0	2 b

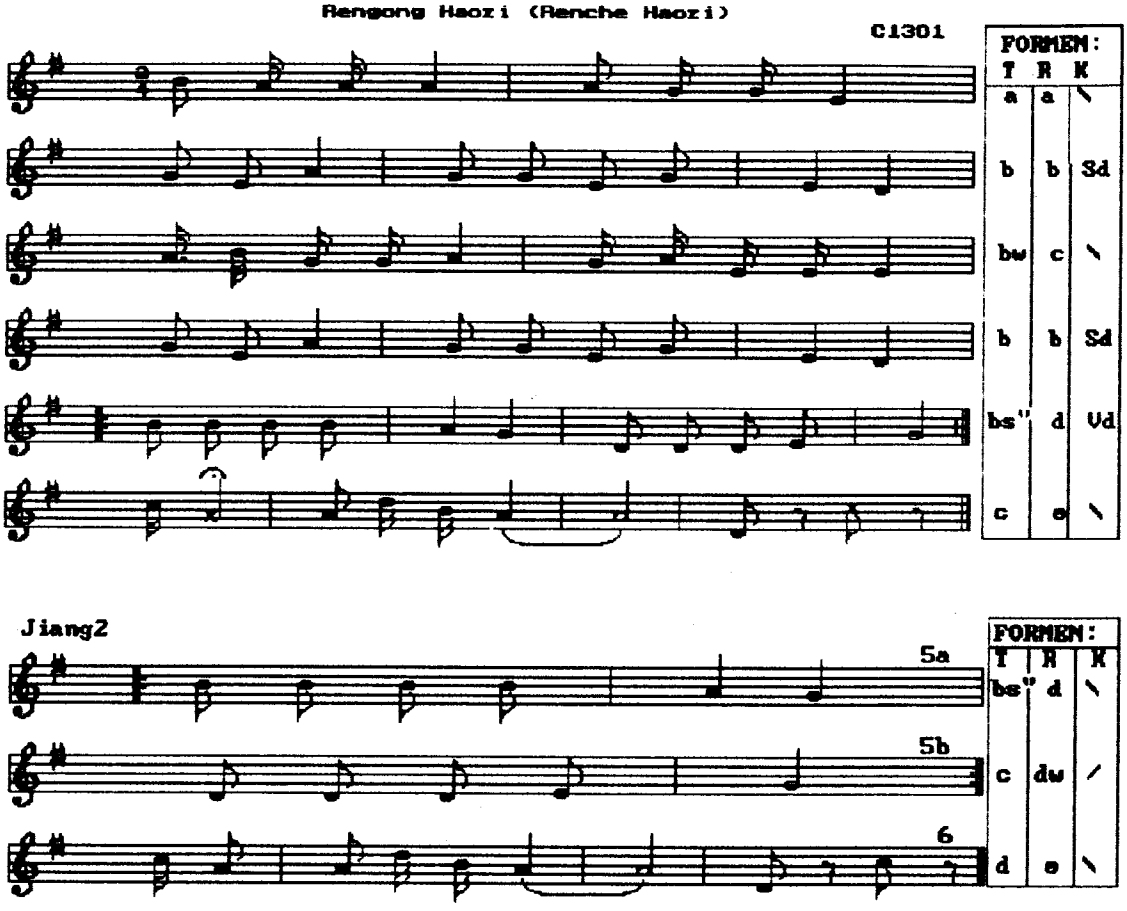
You can read which of the tones are likely to become the ending tone of the phrase (which is the definition of "cadential tone"; see: total) and further which of the tones are likely to become the ending tone of the first and of the second phrase. So you will find out that the ending tone of phrase 1 harmonically interpreted in most of the cases refers to the dominant while the second phrase in nearly every case ends on the tonic. This kind of harmonic tension of European melodies will never be found in other repertories - at least not in such large numbers.

You can also read from the first table that quite a few combinations for this repertory are completely unlikely. The ordinal range of the tones does not yet explain their probability but this can be taken from the second table. One may examine the tones 7 and 7b as a quantitatively irrelevant "error" because they most probably occur as the consequence of a variation within the melody. ESAC is not so clever in this respect.

