Transduction between Image and Sound in Compositional Processes

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1. Introduction

The differences between sonic and visual materials have set complex polemics about the correspondences between their properties. Artists and theorists from diverse backgrounds and times (like Wagner, Kandinsky, Eisenstein, Schoenberg, Cage, McLaren, Chion and many others) have approached this situation from different angles. Nevertheless, the relationships between sound and image follow complex logics that are still not easy to identify.

The concept of transduction has been evoked in artistic research in reference to the mappings that can be established between sound, body gestures and images in the context of cross-modal computer aided composition (Sedes et al. 2003). This article intends to develop the idea of transduction by using it as a tool for describing and analyzing the mechanisms that enable the circulation of objects between the visual and sonic domains at different levels of a compositional process. Its main purpose is to present a conceptual framework in which sounds and images can be put into interaction by means of transduction. Several practical and theoretical disciplines (instrumental and electroacoustic music composition, cognitive sciences, visual arts and musicology, among others) could profit from focusing on the application of this concept to their work.

2. Definition of transduction

As Jesús G.Maestro (Maestro 2005) states, the word “transduction” derives from the Latin *transductio*, whose meaning was the transmission (*ducere*, “to carry”) of something through (*trans-*) a determined medium that acts on the object, carrying in it certain transformations. In this process, the transducer would be the agent that transmits or carries (*ductor-oris*) an object that, by the very fact of being transmitted, is also transformed as a consequence of coming into contact or interacting with the medium through (trans) which it is expressed.

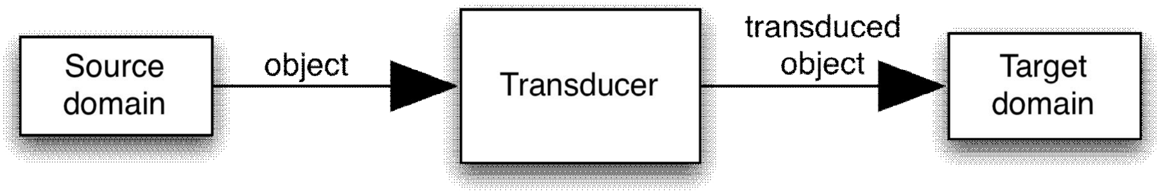

Fig.1 Basic schema of a transduction process

3. Application of the concept in different contexts

The fields in which the concept of transduction is used are varied:

a) In the field of physics “transduction” is understood as the conversion of a quantity of energy from one form into another (Oxford Dictionary of Science 2005).

b) In genetics, it describes the way in which ADN (genetic code) is transferred from a bacteria to another one by a virus (Nair, 2008). This is a common tool used by molecular biologists to stably introduce a foreign gene into a host cell's genome.

c) In semiotics, the term refers to the transmission and transformation processes that literary works go through in activities such as the incorporation of a literary text (or some of its parts) into another one, changing from one genre to another one (novel to theater, cinema, etc.), translating a text to foreign languages, etc. The concept of transduction is understood here as the transformation of signs from one field of knowledge to another one that keeps an original connection in its phenomenological deepest level (Maestro 2005).

4. What objects can we transduce between the sonic and visual domains?

We have seen that the process of transduction may vary depending on the context and the characteristics of the objects that we intend to transfer between two different domains. Hence, the first thing to identify in this kind of process is the nature of the objects that we intend to transduce within a compositional context.

We know that the perception of sound is possible because of air pressure variations that travel from an emission source to its surroundings at approximately 345 m/s. Images, on the other hand, are produced by electromagnetic waveforms that travel at a speed of nearly 300 million meters per second. ¿How can we possibly transfer something between such different physical media?

Our ideas of the world are interpretations of sensory signals. Just as the currents in a wire going to a loudspeaker vary proportionately with the sounds that emanate from it but have no other likeness, so too does sensation vary proportionately (and not necessarily directly) with what causes it but bears no other resemblance to the input. This implies that the sounds and images that we experience are actually cortical occurrences, and that light rays and air pressure variations are neither colored nor pitched. The proportional variations with which images and sounds change are there in the external world, but not the images and sounds as we experience them. Hence, the objects that we can transduce between the sonic and visual domains are meanings created by our brains after the codification of raw sensory signals (auditory and visual). In a nutshell, sounds and images are subjective constructions of our minds.

