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Vizualne in avditivne reprezentacije prostora in mrežnega prostora

The Visual and Auditory Representation of Space and the Net-Space

Ključne besede: kognitivni prikaz (avditivnega) prostora, eksperimentalna raziskava, glasbeni prostor, mrežni prostor

Izvleček

Raba pojma *prostor* v zvezi *mrežni-prostor* temelji na mehanskem gledišču, gre za prispodobo vidnega prostora, ki je izpeljan iz telesnega izkustva sveta. S tehničnimi obrati se aktivna interakcija raziskovanja prostora vedno bolj pogreza v pasivnost. Na tej točki nastopi slišni prostor in postane prispodoba mrežnega prostora.

Eksperiment je dokazal, da avditivne prispodobe vzbudijo že različne ostrine/tonske višine. Udeleženci eksperimenta so dobili navodilo, naj pokažejo točko v prostoru, kamor so v mislih postavili določeno zvočno barvo.

Rezultati delijo udeležence na dve skupini: vizualni tip, ki si umišlja prostor po lastnem gibanju, in raziskujoči avditivni tip, ki si umišlja prostor v skladu s ponotranjenim znanjem o obnašanju zvoka: medli zvoki so daleč stran, ostri zvoki so blizu. Tonska višina je razkrila pomemben učinek v sinestetični domišljiji na osi Y.

Sekundarna interpretacija zvoka kot prostorske lokalizacije nakazuje, da je avditivni prostor pojavljanj in pritrjuje McLuhanovi domnevani analogiji med »ušesom in elektriko«, med avditivnim prostorom in prostorom elektrike, dandanes mrežnim prostorom. Metaforični rabi prostora navkljub umetnostni eksperimenti uvajajo avditivno-prostorski imaginarij kot psihološki vmesnik do mrežnega prostora – še enega prostora pojavljanj, ki jih določa komunikacijski proces.

Key words: cognitive representation (auditory-) space (exp. study), musical space, net-space

Abstract

The use of the term space in net-space is based on a mechanistic point of view, an imagery of visual space out of bodily experience of the world. By technical turns the active interaction to explore space more and more becomes a passive one. This is where the auditory space comes in and serves as an imagery for net-space.

An experiment proved an auditory imagery just evoked by different sharpness/pitch. Subjects were instructed to show the point in space where they imagined a sound with a specific timbre is located.

The results show two groups of subjects: a visual type that imagines space by his own movement and an exploring auditory type which imagines space according to the internalized knowledge of the behavior of sound: dull sounds are far away, sharp sounds are near. Pitch revealed a significant effect on the synesthetic imagination on the Y-axis.

The secondary interpretation of sound as space-localization indicates auditory-space to be a space of occurrences and supports McLuhans assumption of an analogy of "ear and electricity", of auditory space and electric space, nowadays net-space. Despite the metaphoric use of space artistic experiments initiate auditory-space-imagery to use it as a psychological interface to the net-space, another space of occurrences defined by communication-processes.

Science and the New Arts

The crossover of science and the arts is mainly led by the scientific interest in perception. Science is interested in the effect of perception on reconstructing reality, arts (especially the media arts) on constructing reality. Baumgarten's[1] philosophical concept of aesthetics as a theory of sensory knowledge is the modern basis and led to an immersion of (natural) science in science of arts and the arts, Wiener[2] sums up the epistemological demand on art: "aesthetic experience [....] is not the opposite of recognition, it comprises recognition, it is recognition". In science systematic musicology is one of its consequences – media art is the most important consequence in the arts.

This interest in perception shares the common aim of getting knowledge about reality. It brought into the assumption of constructing reality from the arts to science and scientific methods to the arts: empirical knowledge goes along with personal experience, the scientific experiment with the artistic one, like in the community of science the collective authorship replaces the ownership and this way scientific communication becomes standard for the artistic discours and makes the genious creator become the initiator of an experimental setting to study concepts of constructions of reality – these mark positions of cognitive science as well as postmodern philosophy as well as media art, communication- and net-art.[3]

Net Art is collective art using a technical medium which allows self-structuring processes by communication: The movements of information define the net-space, not its physical basis, the web-space.[4]

The metaphoric use of the term space in the net-arts leads us to a kind of new arts, where the dominance of the principles of the fine arts (based upon what is visually represented of our world) is being broken more and more and the basics of music come in. After time and its arbitrary use in the abstract film, the most prominent example of this paradigm-shift is space as a category that is perceived as "passive" (without our immediate movement) and as being always around us (e.g. in net-art). "In a way of listening to ... instantaneous movements of information"[5] we detect the net-space; this is the way we experience the auditory space.