The example defeats the rumour that counting numbers is only related to statistics and cannot produce any knowledge about the structure of melodies.

2.4 Analysis of forms

ANALYSIS offers 3 different formal attributes which I wish to explain first by just one musical example. The Chinese working song "Rengong Haozi" was first segmented into 6 different phrases:



On the right hand side you can see the results of pitch-, meter- and contour analysis. You learn that according to the pitch analysis the third phrase is a variant of the second in "a broader sense of the word", while the analysis of meter can no longer accept this and starts with a new letter. The analysis of contour, however, states that the first and the third phrase consist of a descending line only. The identity of line 4 and line 2 has to be reported by all analytical parts, of course. The relation between line 5 and line 2, however, is only observed by the analysis of pitches: **s"** has to be read as *"further sequence"*. This might still be surprising. But I will come back on this.

Those procedures naturally rely on the user defined segmentation of phrases. It would not be strange to divide phrase number 5 of the song into two segments. If you compare the contour analysis of 5a and b to line 5 above, then you will see, for instance, how the symbols for descending \

and ascending / of 5a and b are combined to the symbol **V** in the upper example, while they describe only half of the phrase in the lower. The sequenced relation between line 2 and line 5 now looks also a little more plausible.

The first two procedures compare line by line according to certain principles. The first line is always represented by the letter "a". Especially the pitch analysis examines the stressed tones within every bar, which certainly cannot be defined in melodies without meter. In this case we move line "a" above line "b" and when there are no identities "a" will be shifted for a certain number of tones to the right and to the left etc. The results of the pitch analysis in free meter are not based on the same principles as above. But the comparison of the uncomparable in this case is due to the structure of the melodies themselves.

The complete analytical repertory of pitch analysis can be explained by the following table:

KEYWORDS	OUTPUT SYMBOLS	in 6008 dt. Liedern	%	%	in 1203 chines.
Identity	1. a a	??			??
Sequence	2. (a a)s	262	**4,3**	**16,2**	195
Variant	3. (a a)v	1079	**18,0**	**20,9**	251
Variant of Sequence	4. (a a)s'	762	**12,7**	**2,3**	28
"further" Variante	5. (a a)w	1398	**23,3**	**37,2**	448
"further" Sequence	6. (a a)s"	1148	**19,1**	**13,9**	167

In order to compare Chinese and German repertories we have placed the percentages in neighbouring columns. I cannot evaluate the differences between them at this moment.

The vocabulary of the analysis of durations is much more restricted because we had no real idea about rhythmic similarity. We will for this reason try to examine a theory of Professor Boroda (Ruhr Universität Bochum) and then perhaps do an alternative analysis.

We have also used associative symbols to depict the results of the contour analysis. The following table contains 10 basic symbols of contours which can be combined with the letters "d" for descending and "a" for ascending. One theoratically could such combine 30 different contours but practically there are only 24 because the first 3 symbols are already descending, ascending or balanced:

KEYWORDS	OUTPUT SYMBOLS	in 6008 dt. Liedern	%	%	in 1203 chines.
ascending	/	2738	45,6	16,5	198
descending	\	3975	66,2	40,0	481
Repetition/Schwebemelos ...	-	446	7,4	6,3	76
convex arch (1 peak)	^	4998	83,2	62,5	752
concave arch (1 bottom) ...	V	1673	27,8	30,2	363
1 peak - 1 bottom	~	170	2,8	28,8	347
1 bottom - 1 peak	S	1532	25,5	56,4	679
2 peaks - 1 bottom	M	605	10,1	43,6	525
2 bottoms 1 peak	W	133	2,2	17,2	207
undefinable	$	69	1,1	33,9	408

Both attributes, symbol and tendency, can be important for further analytical research. So one might only be interested in the central tendency (i.e. ascending, descending etc.) and search them only or do both, tendency and symbol. Phrases that cannot be analyzed by our methods are signified by $-symbols but one still can rely upon their central tendency.