5. Cognitive principles and their relevance in transduction processes

5.1 Integration of auditory and visual signals in the brain

Alain Berthoz states that a true psychology of perception should resign to separate sensory functions and, in contrast, focus on its multimodal nature (Berthoz 1997). In regard to this, we could mention that the superior colliculus is the main place of convergence between the visual, auditory and proprioceptive sensory signals that arrive to the brain.

Berthoz describes the way in which the brain ensures the temporal integration of multimodal stimulation in the colliculus through “time windows” of great flexibility and simplicity. It has been proven through electrophysiological observation that a luminous stimule provokes a charge in the brain that can be mantained more than 100 miliseconds, allowing the brain to give an integrated response to it and the auditory sensory signals that could arrive several miliseconds after.

If we, for example, listened to a door slamming at our right and turned our head to look towards it, we would have to put at least three sensory modalities in interaction: vision, audition and movement. These adjustements between our senses are achieved thanks to the superior colliculus. The way in which the colliculus works indicates us that (1) the perception of a sound or an image is usually accompanied by neural activity in other sensory modalities and (2) that motor control is strongly connected to visual and auditory perception.

5.2 Perception is an act of simulation

Schmidt (Schmidt 1975) indicates that the brain stores structures of movement that he calls “motor programmes”. These programmes can be regarded as memorized relationships between various components of an action (such as the position of members of the body, the trajectory that a moving object depicts, etc.). Motor programmes act like cognitive maps with which the brain can predict the consequences of the actions that it perceives. Such predictions are achieved by comparing the perceived actions with motor programmes invoked through the memory of past actions. This is one of the reasons why the Motor Theory of Perception stands for the idea that perception is not passive, but that it is an active and constant simulation of perceived actions.

Rizzolatti (Rizolatti, G. et al. 1990) discovered a particularly interesting kind of neurons that verify the existence of motor programmes: the mirror neurons. Mirror neurons influence the motor system when a subject observes the action of another subject (Delannoy, 2008). This mechanism allows not only to understand an action, but also to understand the intentions behind that action. Mirror neurons are the basis of empathy because they allow us to mimetize with (simulate) the emotional condition of an individual (human or animal). The affective communication between musicians and audience, for example, is possible because of the strong links that exist between the mirror neurons and the limbic system, which is the part of the brain that supports emotion.

5.3 The concept of isomorphism

The concept of isomporphism could allow us to deepen further into the idea of transduction between sound and image. This term literally means equality or sameness (iso) of form (morphism). In mathematics an isomorphism implies a one-to-one correspondence (relation) between the elements of two number systems (Levi 1956). This definition expresses an equality of structure between two different systems. The isomorphism required by Gestalt theory, however, is “not a strict *structural* isomorphism (Köhler 1969), but merely a *functional* isomorphism, i.e. a behavior of the system *as if* it were physically isomorphic”. A *functional* isomorphism “accounts for the properties of objects as perceived subjectively, preserving the functional transformations observed in perception”. We could argue against this definition of functional isomorphism that everything that we perceive is perceived subjectively. Hence, we will not make a distinction between structural and functional isomorphism.

6. Transduction as a metaphor of genetical inheritance

Being able to trace the way in which the properties of sounds and images change in time makes it possible to measure and codify their evolution under different supports (such graphics, musical notation, alphanumeric code, etc.). Represented as code, the dynamics of the movement of an object in a source modality may be mapped onto another modality while preserving a structural correspondence. This mechanism evokes the way in which transduction is understood in the field of genetics, in which ADN (genetic code) is transferred from one bacteria to another one by a virus (Nair 2008). The presence of this kind of transduction in the audiovisual domain reflects in the use of concepts for describing, analyzing or operating on properties of visual and sonic morphologies (motion, growth, texture, behavior, spectra, noise, density, space, etc.), providing us with insight on the way in which the elements of both modalities relate “genetically” between them.

