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Photosonic disk : interactions between graphic research and gestural controls

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The photosonic instrument

The photosonic instrument uses the interception of light beams by semi-transparent disks and filters, and as the disk rotates the sound is created by the induced current in a photocell. It has been invented by Jacques Dudon in 1972, and it uses graphical disks produced with the help of computer programs developed by Daniel Arfib (1986) and Patrick Sanchez (1996). Jacques Dudon is regularly giving solo concerts with that instrument, while in 1998, a research grant from the French Ministry of Culture was awarded to the Atelier d'Exploration Harmonique for a study of the acoustical resources of the photosonic disk.

The aim of this article is to show which gestures are used by an interpreter of this instrument, and to understand the relation between the graphics and the gestural resources. This instrument emphasises the importance of a gesture truly guided by the ear.

The photosonic process

A "basic" photosonic disk drive is essentially composed of 4 elements :

- a mobile light source (L);
- interchangeable semi-transparent disks (D) on which sonic waveforms are printed;
- optical filters (F) of various shapes, manipulated in the manner of a bow, but mainly controlling the timbre;
- at last, a photovoltaïc sensor (C) connected to an ordinary audio amplifier.

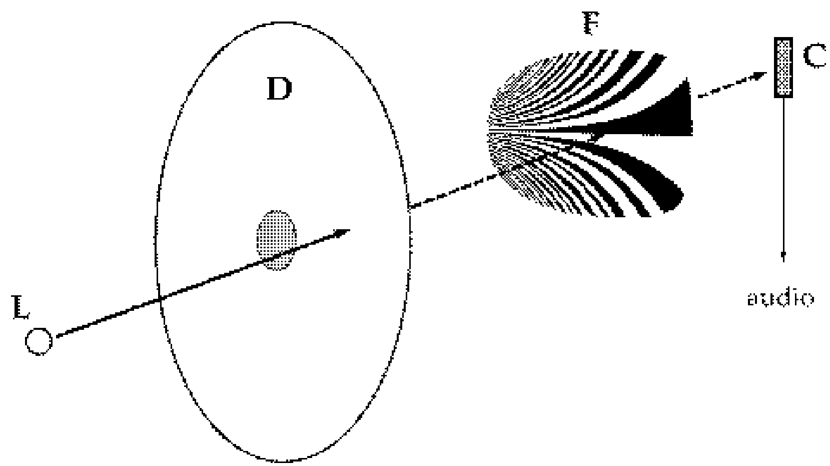


Fig. 1. The photosonic process.

The disk is the vibration-causing element of the instrument which pulses the light beams at audible frequencies. Then the light is converted by the photocell into an electric signal.

What is the interest of a surface sensor, intead of a sensor limited to a point ? It allows to operate an optical filtering of the sounds by means of manually controlled semi-transparent films called "optical filters" (F). At every moment this type of sensor adds the light intensities received all over its surface after it has passed through the optical filter. This filter then selects and amplifies harmonics from the disk's projected shadow on its surface, that are in concordance with its own patterns. Such a filter operates in the time domain, which is also correlated to a control of the response in the frequency domain. Through its movement the filter allows also dynamic controls and a vibrato effect on the sound.

Disk Creation

A disk is the result of the disposition within usable radius of specific waveforms repeated at specific frequencies.

Presently disks are produced with the help of a computer program initially conceived by Daniel Arfib and recently perfected by Patrick Sanchez. This software (Waveloom 2.0) works in two steps :

- creation of virtual geometrical waveforms, composed of arcs to which different grayscale values are assigned ;
- projection of these waveforms on rings between two radii values.

The operating codes consist in approximately twenty operations among which :

- drawing of arcs ;
- selection of different zones ;
- omission of zones ;
- erasing ;
- inversion ;
- symmetry ;
- rotation ;
- frequency modulation ;
- stretching or compression ;
- memory and recall ;
- import of waves created with the help of functions ;
- import of sampled audio signals ;
- addition of waves, and so on ;
- repetition of a wave : the number of repetitions applied to these waveforms determine the musical scale of a disk.

These operations allow a impressive variety of sound possibilities. Further on, the same waveforms can be spread on the surface of the disk according to various techniques which are directly going to influence the musical interpretation.