Also in this table the relative frequencies of a German and a Chinese repertoire are placed next to each other for an immediate comparison, while you can read the absolute numbers in the outer columns. There is at least one significant result because according to our definitions nearly 34% of the Chinese songs cannot be exactly identified, while there are only 1.1% in the German repertory. We consequently must examine those 34% and might add the results to our definitions. But eventually we could also follow a different method because the new program PAT allows more flexible definitions also of the contour-symbols. I will soon report on this.

2.5 Further attributes

Some of our attributes are a matter of course and actually have not to be especially described:

....

(4) RHYTHMIC INCIPIT
(6) RANGE
(12) UP/DOWMBEAT of phrases
ZZ = number of phrases

We do not often use the method to store the rhythmic incipit because there is another program (STRIP3) replacing the pitch by rhythmic symbols for the whole song.

The 12th parameter informs you about the tendency of up- and down- or full beats of phrases, and ZZ (not included in the list) contains the number of melody lines or phrases.

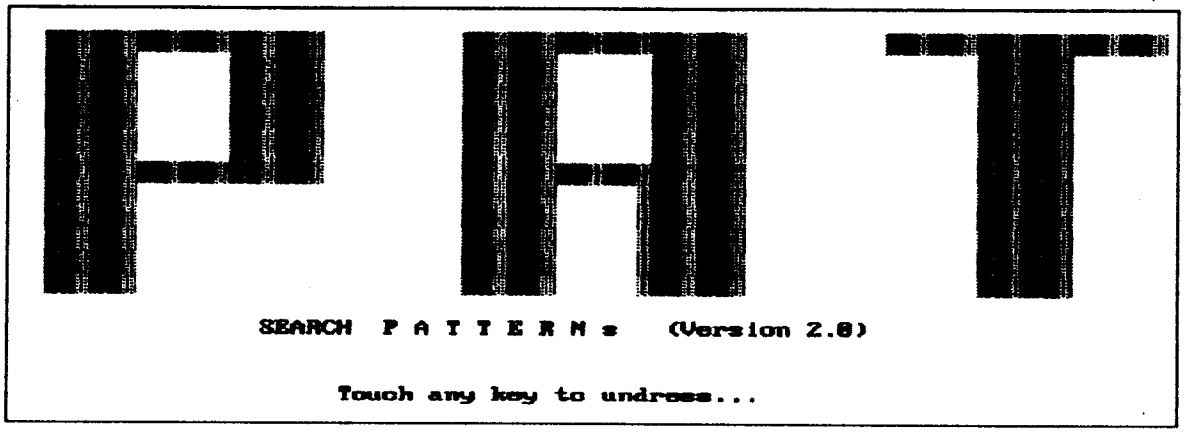
When we wish to give a modest summary of the whole analysis system we could say that it just sorts our melodic data according to many a definition. But if you look at the whole system surrounded by other programs and retrieval methods, it has proved to be extremely useful. This is what for instance the German Volkslied Archiv, two institutes in Peking and Shanghai, the institute SZTUKI PAN in Warsaw and many others appreciate. This paper wanted to stress the practical use of the analysis of large data collections by some examples. Before a final evaluation, however, I would like to look at our latest program PAT.