An example of transduction through isomorphism can be found in the relationship between Iannis Xenakis’s score of “Metastasis” and the Phillips Pavillion’s architectural planes. “Metastasis” and the Phillips Pavillion are structurally isomorphic because they have the same information content as the structural percept that they represent.

Nowadays, transduction based on isomorphism has spread widely in computer art through various softwares (such as Jitter, Praat, Spear, Soundhack, etc.) that allow us to represent different parameters of sounds and images as code that can circulate between both domains[1]. In my audiovisual piece “Elastic Study” for example, transduction was established by coding variations of different parameters of sound objects and mapping them onto different parameters of visual objects. Represented as numbers, the fluctuations of psychoacoustic characteristics (such as noisiness, intensity and brightness) were scaled to control parameters of visual objects (such as speed, color and movement). The scalings between the coded parameters of the analyzed sounds and the coded parameters for the real-time generation of images were adjusted depending on the expressive needs of each particular moment while remaining isomorphic thoughout the piece.

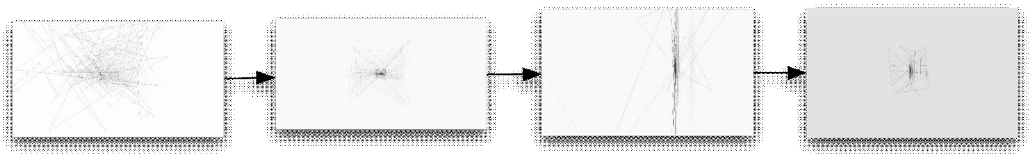

Fig. 2 “Elastic Study”: visual objects resulting of a transduction between sound and image

through isomorphism

7. Transduction as a metaphor of the body

Transduction is a basic procedure for musical ideas that draw from the perceptual dynamics of images. For example, in Javier Álvarez’s piece for cello, electroacoustic sounds and video “Le repas du serpent/Rétour a la raison”, the video part portrays a scene in which a snake swallows a rabbit while the cello player performs rotations, variations of speed, bow pressure, changes of trajectory and muscular tone that are coherent with the structures expressed in the video. In this piece, the instrumental and electroacoustic sounds remain isomorphic with the visual percepts that they simulate.

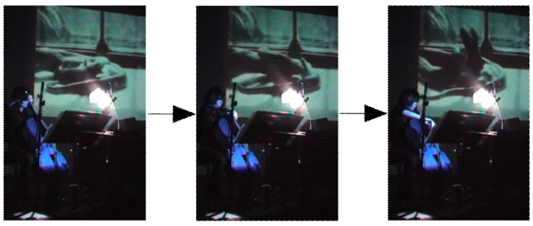

Fig. 3 Transduction from image to sound in Javier Álvarez’s “Le repas du serpent”

In music performance we can find various examples of how simulation plays a key role for achieving transduction between image and sound. The most common one would be the feedback loop that is created between the body expression of a conductor and the actions of a performing orchestra. In a performance situation, musicians have to make a constant prediction of the nuances of the conductor’s gestural expressions and simulate these through sound-producing actions. In turn, the conductor has to develop a constant adjustement of his body image depending on the sonic results that he wants to modify in response to the way the orchestra is playing.

8. Transduction from mental imagery

It is important to note that a perceived experience can be actual or imaginary. Studying transduction from an imaginary experience poses serious methodological problems because of the difficulty of observing what happens in the mind during the process of imagining. Nevertheless, there exist several imaging methods for observing what is assumed to occur in the brain during the act of mental imagery, which consists on imagining perceptual experiences in the absence of their corresponding external stimuli (Godoy 2003). Mental imagery can be activated in different sensory modalities, and its varieties (auditory imagery, visual imagery, motor imagery, etc.) refer to specific kinds of imagined perceptual experiences.

A significant discovery is that of “functional equivalence”. This term refers to the fact that motor imagery and motor preparation and execution are related to the same neuronal areas (Decety & Graces, 1999), meaning that there is a close resemblance between the ways in which the neuronal apparatus is activated when experiencing actual actions and/or perceptions and when experiencing imagined actions and/or perceptions. Considerable evidence in support of the functional equivalence issue is provided by analysis of the neural mechanisms that are active during the processes of imagining and executing actions (Holmes et al. 2001).