Gestural Controls

The photosonic disk, harmonic palette, is a creation of the mind, extended by a creation of the ear, helped by a creation of the gesture. Depending on the instrumental performance, a disk never plays the same sounds, and this reveals indeed a "listening gesture", which finds in the photosonic disk an essential dimension. This is linked to various specificities of the instrument, such as the absence of inertia and the great freedom of the motion gestures (moving the hands in a 3D space) controlling the sounds.

In opposition to the MIDI keyboards, rich in selection gestures but poor in expressive gestures, which introduce a dichotomy - either pleasant or deceiving - between the gestural interface and the virtual generating devices, the photosonic disk controls require an intuitive, a purely analogical attention of gesture, directly linked to listening potentialities. Thus, the photosonic disk opens radically new perspectives in the domain of gestural control.

The following figure shows the instrument played with a mobile light and an optical filter.

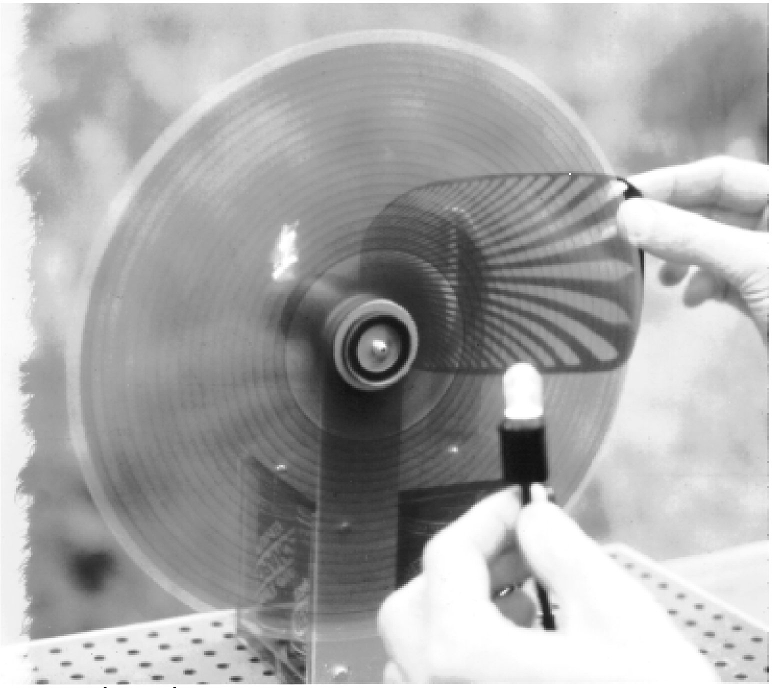


Fig. 2. "photon" (1986).

Moving the light

The light moves in the three directions in front of the disk. A lateral movement (x axis) sweeps the different rings of the disk. So one can position the light in front of a specific ring, or between two rings. A forward movement increases the intensity and at the same time brings a variation of timbre due to the projected size of the sensor on the disk from the point of view of the light source. A vertical movement plays on the instant pitch of the sound. If the disk turns clockwise, a downward movement (accompanying the disk rotation) brings up a temporary fall of the pitch and conversely.

Fig. 3. Video sequence. A disk played with the help of a light source and an optical filter both in motion.

Moving the filter

A left to right movement increases the filtering frequency whereas a vertical movement of the filter produces the same effect as a vertical movement of the light. The introduction of the filter in the field of the sensor provokes a specific dynamic attack effect. The inverse arises when the filter is removed vertically. The filter is also used to add a vibrato effect by means of a vertical oscillation.

Fig. 4. Video sequence (left): the filter is moved horizontally.
Fig. 5. Video sequence(right): the filter is moved vertically.

Sound examples of a disk and associated gestures

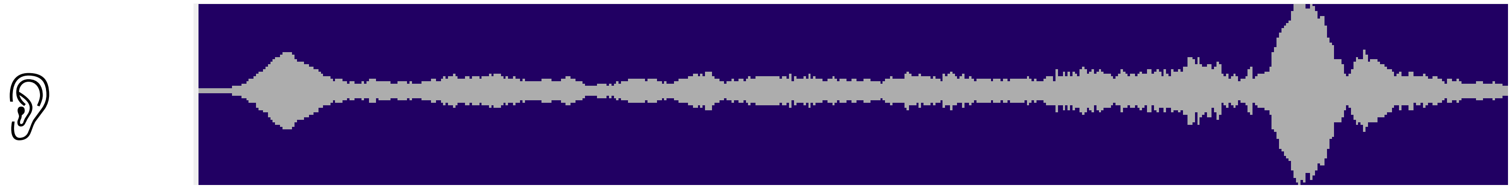
The disk 523 (see page 553) is built on a heptatonic scale based on the antique persian tetrachord Buzurg, whose repeating frequencies are issued from multiples of 3, 7 and 13 : 78, 84, 96, 104, 117, 126, 144. The waveforms used here are intermodulations (graphic superimpositions) between different couples of tones chosen in this scale.