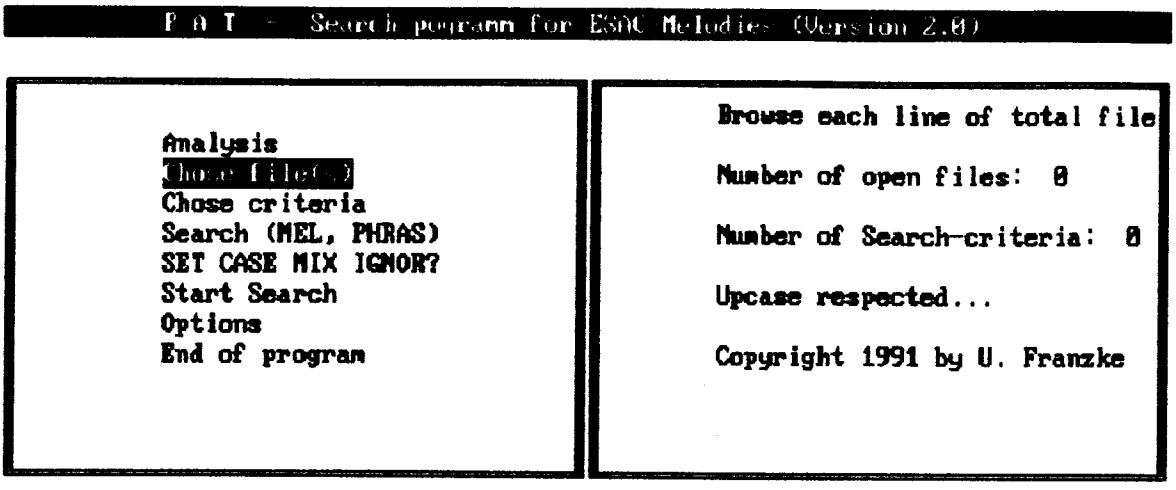
3 PAT

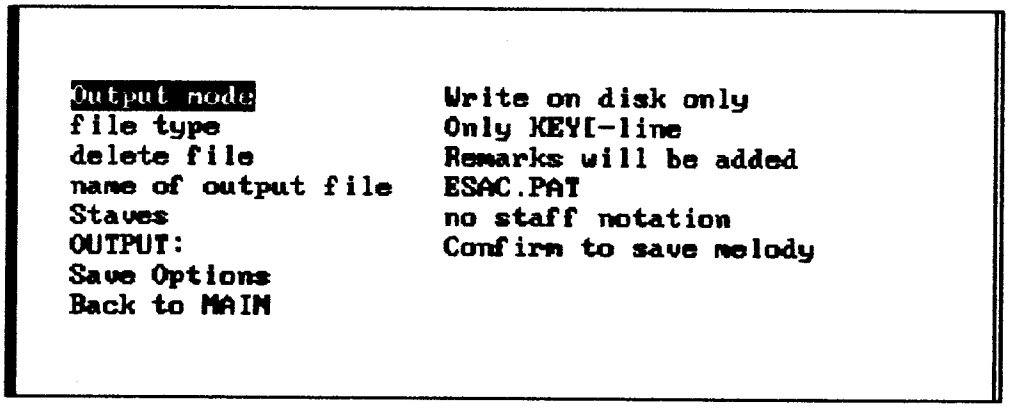
PAT has been only recently finished (which does not mean that we never will write an update). Please bare and forbare some respectless texts which we can afford because every user may change any lyrics according to his or her own taste. The programs have been written for different users all over the world and are therefore translatable, i.e. the respective institute or user has only to translate a relatively short text file into his or her own language. One of our programs consequently runs in German, English, Polish and Italian at the moment. Other languages will follow. This is also the method which allows a user to copy his own jokes and respectlessnes above our texts.

PAT was designed to replace some parts of commercial database systems or even give more elaborate retrieval possibilities in the special case of our data.

At the moment you can do the following:







PAT theoretically searches an unlimited number of files[8] for a user defined pattern (= criteria), which has to occur in the order of the definition. This can be illustrated best when you look at the pitches of the melody. One could, for instance, find out the definite number of those folksongs which begin with the boringly often appearing upbeat "-51". You can search this pattern independently from meters (1/8, 1/4, 1/2 etc.). In this case you learn that the interval occurs in the first phrases of 2.196 songs[9], but only in 1.935 first places of the first phrase. These are 32% of the whole repertory[10]. If you want to compare this with 1.217 Chinese folksongs: it occurs only in a single example; and among 62 Irish folksongs still five times.