Functional equivalence indicates that a creative strategy based on an imaginary perceptual experience (visual or auditory) can be as effective for establishing a transduction relationship between sound and image as an actual experience. Also, another interesting finding here is that, because any imagined movement and associated actions will take place in imagined space, there will usually be some associated imagery in other sensory modalities (Decety & Graces, 1999). Berthoz (Berthoz, 1997) reminds us that our action inhibition mechanisms play an essential role in internal simulation, allowing us to imagine (simulate) actions without necessarily executing them.

9. A semiotic perspective on the concept of transduction

As we have mentioned before, sounds and images are mental elaborations and their relationships to experience and culture cannot be separated from them. Perception is a constant elaboration of meaning and a transductive approach should take into consideration the transferences of the different kinds of meaning that take place between sounds and images. If we thus regard an audiovisual system as a semiotic system, then we can draw on the literature of semiotics for some useful analytical concepts.

Jesús González Maestro (Maestro 2005) states that for semiotic transduction to take place, an intermediary agent has to transform the meaning of the message sent to the receiver. In audiovisual creation, this process places the intermediary subject in the center of a net in which different kinds of musical and visual signs are transformed and transmitted through his mediation. Factors like intuition, personal motivations, experiences, cultural context and the knowledge or skills that an individual may have on sonic and visual areas play a key role in creating meaningful (semiotic) contents out of sonic or visual signs. In this context, sonic and visual signs mean sounds and images that can express something, that embody a special meaning that become actual through their appropriation by a receiver (audience).

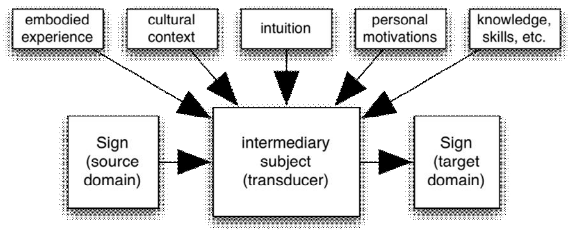

Fig. 4 Transduction of meaning between a source and target domain

In some art forms like theatre, opera, video-art and cinema, the complexity of transduction can increase in particularly interesting ways in virtue of the variety of semiotic systems that they integrate. T. Kowzan (Kowzan 1969), for instance, classifies thirteen semiotic systems used in a theatre representation: 1. word; 2. tone; 3.mimics; 4.gesture; 5.movement; 6.makeup; 7.hairdress; 8.clothes; 9. accesories; 10. decoration; 11. illumination; 12. music; 13. sound effects. Of course other categories could be added, and the boundaries between some of the above are fuzzy, but this classification can help us to get an idea of the different sonic and visual systems that can interact in a creative process. A glimpse of an eye, a color, an inflection of the voice, a camera angle, an accesory or a sound... in a creative context anything can act as a sign (Kowzan 1965) because signs are created by human activity.

The richness of such art forms would imply the consideration of various kinds of visual and sonic semiotic systems that, in spite of their differences, are related by an intermediary subject (a transducer). This transducer takes on an objective form from the moment in which its action upon the message and during the communication process is able to condition the reception possibilities on the part of the audience (Maestro 2005).

10. Final remarks

Exploring different ways in which transduction processes between sound and image can take place could prove beneficial for expanding the existing compositional strategies in sonic, visual and audiovisual arts. From my perspective, a transductive approach to software design could be particularly useful for enhancing the possibilities of the existing audiovisual systems. An interesting technique developed in machine learning called "transductive inference" (Gammerman et al. 1998) could be a fruitful research path for creating technologies in which observed (training) cases of transduction between sound and image serve as a basis for generating new specific ones in response to either sonic or visual input.

Finally, I believe that a theory of audiovisual creation that seeks to study the actions of the subject beyond structures, analogies or referents must consider the use of a poetic of intermediaries: a poetics of transduction (Maestro 2005). This approach would allow for a more far-reaching holism that could give new insight into the neural activity, experiences, concepts, intentional actions and thoughts with which subjects may intervene to transduce meaningful contents between sonic and visual systems.

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