This technique has the property to generate strong difference tones. For example the first ring of this disk makes up a superimposition between frequencies 96 and 117, adding to those two tones a bass sound of frequency 21 (= 117 - 96).

As an application of the "differencial coherence" consonance theory developped by J. Dudon, all the difference tones generated similarly on each ring belong to the scale.

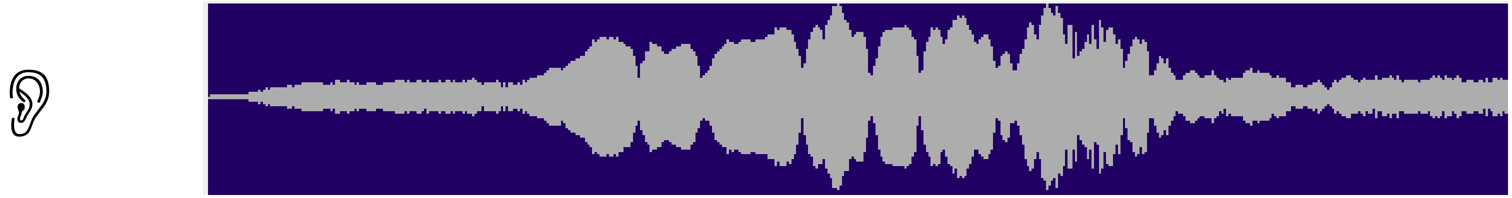
This type of waveform is well suited to gestural techniques making good use of the optical filter which is one of the essential devices of this instrument.

The following sound examples illustrate some of those different techniques :



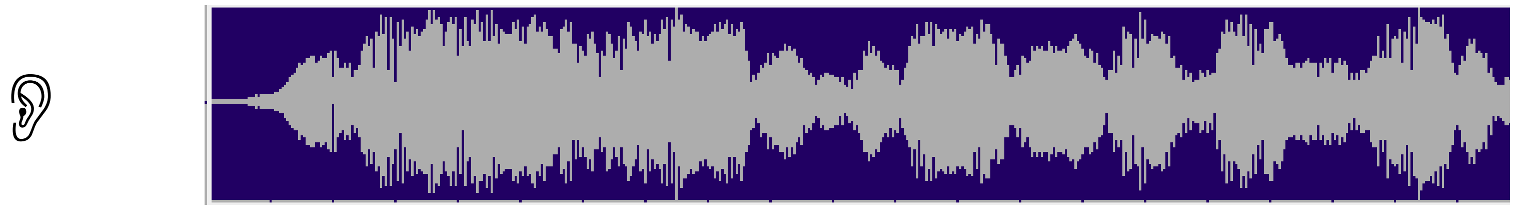
Sound example 1. First gesture.

Horizontal lateral sweeping of the light, the filter being kept steady. Then one successively scans some of the rings from the outside to the inside of the disk.



Sound example 2. Second gesture.

Horizontal movement of the filter, the light being kept steady in order to play a single ring. One can perceive a melody of overtones coming from the different components of the chosen waveform.



Sound example 3. Third gesture.

Similar type of lateral movement of the filter, the light being still kept steady but placed in order to read two rings simultaneously. One can perceive an even richer melody of overtones that is issued from the addition of the components of two adjacent rings.

Sound example 4. Fourth gesture.

Lateral movement of the filter combined with rhythmical motion, the light being kept steady.

Sound example 5. Fifth gesture.

Vertical oscillation of the optical filter, the light being kept steady. A vibrato effect results from this action.