If somebody believes he could explain essentials of the German folksongs by 32%, he might become an interesting case

---

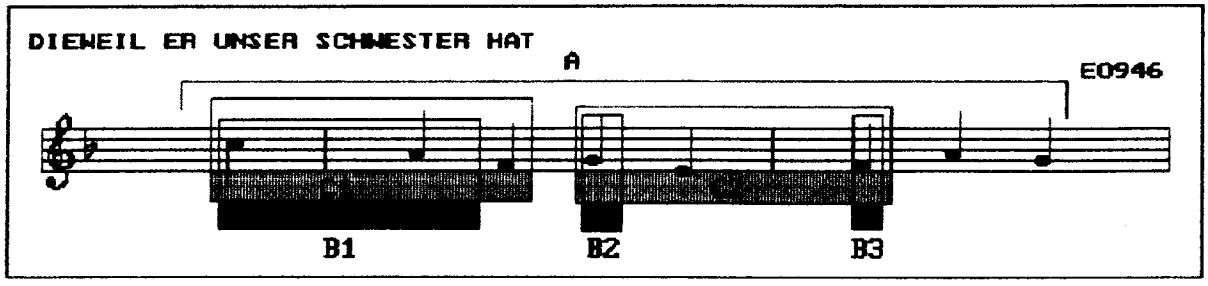
[8] only 30 when they all have different names

[9] out of 6067

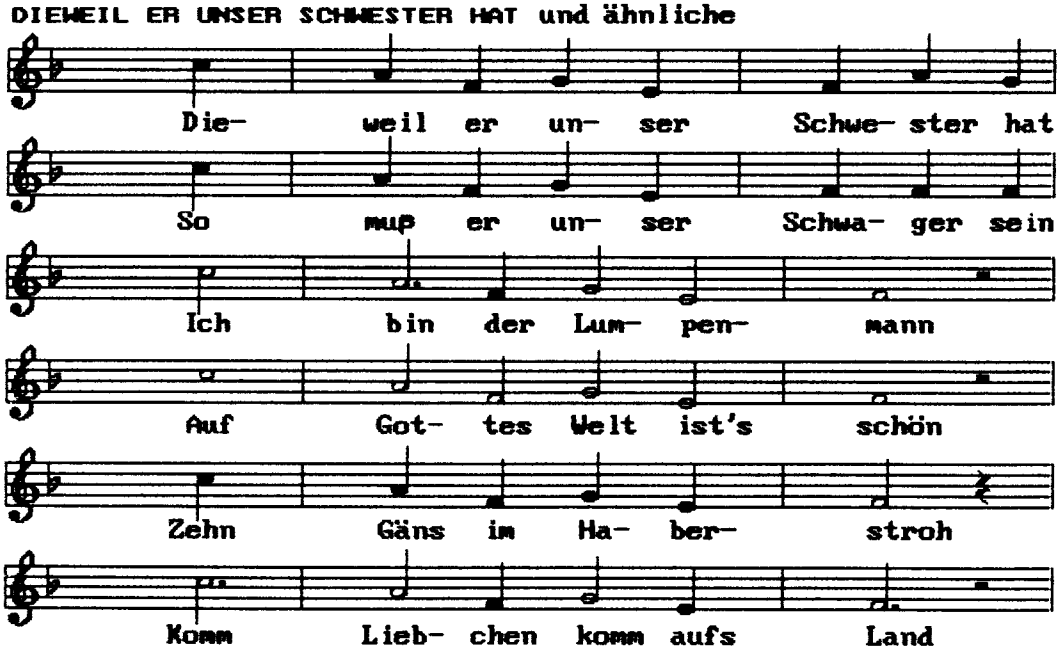
[10] U. Franzke has just counted the precise number: The initial tones -5 or 1 or 5 or 3 (Rank-order) explain 94,08% of the total German repertory!

for the previously mentioned music psychology whose empirics probably would die in shock when they hear of an error probability of 68%. But it is also obvious that the *effect* of this interval on the listener has to be judged by different means.