The analogy McLuhan[6] assumed between the "semper and ubique" auditory-space and the simultaneity of the electricty and Thall's extension to the "all-at-onceness" of the net-space is of main interest. The scientific experiment tests the auditory space-imagery to be a space of occurrences, the artistic experiments prove the transfer of this imagery to net-space, another space of occurrences generated by interactive processes of commu-

1 Alexander G. Baumgarten. *Meditationes philosophicae de nonnullis ad poema pertimentibus*. Halle, 1735. Zit. nach der Ausg. *Meditationes philosophicae de nonnullis ad poema pertinentibus – Philosophische Betrachtungen über einige Bedingungen des Gedichtes*. Hamburg: Meiner, 1983 CXVI, 86–87.

2 Oswald Wiener. 'Wozu überhaupt Kunst?'. In: *Literarische Aufsätze*, hrsg. von Oswald Wiener. Wien: Löcker, 1998, 21–41.

3 Werner Jauk. 'Entortung/Identität'. In: *Kunst-Wissenschaft-Kommunikation. Comm.gr2000az. Chip/Schloß Eggenberg*, hrsg. von H. Konrad, R. Kriesche. Wien, New York: Springer, 2000, 134–141.

4 Derrick de Kerckhove. 'Kunst im World Wide Web'. In: *Prix Ars Electronica 96*, hrsg. von Hannes Leopoldseder und Christine Schöpf. Linz, 1995, 37–49. Werner Jauk. 'Gestaltung durch kommunizierendes Verhalten: Musik und Net-Art'. In: *Forschungsbericht Klangforschung* 98 (1999), 163–173.

5 Nelson Thall. *The McLuhan Millennium*. Cambridge/Mass: MIT Press, 1996.

6 Marschal McLuhan. *Understanding media: the extensions of man*. Cambridge/Mass: MIT Press, 1994. Marschal McLuhan. *The global village: der Weg der Mediengesellschaft ins 21. Jahrhundert*. (transl. C. P. Leonhardt). Paderborn, 1995.

nication. Using the auditory-space-imagery as a psychological interface to net-space the metaphoric use of space is substituted by an adequate experience of this kind of space.

First space became a musical parameter in addition to being a more or less given parameter of performance. In the beginning, the sound source itself was located at a specifically composed position or was moved between positions. This physical dislocation was achieved by placing the musician or routing a sound signal through loudspeakers. The next step (achieved by technical development) was the electronic simulation of the physical conditions describing acoustic space and the location and movement of sound in it. Now the third step is the illusion: An imagery is evoked without setting the immediate adequate stimulus. Space imagination is produced just by timbre, pitch and loudness in a spatially indifferent acoustic environment.

Space-Representations

Although our body-environment-interaction ist based on cross-modal sensory controll, our "daily life-perception is based on multi-sensory information",[7] primarily our imagination about space is based on a visual representation (out of embodied visual controlled experience) of physical space. This experience is consequently transferred to the musical space, its notation and the way it is verbally expressed.[8]

We gain knowledge about space from our bodily experience of the physical space. These experiences represent the mechanistic system defined by the relation of velocity – distance – time.

In terms of the visual-sensory-system we construct space out of a series of two-dimensional visual-fields in front of us which emerge through motion. This space is always associated with time, the space behind us with passed time, it has to be constructed out of stored pictures of the past: the space behind us is left behind. We move through the space passing locations by time!

We attribute invariants to the dimension space, variants to the dimension time.[9]

The development of space perception is connected with the notion of time. Both are connected with the development of relational thinking.[10]

We perceive auditory space in a different way. Auditory space is some kind of "semper et ubique" – space. It is always around us ("egocentric") and we have a notion of it without our movement – sound informs us about space!

Because of its low velocity of propagation and the high resolution of our time-detecting acoustic information processing system, we are able to follow the behavior of sound, its modulations. Sound does not only carry information about the vibrating system which generates it, but also about its propagation in space. This means that it indicates quantitative and qualitative aspects of the space.

