ON THE NOTION OF TRANSMUTABILITY: FROM CONCEPT TO PRACTICE

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The study documented in this paper aims to explore the creative potential that is inherent to the notion of transmutability of digital data. It begins by addressing the topic, discussing its principles and possibilities, while also examining the diverse approaches and practices that it encompasses. Based on these guidelines, we develop a project as a practical illustration of the topic, outlining a methodology that provides a starting point for further creative explorations of the concept. This study suggests the expressive and communicative potential of audiovisual languages that creatively explore the inherent mutability of digital data.

1. INTRODUCTION

This study was developed under the Communication Design and New Media MA program at the University of Lisbon and assumes as its starting point a focus on sound-image relations in the digital context. With the computer, "all new media objects are composed of digital code; they are numerical representations" (Manovich 2001: 27) which, when regarded as raw material, can be translated into other formats through algorithmic manipulation. New possibilities for linking, generating and manipulating sounds and images arise by corresponding its parameters. This represents a creative potential that is expressed by practices that rely on software to develop aesthetic artifacts that can involve not just articulations between the visual and auditory, but also with any physical or sensory domain.

According to Levin (2010: 271), a principle that motivates the development of this kind of artwork is the transmutability of digital data, which refers to the mapping of some input data stream into sounds and graphics. This paper explores the concept from its theoretical discussion to its practical exploration. We begin by providing an overview of the theme by relating the terms and principles that can be associated with this concept. We then outline the diverse approaches that it can encompass through an analysis of artworks that address or express the concept of transmutability. Based on this framework, we develop a project that aims at highlighting the expressive potential of the theme, while following a methodology that provides a starting point for further creative explorations of the topic. This study considers the notion of transmutability and its significance in exploring, through technological means, dynamic audiovisual languages that can promote new ways of perceiving and experiencing data.

2. TRANSMUTABILITY (IN THEORY)

2.1. CONCEPT AND ASSOCIATED TERMS

The principle of the transmutability of digital data is expressed by the mapping of any input data stream into sounds and images. According to Golan Levin, "the premise that any information can be algorithmically sonified or visualized" motivates the development of aesthetic

artifacts, either as “a starting point for a conceptual transformation and/or aesthetic experience”, or as “a means to an end, in enabling some data stream of interest to be understood, experienced, or made perceptible in a new way” (Levin: 273-274).

In order to provide a deeper understanding of this concept one can address related notions that similarly express the inherent ‘mutability’ of digital data, as explored by mapping different physical and sensory domains into new tangible (visual and auditory) forms. This idea relates to the *transcoding* or “conversion of one type of digital information into another” as a direct consequence of describing information numerically (Reas, McWilliams and LUST 2010: 79). As argued by Manovich, this reflects one of the “most substantial consequences” of media computerization, since all “cultural categories and concepts” can be substituted by new ones “which derive from computer’s ontology” (Manovich 2001). Similarly, this notion supports *transmediality*, as a “translatability across media” (Hayles 2006: 194). It is also associated to *transmateriality* as a view of “digital media and computation as material flows, ... transducing anything to anything else”, while “expanding its connections with the environment” by “sourcing new inputs and/or manifesting new outputs” (Whitelaw 2009). These terms invoke software as a means of exploring digital data as a “self-contained abstraction” or its “inherent malleability” (Whitelaw 2008).

2.2. PRINCIPLES AND POSSIBILITIES

Transmutability can be seen as a theme of aesthetic artifacts that use software as their medium and whose focus is on data. This interest is tied to the “nature of our now ubiquitous data systems”, as creatively questioned through practices that make data “explicit” and tangible, while probing its “potential, and significance” (Whitelaw 2008).

These practices may entail different approaches and methods for reconfiguring data. Some projects emphasize transmutabilty *per se* as subject matter, or the (transformational) mapping process of data as “an abstract set of potentials, an array of values waiting to be mapped”. They explore how any given data can be mapped onto a new representation or tangible form, regardless of its source or origin. In contrast, other projects focus on some data stream of interest, seeking to provide a new perception of

it, or to "portray not merely data, but the personal, emotional reality that the dataset refers to" (Whitelaw 2008).

These strategies evoke "the promise of rendering the phenomena that are beyond the scale of human senses into something that is within our reach, something visible and tangible" (Manovich 2002).[1] Following different aesthetic intents, the process of mapping is used as a means to completely reconfigure a dataset into an aesthetic or communication artifact (Whitelaw 2008). In this sense, transmutability puts an emphasis on data as content, on its representation and perception, and on the mediating transformational process.