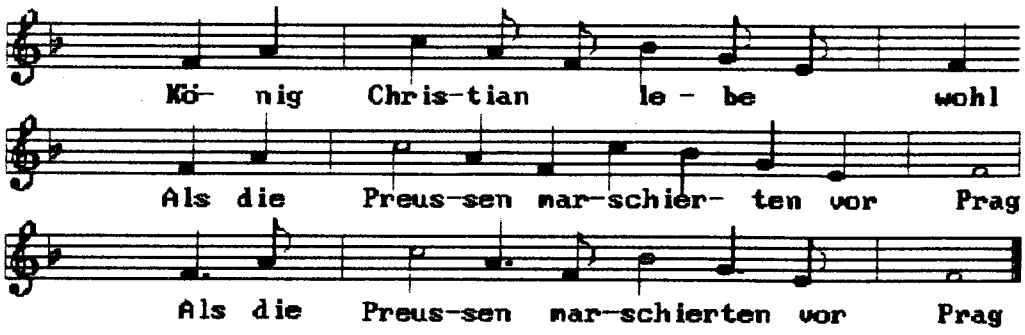
You can search freely defined patterns like motifs, or formula whether they contain grace notes, different rhythms or both. I have prepared another example:



If you take the whole melody line as a single question and search the first phrases of every song, then you will find only the original among more than 6.000 folksongs. If you define the contour yourself using the criteria B1 to B3, then you will find 183 phrases. This would be too many for this article. But I could also define only the two criteria C1 and C2, and then find within 30 seconds[11] 9 songs which we really can look at:



[11] This file contained only pitches (reduced by STRIP5) and the computer was an AT 3-86 with 33MHZ.



We have placed the titles of the songs as their lyrics under the melody line which in most of the cases is correct.

You judge these results from different angles. To quote only two:

- How exchangable are the texts...

- The chauvinist country needs the melody more notched, the folk likes it softer (or is there anybody who would like to march on the first six lines?).

Problems should not be generated but solved by the software. This program may serve, for instance, to find out how individual the mentioned Chippewa song might be. We have examined that there is only one among more than 7.000 German folksongs which begins with a different rhythm and ends on the major third. But even this is an exception because this "relative" comes from the *"Wenden"*, a kind of German "national minority" in the eastern part of the country.

If you do larger searches, the program supports the following strategies:

1. It only does an internal search and you read how many occurences would be evoked by your question(s). This is the fastest method.

2. You ask for a tone pattern and the program writes the complete song into another file for further searches.

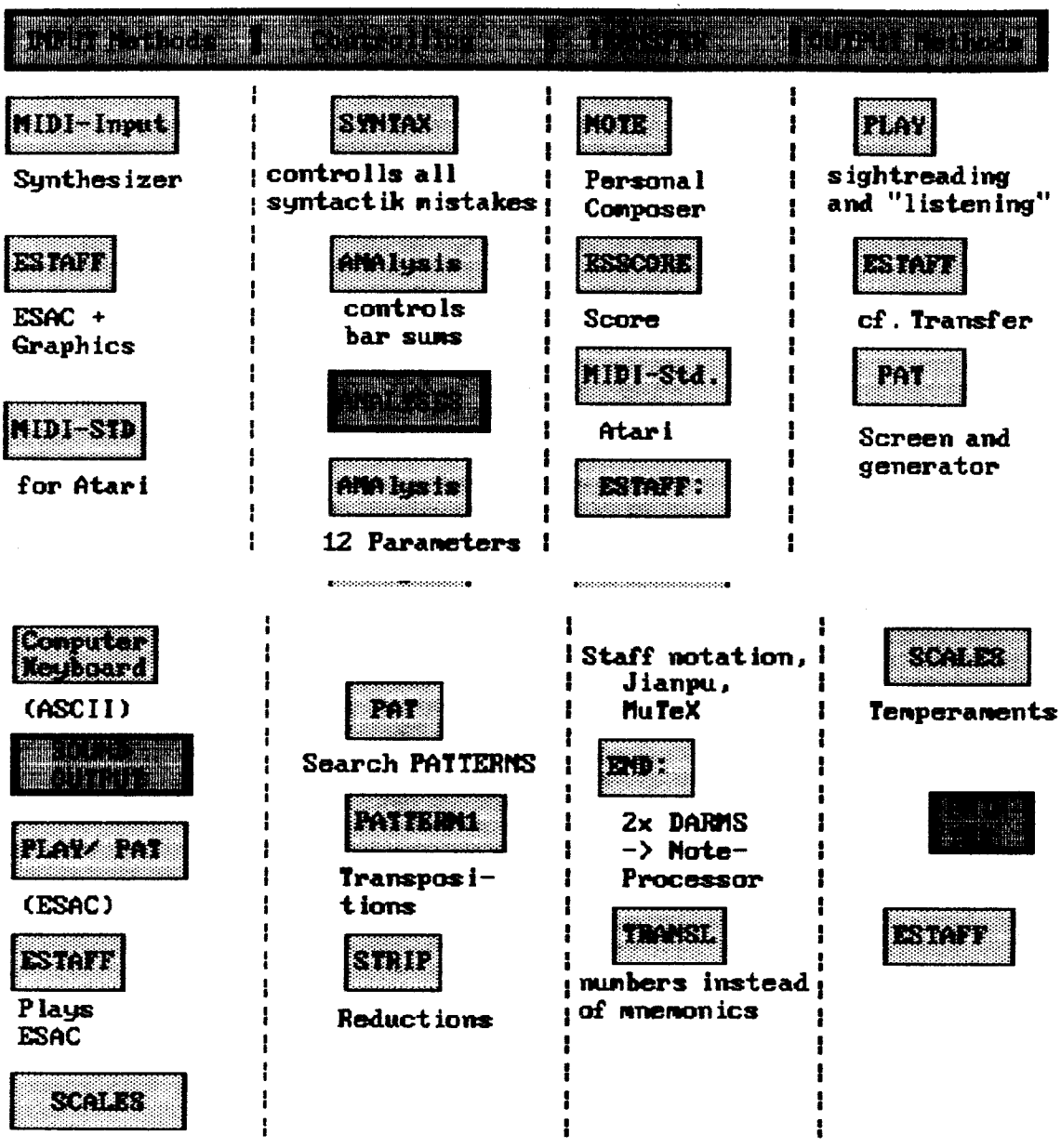
3. You can restrict your research to the first or the last melody line or enlarge it on the total melody or to every line of the file, in which case you can also search for any text.