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7 Helga de la Motte-Haber. 'Audio-visual perception and its relevance in science and art'. In: *Musikpsychologie – Inter- und Multimodale Wahrnehmung. Jahrbuch der Deutschen Gesellschaft für Musikpsychologie* Bd. 18, hrsg. von K.-E. Behne, G. Kleinen, H. de la Motte-Haber. Göttingen, 11–21 (2006), 11.

8 Albrecht Schneider. 'Musik sehen – Musik hören. Über Konkurrenz und Komplementarität von Auge und Ohr'. In: *Hamburger Jahrbuch der Musikwissenschaft* Bd. 13. *Theorie der Musik. Analyse und Deutung*, hrsg. von C. Floros, H. J. Marx, P. Petersen, W. Dömling and A. Kreutziger-Herr. Hamburg, 123–150 (1995), 144.

9 James J. Gibson. *Wahrnehmung und Umwelt. Der ökologische Ansatz in der visuellen Wahrnehmung*. München, Wien, Baltimore: Urban & Schwarzenberg, 1982.

10 Jean Piaget. *Le développement de la notion de temps chez l´enfant*. Paris, 1946.

Absorption by some materials in the space and surrounding materials as well as damping in the air first effect the higher frequencies in the frequency spectrum. The sound closer to the vibrating system is always sharper than the sound of the same system far away.

The sharpness of sound indicates the position on the z – axis; this is the cognitive interpretation of the knowledge about physical behavior of sound. The secondary interpretation of timbre indicates distance (and even the direction of a sound-source and the space).

Our two ears allow us to perceive the sound at two slightly different points. The phase-differences and differences in intensity are interpreted as position of the sound source on the x-axis.

Sound indicates the position on the y-axis too, but in a different way. The facts that theoretical descriptions, notation as well as the subjective experience of pitch are expressed in terms of up and down and sharp and flat ... indicates the phenomenon of synesthesia, which is a kind of "translation of attributes of sensation from one sensory domain to another".[11] Basic concepts explain this synesthetic effect from the knowledge of gravity and physiological processes producing sound.

Maybe synesthesia of pitch and height results from (a thinking which itself results from) the experience of the physics of the world (gravity) as Gibson[12] assumes, that small objects are light and belong to the higher regions and produce high tones or that we generalize an implicit knowledge of the position of the Adam's apple, which goes up when singing a high tone and goes down when singing a low one.

Timbre/Pitch and Space-Imagination

As multidimensional concepts of timbre (succeeding to Wessel's study)[13] and pitch[14] postulate and Garner's[15] theoretical implication of integral dimensions of timbre and pitch suggest there is empirical evidence of an interaction of timbre and pitch and their spatial representation. Timbre and pitch are not independent phenomena: at least timbre and pitch are just artificial aspects of sound (see also Schneider & Beurmann[16]) and are spatially imagined, described and notated.

For isolated sounds "there is a crosstalk between timbre and pitch, just as Melara and Marks[17] found".[18] This "interaction can be shaped by experience".[19] Non-musicians

[11] Lawrence E. Marks. 'On colored-hearing Synesthesia: Cross-modal Translations of Sensory Dimensions'. In: *Psychological Bulletin* 82/3 (1975), 303–331.

[12] James J. Gibson. *Wahrnehmung und Umwelt. Der ökologische Ansatz in der visuellen Wahrnehmung*. Op. ct.

[13] David L. Wessel. 'Timbre Space as a musical control structure'. In: *Computer music Journal* 3(1979), 45–52.

[14] Roger N. Shepard. 'Geometrical Approximations to the structure of musical pitch'. In: *Psychological Review* 89 (1982), 305–333. Roger N. Shepard. 'Structural Representations of musical pitch'. In: *The Psychology of Music*., hrsg. von Diana Deutsch. Orlando: Academic Press (1982), 343–390.

[15] Wendell R. Garner. *The Processing of Information and Structure*. Potomac, MD: Lawrence Erlbaum, 1974.

[16] Albrecht Schneider / Andreas Beurmann. 'Tonhöhe – Intervall – Distanz: zur Wahrnehmung von Klängen mit inharmonischen Spektren'. In: *Systematische Musikwissenschaft* 2 (1994), 113–143.

[17] Robert D. Melara / Lawrence Marks. 'Interaction among auditory dimensions: Timbre, pitch and loudness'. In: *Perception & Psychophysics* 48 (1990), 169–178.