2.3. VISUALIZATION AND SONIFICATION

By suggesting that any given data can be mapped onto a visual and auditory form, the notion of transmutability is a term that encompasses both the concepts of visualization and/or sonification. In general, visualization refers to the "visual representation of quantified data which by itself is not visual" (Manovich 2002); it involves an interpretative process that implies "the development of a visual image in the human mind" (Tavares and Alexandre 2007). In parallel, sonification is commonly defined as the use of non-speech audio to convey information (Kramer, *et al*. 1997); more precisely, a technique that uses data as input to generate sound signals that reflect objective properties or relations in the input data, and which transformation is systematic (Hermann 2008: 2).[2]

A particular interest of this study is on the associations of these concepts, as circumscribed to sound visualization and image-based sonification processes. Although their logic and representation principles may be similar, the source data diverges, being respectively sound or image.

When assuming visualization and sonification as complementary concepts, it is possible to identify common traits or methodologies. Both involve "two nodes in the process: encoding and decoding", meaning, a method of mapping data relations to sounds, and the interpretation of relationships contained in the information (Song and Beilharz 2006: 450). While encoding entails "evaluating interesting aspects of data, extracting data relations and choosing appropriate parameters for matching the variation in data", decoding relates to how users "understand the information embedded in sounds" and images (451).

1 While this may encompass diverse possibilities of representation or tangible forms, including multimodal or tactile experiences, this study focuses on visual and auditory forms.

2 As defined by Hermann, a technique that uses input data to generate "sound signals (eventually in response to optional additional excitation or triggering) may be called sonification, if and only if: (C1) The sound reflects objective properties or relations in the input data. (C2) The transformation is systematic. This means that there is a precise definition provided of how the data (and optional interactions) cause the sound to change. (C3) The sonification is reproducible: given the same data and identical interactions (or triggers) the resulting sound has to be structurally identical. (C4) The system can intentionally be used with different data, and also be used in repetition with the same data" (2008: 2).

Another aspect of this general methodology concerns the nature of the approach; if it is mainly analytical or aesthetic. The objective may be to provide a new reading or understanding of the information, therefore, the mapping "should convey the unique properties of the data set it represents" (Fry 2008: 16). Conversely, the aim can be to create expressive languages or sensory experiences, when the artist defines subjective criteria, and takes advantage of the arbitrary nature of the mapping process, as suggested by Manovich (2002). However, as mapping is always a systematic process, any of these approaches entails "a pragmatic information aesthetic that combines the functionality of information design with the aesthetic sensibilities of the sonic [and visual] arts" (Barrass and Vickers 2011: 152).

3. TRANSMUTABILITY (PRACTICES)

3.1. SELECTION OF WORKS

In order to demonstrate the range and scope of transmutability in creative practices, we selected and analyzed a group of 28 projects that, in a more or less explicit way, relate to, imply or express this concept. We assume a correspondence to the idea of transmutability when the artifact: (1) uses software as its medium; (2) explicitly works on or explores some given input data; (3) entails visualization and/or sonification, and (4) emphasizes as subject matter, or renders significant and meaningful, its data or transformation processes.[3] Having these common traits, we distinguish them in terms of their objectives, format, presentation context, and also data and mapping processes, as well as their variability and audio-visual modes of expression.

1. Nicolas Reeves. *Cloudharp*. 1997.
2. Ken Goldberg, *et al*. *Mori*. 1999.
3. Ken Goldberg, *et al*. *Bloom*. 2013.
4. Lisa Jevbratt. *1:1*. 1999–2002.
5. Lisa Jevbratt. *Mapping the Web Infome*. 2001.
6. Alex Galloway/Radical Software Group. *Carnivore*. 2001.
7. John Klima. *Ecosystm*. 2001.
8. Mark Napier. *Feed*. 2001.
9. Mark Hansen and Ben Rubin. *Listening Post*. 2001.
10. Mary Flanagan. *Collection*. 2002.
11. Cory Arcangel. *Data Diaries*. 2002.

3 Following these criteria, we selected these artifacts primarily from the bibliographical sources consulted during the research process, provided that there was sufficient information about the work, even if we had no direct contact with it.