We have, for instance, searched for the order of pitches 1-2-3-5-4-3 per phrase and found out that the incipit of a very old and famous German folksong "Innsbruck ich muss dich lassen" occurs 144 times in 133 songs. It also contains the melody of the Bach choral "Oh Welt ich muss dich lassen" or the more secular title "Ach Lieb ich muss dich lassen", and if you cancel the first tone of this sequence, you also will find a title called "Nun ruhen alle Waelder", which in many cases is the only version students really know.

PAT also allows you to display the melody which has just been found in Staff notation and plays it according to your tempo definitions pointing at every note which just is being played. The program has many more facilities but those have to be depicted in a different paper.

"Glossary" of the Essen Programms

(Replacing the Summary)



Quoted L i t e r a t u r e

Baroni, Mario: **Antiche canzoni francesi: Uno studio di metrica generativa.** In: QIM 5, pp. ??. 1984a)

Baroni, Mario and Callegari, Laura (Hrsg.): **Musical Grammars and Computer Analysis.** Florenz 1984b)

Baroni, M., Brunetti, R., Callegari, L. and Jacoboni, C.: **A grammar for melody. Relationships between melody and harmony.** In: Baroni, M. und Callegari, L. (Hrsg.): Musical Grammars and Computer Analysis. S.201-218. Florenz 1984c)

Becker, Alton P. and Becker, Judith O.: **A Grammar of the Musical Genre Srepegan.** In: Journal of Music Theory 23.1, S. 1-44. 1979

Dillon, Martin and Hunter, Michael: **Automated Identification of Melodic Variants in Folk Music.** In: Computers and the Humanities Vol. 16, S.107-117. 1982

Grijp, Louis Peter: **'VOETENBANK': een methode om melodie n te zoeken bij liedteksten,** beproefd op de reien in de 'Geeraerdt van Velsen' van P.C. Hooft (1613). In: TVNM 34 pp. 26-48. 1984

Jesser, Barbara: **Interaktive Melodieanalyse.** Methodik und Anwendung computergestützter Analyseverfahren in Musikethnologie und Volksliedforschung: typologische Untersuchung der Balladensammlung des DVA. Bern (P. Lang) 1991 (Dissertation)