[18] Mark A. Pitt. 'Perception of Pitch and Timbre by Musically Trained and Untrained Listeners'. In: *Journal of Experimental Psychology: Human Perception and Performance* 20/5 (1994), 976–986. P. 984.

[19] Ib.

showed a stronger influence of the timbre to the pitch – they have more difficulty distinguishing between the dimensions. "The Interaction effects were symmetrical".[20]

Maybe sharpness is a psychological dimension, which reflects this interaction of fundamental pitch, spectral envelope and loudness.

On the one hand sharpness is determined by the high frequencies of the Fourier spectrum and increases with increasing sound pressure.[21] On the other hand sharpness increases independent of the sound-spectrum with the frequency of a sine-wave. To decrease the high cut-off-frequency of a bandpass makes noise less sharp, to increase the lower cut-off frequency makes it more sharp.[22] In general it is considered to be an integral dimension of pitch of complex sounds.

There are spatial models to describe these aspects of sound. Révész's[23] two-component theory of pitch uses a spatial model to describe "Helligkeit" as its linear element and "Tonigkeit" as its cyclic element. The concepts of sharpness and fundamental pitch are somewhat similar to "Helligkeit" and "Tonigkeit".

La Motte-Haber assumes that there is an "Assoziation des Eindrucks der Helligkeit mit der räumlichen Höhe".[24]

The correlation of spatial imagination and musicality is another cue to show the spatial representation of music in general.[25]

Early and graphic notations use the representation of pitch (contour) on height immediately.[26]

These representations are based on "knowledge" of our acoustic information systems about the filtering effects of materials in the surrounding environment and our head.

There is clear evidence, that a specific acoustical environment[27] evokes a specific impression of sound localization, or that a specific sound structure reflects a specific hearing situation. The head modulates a sound coming from a certain position in a specific way. Diffuse sound modulated in the same manner evokes the impression of a sound coming from this direction on the median-plane where such filtering is normally being done by the head.[28]

It is not the aim of the following experiments to provide the explanation and simulation of those physical effects, but to explore an association of space position to timbre in general resulting from the knowledge of the experience of the behavior of sound in the natural world. This knowledge – a cognitive representation of auditory space – is in general represented in a (passive) "mechanistic" view of the world.

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20 Carol Krumhansl / Paul Iverson. 'Perceptual Interactions Between Musical Pitch and Timbre'. In: *Journal of Experimental Psychology: Human Perception and Performance,* 18/3 (1992), 739–751. P. 744.

21 Miguelina Guirao / Stanley Smith Stevens. 'Measurement of auditory density'. In: *Journal of the Acoustical Society of America* 36 (1964), 1176–1182.

22 Gottfried von Bismarck. 'Sharpness as an attribute of the timbre of steady Sounds'. In: *Acustica* 30 (1974), 159–172.

23 Geza Révész. *Einführung in die Musikpsychologie*. Bern, München: Francke Verlag, 1946.

24 Helga de la Motte-Haber. *Handbuch der Musikpsychologie. IV: Individuelle Determinanten musikalischer Kompetenz*. Laaber: Laaber Verlag, 1985, 307.

25 Marianne Hassler / Niels Birbaumer. 'Musikalisches Talent und räumliche Begabung'. In: *Archiv für Psychologie* 136 (1984), 235–248. Marianne Hassler. 'Kompositionstalent bei Mädchen und räumliche Begabung. Zwei Untersuchungsdurchgäng einer Längsschnittuntersuchung'. In: *Jahrbuch der Deutschen Gesellschaft für Musikpsychologie,* Bd. 2, hrsg. von K.-E. Behne, G. Kleinen, H. de la Motte-Haber. Wilhelmshaven: Hogrefe Verlag, 1985, 63–85.

26 Willi Apel. *Die Notation polyphoner Musik*. Leipzig: Breitkopf & Härtel, 1979, 221.

27 Hans Wallach. 'The role of head movements and vestibular and visual cues in sound localization'. In: *Journal of Experimental Psychology* 27 (1940), 339–368.

28 Jens Blauert. *Räumliches Hören*. Stuttgart: Hirzel Verlag, 1974.

Experiment

A general association of pitch and timbre of a sound with an impression of a position on the Y- and Z-axis (in visually represented space) was proved by experiment.