12. August Black. *Datadada*. 2003.
13. Andrea Polli. *Atmospherics/Weather Works*. 2003.
14. Peter Luining. *ZNC Browser 2.0*. 2003.
15. Jens Brand. *G-Player*. 2004.
16. Stanza. *Sensity*. 2004.
17. Semiconductor. *Brilliant Noise*. 2006.
18. Semiconductor. *20Hz*. 2011.
19. Ryoji Ikeda. *Datamatics*. 2006.
20. Ryoji Ikeda. *Test Pattern*. 2008.
21. Art of Failure. *Laps*. 2007.
22. Lab[Au]. *Binary Waves*. 2008.
23. Ubermorgen. *The Sound of Ebay*. 2008.
24. Chris Sugrue and Damian Stewart. *Waves to Waves to Waves*. 2008–2009.
25. R. Luke DuBois. *Hard Data*. 2010.
26. Nicolas Maigret. *Pure Data Read as Pure Data*. 2010.
27. Marco Donnarumma. *The Invisible Suns Project*. 2010.
28. Carrie Bodle. *Wavelines*. 2012.

3.2. MODEL OF ANALYSIS

The analysis is anchored on the frameworks proposed by Wardrip-Fruin (2006) and Hunicke, LeBlanc and Zubek (2004) for considering and understanding digital computational media.[4] According to which according to the model proposed by Wardrip-Fruin, these entail the following elements: author (who selects and creates the work's data and processes); data (non-process elements of the work); process (operations performed by the work); surface (what the work turns to its outside); interaction, defined as change to the state of the work that comes from outside the work (from outside processes and data sources, requested by the work's processes); and audience (people who experience the work's surface) (2006: 9-11).

These systems can then be distinguished according to the forms and roles of computation they entail, as works that do not just "require computation before the audience experience" (or authoring process), but also require computation during such experience (Wardrip-Fruin 2006: 12-13). They can be "computationally variable" as "works in which the processes are defined in a manner that varies the work's behavior (randomly or otherwise)", i.e., either "without input from outside the work's material", with input from external data or processes, and with human

4 The author establishes a difference between digital computational media and "fixed media" (e.g., fixed music distributed on CDs, video distributed on DVDs) as media that do require digital computation at the time of audience experience, but in a manner that does not define the work. This means "the work does not require digital computation in order to be itself". In contrast, we consider "work which explicitly includes processes of digital computation in its definition, such as a computer game requires digital computation" or interactive work which requires computation to support the interaction – it is "explicitly designed for its surfaces to be experienced in a context employing digital computation", performed by any computational device. (Wardrip-Fruin 2006: 12-19).

input, as audience interactive systems (Wardrip-Fruin 2006: 397-400).

In addition, different perspectives or ways of looking at these systems can be combined, according to the MDA framework (Hunicke, LeBlanc and Zubek 2004), namely: *mechanics* (the particular components of the system, at the level of data representation and algorithms), *dynamics* (the run-time behavior of the mechanics acting on user inputs and each other's outputs over time) and *aesthetics* (the desirable emotional responses evoked in the user, when he interacts with the system).

The conducted analysis was mainly based on the surface of these systems and on the information collected from their associated literature. However, despite the limitations imposed by these means of observation and the absence of direct contact with some of the works, we were able to deduce aspects of their mechanics and dynamics. According to the previous frameworks, our model combines both the focus on processes and on the work's experience, articulating the following dimensions:

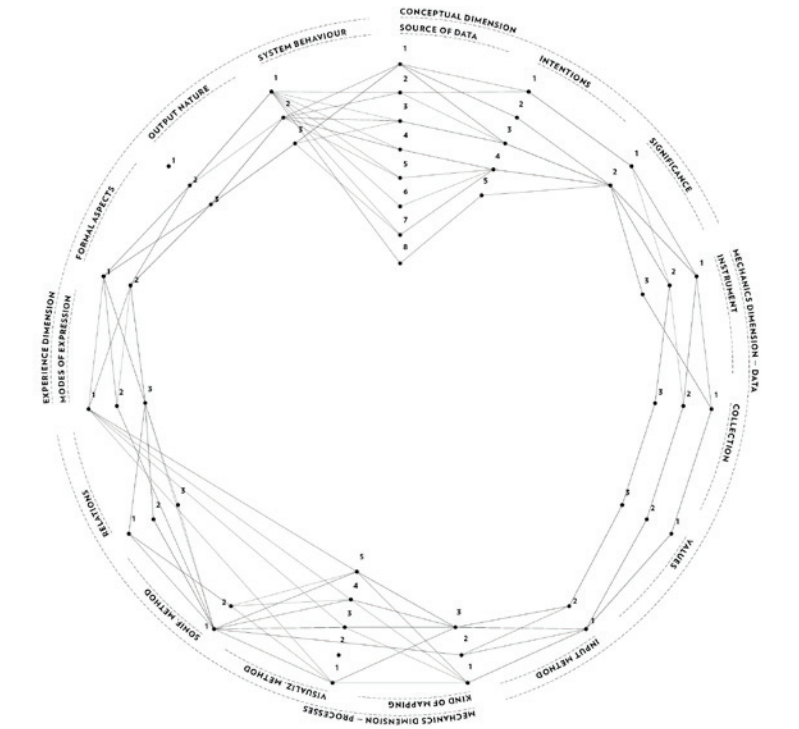
Conceptual dimension (theme and content)
Focusing on the objectives and subject matter of the work, namely, its source of data (as information or content), and the significance and relevance of transmutability (as artistic argument).