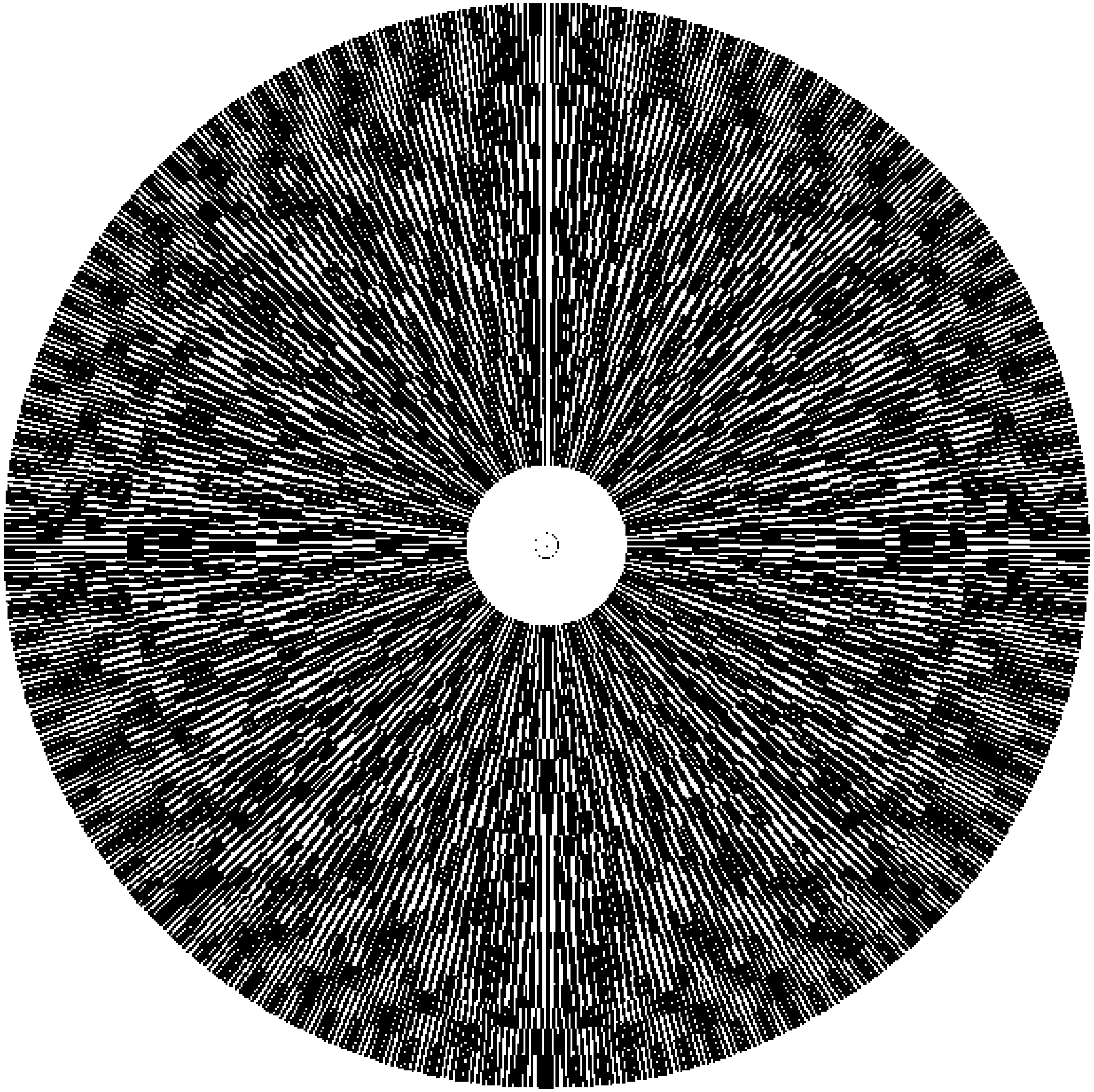


Fig. 6. Disk 523.

Relations between the instrumental play and the visual aspect of disks

A quick study of the different disks reveals a relation between the visual aspect of the disks and some of their most caracteristic gestural approaches.

The visual aspect of a disk is much more linked to the spreading of the waveforms than those waveforms themselves (by "spreading", we mean the way the different waveforms are disposed within concentrical rings on the surface of the disk). Among the most remarquable spreading types inducing specific gestures we will consider five important factors :

1. the width of the rings;
2. the use of radial gradients;
3. a spreading ordered according to fundamental frequencies;
4. a spreading ordered according to harmonic frequencies;
5. heterogeneity of waveforms.

In the following spreading examples which illustrate the influence of these factors, we will note each time the importance of the "listening gesture" which remains of course the conclusive element in the choice of the motion gestures.