Lombardi, Luca: From the Ivory Tower to the Tower of Babel. in: INTERFACE Vol. 17, Nr. 3, S. 173-176. Lisse (Swets & Zeitlinger B.V.) 1988

Schaffrath, Helmut: **Computer aided Archiving and Retrieval of Chinese Folksongs.** Relations between Performance, Notation, Transcription, Encoding and Analysis. In: Maschinenschriftliches Manuskript des Vortrags zum Meeting der ICTM Study Group on Computer Aided Research, Edinburgh 28.9. - 2. 10. 1988. 1988

Schaffrath, H.: **Notation, Transkription, Tradition im Spiegel computerisierter Lösungen.** In: Schumacher, R.: Festschrift Kuckertz. Berlin 1991

Steinbeck, Wolfram: **Struktur und Ähnlichkeit. Methoden automatisierter Melodieanalyse.** Kassel, Basel, London (Bärenreiter) 1982

Weitere Literatur und Entwicklungen (Essener Datenbanken)

Franzke, U.: **PAT - Ein Pattern-Suchprogramm für Essener und andere Software.** Essen 1991

Franzke, U., Schaffrath, H.: **ESTAFF 1.0: Ein Notationsprogramm für einstimmige Melodien.** Handbuch. Essen 1990

Jesser, Barbara: **Rechnergestützte Melodieanalyse - Sackgasse oder Inspiration für die Volksliedforschung?** In: "Musikpädagogische Forschung". Laaber (Laaber) 1989

Schaffrath, H.: **Computer Cataloging. A Database System for Ethnic Music at Essen University, West Germany.** In: IASA phonographic bulletin, No 39/July. 1984

Schaffrath, H.: **Computer - wozu?.** In: Musica 2, S.135-139. 1987

Schaffrath, H.: **Datenbanksystem zur Dokumentation von Musik auf Tonträgern.** In: Dittmar, J. (Hrsg.): Dokumentationsprobleme heutiger Volksmusikforschung. Studien zur Volksmusikforschung 2, S.183-197. Bern, Frankfurt, New York, Paris (Peter Lang) 1987

Schaffrath, H.: **Datenbanksystem zur Dokumentation von Schallplatten** I. Ethnomusikologie. = BENUTZERHANDBUCH. Universität GHS Essen, 1984ff

Schaffrath, H.: **Der Umgang mit Information über Musik.** Am Beispiel einer Datenbank ethnomusikologischer Schallplatten der Universität Essen. In: Musikpädagogische Forschung, Band 6, Laaber, S.253-263. 1985

Schaffrath, H.: **Erfassungsregeln zur Melodiedatenbank.** In: Handbuch. Universität Essen 1990

Schaffrath, H. et al.: **Datenbanksystem zur Dokumentation von Schallplatten...** ERFASSUNGSREGELN. Essen 1984ff

Schaffrath, H.: **MAPPET: Music Input, Analysis and Playback for ESAC Transcriptions.** Handbuch, engl./dt. Essen 1990

Schaffrath, H.: **The Retrieval of monophonic Melodies and their Variants:** Concepts and Strategies for Computer-Aided Analysis. In: Maschinenschriftliches Manuskript des Vortrags auf der Tagung "Computers in Music Research" Lancaster April 1988. (Academic Press) 1991 (Marsden&Pople (eds))

Schaffrath, H.: **Zum Einsatz von Computern in Musikwissenschaft und -pädagogik.** In: Schaffrath, H. (Hg.): Musik und Computer - Computer und Musik. Stuttgart (Metzler) 1991

Inhaltsverzeichnis

Duration = 60'. From p.8 = 45'

Unterlagen:

a) DATEN

Test0, Test1, Irland.SAM, 100.SAM, Böhme (720k), Beispieldateien dieses Artikels

b) Software:

ASKSAM, KEDIT, MAPPET, STRIP1-5, PAT, PATTERN1

c) Manuskripte:

Alle Handbücher, Folien, Kassette, Mutex-Beispiele, Kartenspiel(e)