Hypothesis 1: There is a correlation between pitch and the impression of height.

A correlation between pitch and the position on the y-axis is interpreted as synesthesia.

Hypothesis 2: There is an effect of timbre on the impression of distance.

A correlation between timbre and distance is seen as secondary interpretation of timbre. Knowledge of the physical behavior of sound leads to the secondary interpretation of timbre as distance.

Therefore the effect of the two independent variables pitch and timbre on the dependent variable impression of space position was to be observed. Pitch was defined as the fundamental of the first 8 partials in the harmonic structure and classified in distance of a third (1/3-oct.). Timbre was operationalized as sharpness. This psychological concept is directly effected by damping and absorption and indicates distance best. According to the theory of having knowledge about the behavior of sound from bodily experience, this should activate space-imagination. Sharpness was defined as the amount of energy in the higher part of the sound spectrum. The three classes of sharpness varied from linear decreasing to equally distributed to increasing relative amplitudes of the partials. This means that sharpness had a little bias to its higher level amount.

Loudness was kept constant. The effects of loudness on the perception of timbre seems to be less strong/weaker.[29]

The subjective localization of the sound was measured by having subjects point on a sheet placed in the median plane in front of their visual field with the action-radius of their arms. They were instructed to show the position where they had the impression that a sound with a specific timbre was located.

The sounds were presented in random-order. In addition, bursts of white noise were set between two stimuli to reduce memory effects and relational perception.

The 60 subjects listened to the sounds by headphones. This was necessary to eliminate real sound positioning by resonance and movements of the head. On the other hand, a dissonance may have occurred between the perceived inner head-space and the imagination in the free listening field.

Results

The scoring of the dependent variable was done by a grid according to the classes of the dimensions. No transformations were to be done to eliminate wide variations in the subjective range in the use of the dimensions.

[29] Mark Pitt / Robert G. Crowder. 'The Role of Spectral and Dynamic Cues in Imagery for Musical Timbre'. In: *Journal of Experimental Psychology: Human Perception and Performance* 18/3 (1992), 728–738.

The first results show clear evidence that the fundamental pitch is associated with the impression of a position on the y-axis of the space (main-effect pitch: among 64% of communality).

Main-effect timbre was not significant. Only closer access to the data shows that sharpness is generally associated with the distance in space. There are two groups of subjects handling the timbre information in a different way: the first (larger) group interpreted from an object-centered point of hearing: dull sounds are far away, sharp sounds are near. This supports the theory of the knowledge of physical behavior of the sound.

The second group interpreted from a subject-centered point of listening: I have to be near to dull sounds, otherwise I could not hear them, sharp sounds could be far away ... these subjects reported.

Maybe this reflects different logics of auditory and visual representations of space: The auditory representation means knowledge that sound perception is always the perception of a "moving object" in general the perception of an information transmission process. The second group follows a visual representation of space which primarily results from our own immediate movement.

Further on the first group shows an auditory-type-behaving focussing information-analysing; the second group shows visual-type-behaving focussing information-synthesizing.

To perceive moving objects in visually represented space is somehow a mediated experience of movement – not immediately forced by me! This bodily experience is necessary to know basically the mechanism of moving, which then can be generalized to say that something is being moved and further on something moves. Mediatization is a form of perception going away from (immediate) bodily experiences.

This grouping of the subjects should be followed using theories of perception and personality.

An interaction effect within the auditory-type-subjects suggests an interdependance in the perception of sharpness and pitch; this supports multidimensional concepts of sound (see above).

A second experiment used the same design and proved the emotional connotation (measured with the semantic differential[30]) of sounds varying in pitch and sharpness. Both independent variables show significant effects on activity.

A factor analysis (R-rotation, Eigenvalue 1)[31] revealed the well known three factors of connotation ("evaluation": 43.2 – "activity": 18.8 – "potency": 13.6 pct. of. var.). Analysis of variance of the factor scores brought strong effects of pitch on activity and weaker effects of sharpness on activity; especially for the male subjects.

This supports the signal character of sound assumed in Knepler's[32] suggestion of a (common) communication-system before music and language specialized their own possibilities of expression.

The signal character of sound is coherent with the theory that sound informs about space.

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30 Charles E. Osgood, George J. Suci / Percy H. Tannenbaum. *The measurement of meaning.* Urbana: University of Illinois Press, 1957.