The width of the rings

The use of well delimited rings (first factor) is visible in the form of concentrical rings. While sounds of small rings get mixed, larger rings allow individual lecture. This is the case of disk 523 (which has already served as an example for the use of the optical filter) composed of rings of 3 to 6 mm wide, and besides making use of waveforms harmonically very rich. Sound sequences for this disk are audible in the section “Sound examples of a disk and associated gestures”, page 551 . This kind of spreading suggests two cases for the placement of the light source placed either in the middle of a ring or in between two rings. The ear indicates in which case we are and leads us to choose a stable position in which the action of the filter will be, depending on the context, more or less melodic. The left hand chooses the palette and the right hand brings out the notes of the melody.

Fig. 7. Video sequence. Improvisation by means of an optical filter, the light source being positionned to read simultaneously two rings.
Fig. 8. Disk 523 (detail).

The use of radial gradients

The use of radial gradients, obtained in opposition by a succession of micro-rings which results in a gradual continuity between two waveforms (factor 2) visually shows up under a starry form where the rings' limits disappear. This dilution of the radius effect is enough for the filter to become the main emitting element, the lateral movement of the light giving only imprecise indication of pitch.

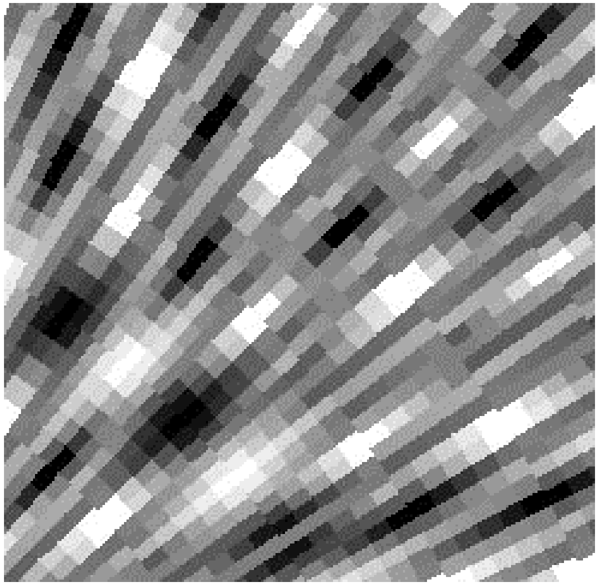


Fig. 9. Video sequence : the filter alternatively selects overtones 1 and 3 of different tones by means of its horizontal approach and positionning.
Fig. 10. Disk 603 (detail).

A spreading ordered according to fundamental frequencies

Entering in a frequency glissando (third factor, applied to micro-rings), which takes the form of different spiraled alignements, all the attention will be given to the left hand which will be responsible of the tuning of the sound. The ear being focalised on this effect the action of the filter will become secondary.

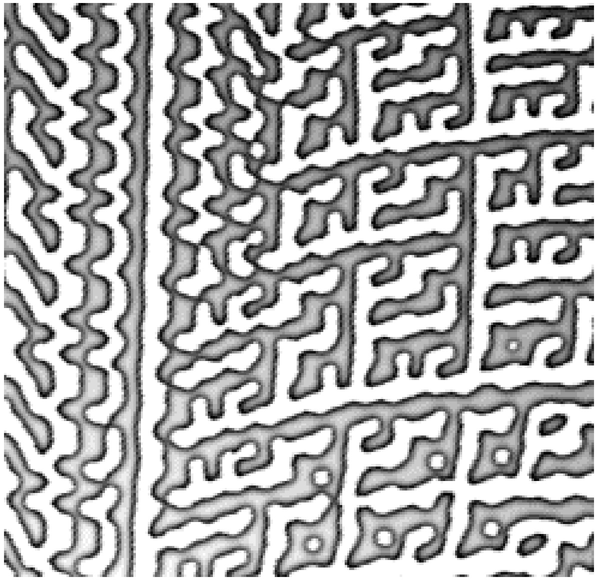


Fig. 11. Video sequence : The light alone plays on movements following both the radius (left to right) and the distance to the disk (back to front).
Fig. 12. Disk 310 (detail).

A spreading ordered according to harmonic frequencies

A spreading with an arborescent type (fourth factor) plays on a variation of the richness of the harmonics according to the radius, the listening of which will usually invitate the left hand (xy parameters for the position of the light) to find a stable point in the research of a certain sound balance. The filter offering the same effect in this context, it will be more often used for dynamic attacks, cut-off and modulations of the sound obtained by means of vertical movements.