Mechanics dimension (data and processes)
Regarding the constituent elements of the system, such as instruments for collecting data, time of data collection, input method, kind of mapping processes (visualization and/or sonification) and their relations (when combined).

Experience dimension (surface and dynamics)
Considering elements that are related to the sensory experience and observable behavior of the work, such as, modes of expression and communication (audio or visual), formal aspects of representation, nature of the outputs (static or not), and the dynamic behavior of the system (regarding its variability).

3.3. OBSERVATIONS

Fig. 1 Projects' analysis diagram



EXPERIENCE DIMENSION

MODES OF EXPRESSION	FORMAL ASPECTS	OUTPUT NATURE	SYSTEM BEHAVIOUR
1 ONLY VISUAL	1 ANALOGY TO THE REFERENT	1 STATIC	1 INTERACTIVE
2 ONLY AUDIO	2 ABSTRACTED FROM THE REFERENT	2 TRANSIENT	2 OPEN
3 AUDIOVISUAL		3 VARIABLE	3 CLOSED

CONCEPTUAL DIMENSION

SOURCE OF DATA	INTENTIONS	SIGNIFICANCE
1 INTERNET	1 EMPHASIS ON TRANSMUTABILITY	1 THEME
2 HARD DISK	2 DATA DENSITY	2 MEANS TO AN END
3 SOCIAL FLOWS	3 DYNAMIC FLOWS	
4 EARTH'S SURFACE	4 NATURAL PHENOMENA	
5 METEOROLOGY	5 NO INFO	
6 ASTRONOMY		
7 MAGNETISM		
8 NO INFO		

MECHANICS DIMENSION – DATA

INSTRUMENT	COLLECTION	VALUES	INPUT METHOD
1 COMPUTACIONAL PROCESS	1 REAL TIME	1 STREAM	1 AUTOMATIC
2 DATASET	2 PROGRESSIVE	2 CHUNKS	2 BY THE AUTHOR
3 SENSORS	3 A PRIORI	3 FIXED	

MECHANICS DIMENSION – PROCESSES

KIND OF MAPPING	VISUALIZ. METHOD	SONIF. METHOD	RELATIONS
1 VISUALIZATION	1 GRAPHIC	1 PARAMETER MAPPING	1 SEQUENTIALLY
2 SONIFICATION	2 DIAGRAM	2 AUDIFICATION	2 IN PARALLEL
3 BOTH	3 MATRIX		3 IN CIRCLE
	4 DYNAMIC MAP		
	5 OTHERS		

The above-mentioned dimensions are inseparable and interdependent, since the work's dynamics arises from the mechanics, which in turn encompasses the formal specification (as data structures and algorithms) of the intentions and aesthetic aims of these projects. Their observation stresses the salient traits of these projects.

We distinguish projects like *Data Diaries* (that fools Quicktime into thinking a computer's memory file is a video file) that explore the concept of transmutability in its essence, while emphasizing the malleability of digital data, from projects that explore representations of human-related dynamic flows of information, or dimensions of natural phenomena that are beyond the scale of the human senses. Such is the case with *Brilliant Noise*, that "reveals the energetic particles and solar wind" in a tangible manifestation.