31 Henry F. Kaiser. *Comments on communalities and the number of factors. The communality problem in factor analysis*. Paper presented on conference "The Communality Problem in Factor Analysis" at Washington University, St. Louis, May 14th 1960. [unpublished manuscript]

32 Georg Knepler. *Geschichte als Weg zum Musikverständnis. Zur Theorie, Methode und Geschichte der Musikgeschichtsschreibung*. Leipzig: Reclam, 1977.

Auditory- and Net-Space

The mechanistic point of view of space primarily results from the visual and tactile experience of our own movement. It is actively explored, visually represented and described in the relation of velocity – distance – time.

When – in technical turns, associated with a speeding up in general[33] – velocity becomes so high that movement goes below the threshold of human perception, space and time are reduced to here and now: This describes the perception of net-space. By the experience of passive interaction with an active environment our visual based representation of mechanistic paradigm becomes irritated. "The transgression of the mechanistic paradigm"[34] happens in virtual reality which is constructed out of immaterial codes having no subject-object-relations (Lyotard, 1985). There the assumption of "Kausalität im Universum der Schocks, Schübe und Verzahnungen von Mechanismen"[35] does not work any more. Even passive interaction based on a mechanistic paradigm is not possible – the alternative paradigm is the hedonistic one.[36]

The internalization of the logic of a visual representation of the embodied experience of space cannot serve as a model to describe this "semper et ubique" space which is (always) present for us without our immediate movement – as the auditory-space is.

This goes together with McLuhan's (1994, 1995) assumption of the parallelism of the electricity and the ear. Thall[37] transfers his teachers ideas to the "all-at-onceness" of the net-space: "Structurally, 'auditory space' tends also to be the characteristic form of an electronic culture. Electronic configurations are, in a structural sense, remarkably acoustic. The way of listening to ... instant movement of information" which "creates a configuration of space-time" enables us to "hear" the net-space.

The net-space as well as the auditory space are spaces of occurrences. The behavior of the information-processing by itself is perceivable and indicates the space. Our own movement is not necessary to decode space – this indicates auditory as well as the net-space.[38]

Aspects of the space effect the propagation of sound and modulate the sound – these modulations indicate the space! This is at least a reactive information system.

But there is a difference in the behavior of the information of the auditory- and the net-space. The auditory-space is a reactive system, the net-space an interactive system of occurrences. The user is participant of the system. The auditory-space is indicated by the occurrences, the net-space is structured by the occurrences – the user is always participant.

Net-space is an interactive communication-system and is – despite of "mechanistic" principles – better explained in analogy to informal structuring by interactions of hu-

[33] Paul Virilio. *Rasender Stillstand*. München: Hanser, 1992. Paul Virilio. *Revolutionen der Geschwindigkeit*. Berlin: Merve Verlag, 1993.

[34] Werner Jauk. 'The Transgression of the Mechanistic Paradigm – Music and the New Arts'. In: *Dialogue and Universalism* 8–9 (2003), 179–186.

[35] Pierre Lévy. 'Die Metapher des Hypertextes' [1990]. In: *Kursbuch Medienkultur. Die maßgeblichen Theorien von Brecht bis Baudrillard*, hrsg. von C. Pias et al. Stuttgart: DVA, 2000, 525–528. P. 526.

[36] Werner Jauk. 'Digital Musics – Digital Culture. Der Körper als Interface'. In: *Studien zur Moderne: 16. Kunstgrenzen. Funktionsräume der Ästhetik in Moderne und Postmoderne*, hrsg. von A. Bolterauer & E. Wiltschnigg. Wien: Passagen Verlag 2001, 225–239. Werner Jauk. 'The Transgression of the Mechanistic Paradigm – Music and the New Arts'. Op. cit. Werner Jauk. *Der musikalisierte Alltag der digital Culture*. Habil.Schr. Graz, 2005.

[37] Nelson Thall. *The McLuhan Millennium*. Op. cit.

[38] Jean Baudrillard. *Simulacres et simulation*. Paris : Galilée 1981.

man communication in group-processes.[39] The meaning of information changes from informing to communicating, to have common information and become common – this describes net-art.[40]

The structure and function of the communication nodes in the net-space as well as the structure and function of the communicating persons interact with the content of the communication and this interaction modulates the structure and the kind of communication dynamically – this is a simple form of an interactive, reflexive system.[41]

Finally the (modulation of the) communication indicates the state of the group as well as the visually unimaginable net-space.