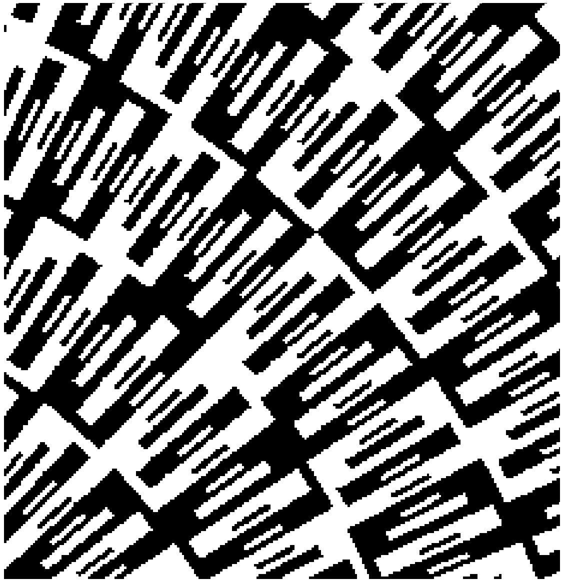


Fig. 13. Video sequence : The filter plays with disk 364 by means of vertical movements.
Fig. 14. Disk 364 (detail).

Heterogeneity of waveforms

At last in the case of a "waveform patchwork" of heterogenous timbres (disk 605, already visionned in the optical filter section: see "Gestural Controls", page 548), the diversity of patterns as well as spreading techniques, resulting in a mosaïc appearance, will invite the musician to a similar diversity of gestures in which the optical filter plays a determinant role, either to accentuate or to harmonise the contrasts between different sounds.

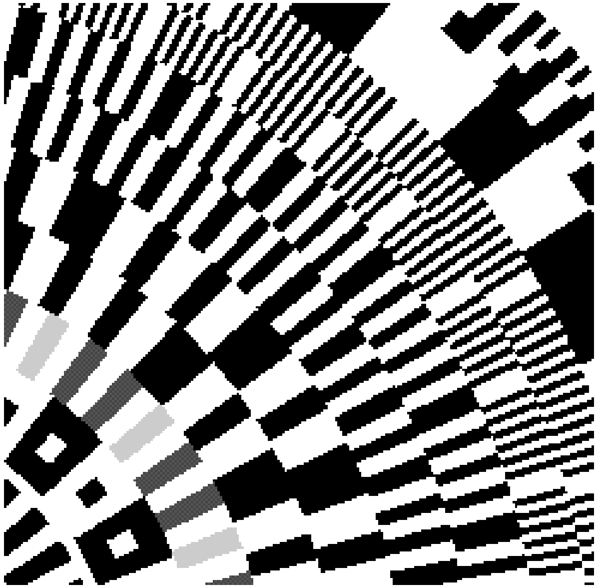


Fig. 15. Video sequence. The filter with mainly horizontal movements expresses the overtones of different ring blends.
Fig. 16. Disk 605 (detail).

Summary of the study in progress

Interpretation of a photosonic disk, altogether an harmonic palette and a geometrical creation, calls forth a great freedom of 3D gestures, essentially of a modulating type, very efficient but hardly reproductible, therefore calling for a particular attention of the ear.

A multiplicity of accessories (filters, guided lines for navigation and resonance, additionnal lights, stands, shutters, optical sequencers, rotofilters, etc.) helps the interpretation and it is important to evaluate their applications.

An analysis of an expert gesture, starting from the study of the relations between the x/y/z displacements of the light sources as well as the filters and the sound parameters, should help define the basis of a gestural langage specific to the instrument, in order to refine the material devices and to perfect the graphic techniques used in the disks composition.

Acknowledgement

Film shots : Bruno Vincendon, CNRS-LMA, 31 Chemin Joseph Aiguier 13402 Marseille cedex 20, France.

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Audio and video documents

Lumières audibles, compact disk by Jacques Dudon, éditions "Mondes harmoniques", available in exchange of US$20 including postage from Atelier d'Exploration Harmonique, Les Camails, 83340 Le Thoronet, France (tel: +33 (0)4 94 73 87 78).

Bernot Monique. *JIM à Tatihou*, video tape including a sequence on the photosonic disk ; available from the author : M. Bernot, 21 rue Noulet, 31400 Toulouse, France.