Collective free improvised music is based on these principles[42] as well as net art[43] – they can be considered to be communication arts. The study of (this kind of) music and of communication art is the study of the space of occurrences despite a "mechanistic" point of view.[44]

Artistic experiments help to lead away from the internalized mechanistic point of view: Soundcube evokes a space illusion without an adequate physical stimulus, liquid space uses the auditory-space-imagery as a psychological interface to the non-mechanistic net-space.

Both artistic experiments are closely related to the reported scientific experiment. They are experimental settings to provoke the transgression of the mechanistic system using auditory-space-imagery to perceive net-space.

Artistic experiments

Sound-cube (Jauk, 1996, Styrian Autumn)

Sound-cube is an installation which initiates the illusion of space just by timbre and pitch of a noisy sound as the experiment showed. It eliminates/irritates the visual and vestibular cues of space-perception of the physical space by darkness and a slightly inclined plane. Movements – usually necessary for the visual exploration of the space – modulates the sound (in sharpness, pitch and loudness) in a way the participant gets the illusion of movements in an open "egocentric" auditory space.

From a point of hearing, the participant directs the sound by his movements: Timbre/sharpness and loudness effect the distance-perception, pitch and timbre/sharpness the impression of height. The left – right – perception has to be simulated by differences in phase and intensity of a stereo-signal.

A cognitive focussing serves as a kind of instruction to evoke the illusion of a sound-space without a physical movement of the sound in the space. Through an entrance, the participant goes to the center of the space and thus triggers the sound modulation to the sharpest amount. From this point he can stretch the space.

39 Robert F. Bales. *Interaction process analysis*. Cambridge: Cambridge University Press, 1950.

40 Werner Jauk. 'Musikalisches Sprechen. Interaktion – Strukturierung durch kommunizierendes Verhalten'. In: *Acta Philosophica* 20/2 (1999) (– XIV ICA Supplement), 349–359. Werner Jauk. 'Gestaltung durch kommunizierendes Verhalten: Musik und Net-Art'. In: *Forschungsbericht Klangforschung* 98, 163–173.

41 Werner Jauk. 'Interaktivität statt Reaktivität'. In: *Prix Ars Electronica 95*, hrsg. von Hannes Leopoldseder und C. Schöpf. Linz: Verlag des Österreichischen Rundfunks (1995), 23–27.

42 Albrecht Schneider. 'Musik sehen – Musik hören. Über Konkurrenz und Komplementarität von Auge und Ohr'. Op. cit., 125.

43 Werner Jauk. 'Gestaltung durch kommunizierendes Verhalten: Musik und Net-Art'. Op. cit.

44 Werner Jauk. 'Musikalisches Sprechen. Interaktion – Strukturierung durch kommunizierendes Verhalten'. Op. cit.

Liquid space[45]

It brings together the behavior of the physical dynamic medium water just evoked to move (the movement of the water controls the illusion of a sound moving in a cube) with the specific qualities of auditory space and the space of occurrences of communication, the net-space. The medium of communication remains sound.

Sound is used as the sonification of the dynamical data-streams in physical- and communication-space. The auditory space leads our perception to analyze the behavior of information and is this way a psychological interface to net space. The systemic behavior forces us to follow interactive behavior despite the expectation of immediately predictable reactions.

Climate converter[46] and **The use of soap-bubbles**[47] follow this highly immersive[48] methode and involve participiants physically and emotionally in systemic mixed realities using sound and the auditory space as a psychological interface.

Conclusion

If we need an imagery of space in the term net-space, auditory space would serve as a better model than visual space: Auditory- and net-spaces are defined by occurrences (characterized by their own movements) rather than by the interpretation of a series of two-dimensional snapshots in front of us which we gain when we bring in movement to explore the physical space.

Ultimately auditory- and net-space are characterized by analyzing their dynamic behavior of information processing from a stable point of view whereas the visual space is synthesized through states.

In perception the auditory space leads to the transgression of the mechanistic paradigm inherent to visually represented space which is always related to our bodily experience of velocity – distance – time.

Liquid space tries to explore these immediate ways of space perception using auditory logic, whereas visual logic would need the assumption of mediated perception to compensate for not performing one's own immediate movements.

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