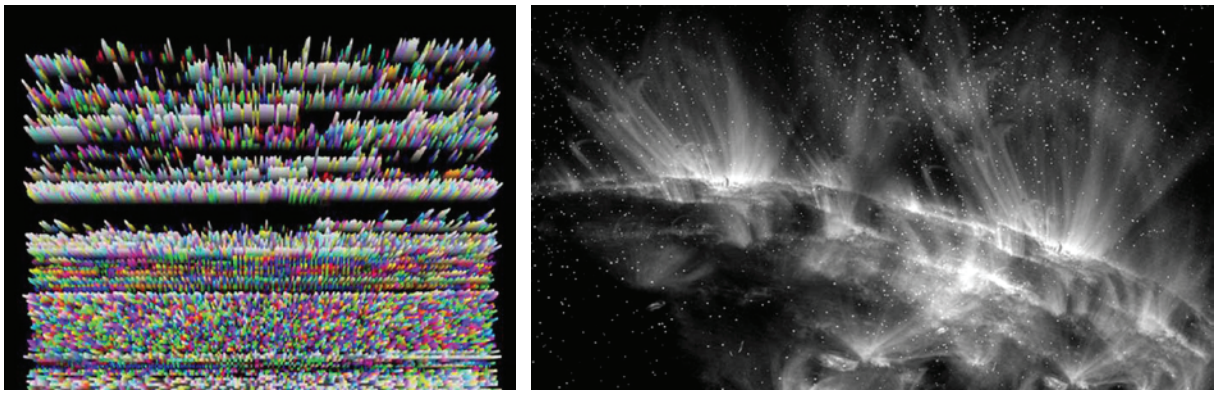
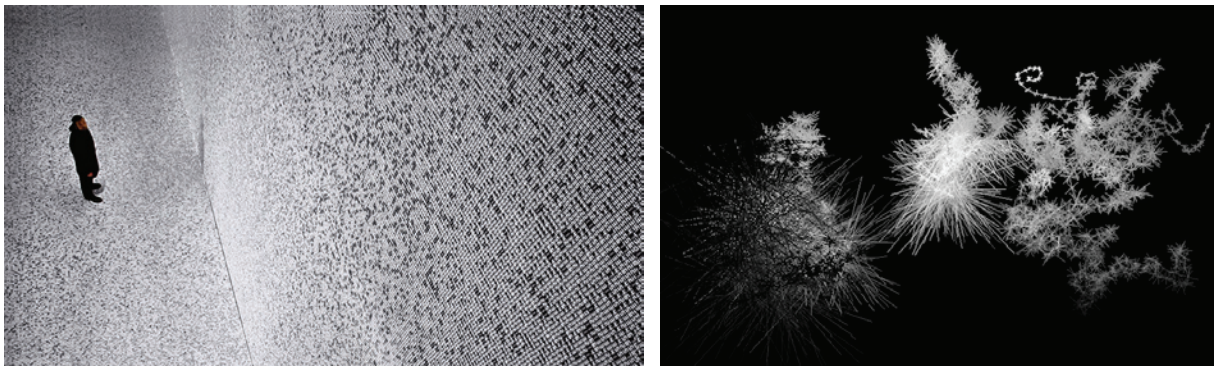


Fig. 2 *Pure Data Read as Pure Data* (Nicolas Maigret 2010) and *Brilliant Noise* (Semiconductor 2006)

These intentions are reflected in formal aspects of expression. Some projects highlight the quantitative nature of data as raw material through abstract visual and auditory forms, as seen in *Pure Data Read as Pure Data* (in which the patterns and sounds are generated by the source code of the program). Other projects deploy more organic languages, such as *Mori*, that uses environmental sound samples (namely rockslides, volcanic eruptions, thunder claps, avalanches, and industrial noise), in order to create an analogy to the represented phenomena.

The source of data and the system's behavior also influence the nature of the output, depending on whether it is open (or not) to interaction with external inputs. For example, the project *Datamatics*, which in its installation version assumes fixed datasets inserted during the authoring process, results in a transient output that favors a contemplative experience of "the invisible multi-substance of data that permeates our world". On the other hand, in *Waves to Waves to Waves*, a continuous data stream determines the real-time variation of the output, promoting interaction and an immediate reading of the mutations generated by the inputs.

Fig. 3 *Datamatics* (Ryoji Ikeda 2006) and *Waves to Waves to Waves* (Chris Sugrue and Damian Stewart 2008–2009)



4. TRANSMUTABILITY (IN PRACTICE)

From the previous observations we extracted principles that guided the practical component of this study, as an exploration and illustration of the topic. This was defined as a meta-project, in the sense that explores different ways of audio-visually translating the textual contents of the dissertation on which this paper is based; it seeks to provide a new perception or experience of this content, through seeing or hearing.

4.1. CONCEPT, MECHANICS, EXPERIENCE

In terms of *concept (theme and content)*, the project departs from an analytical stance towards a more expressive approach. By mapping data relations to graphics and sound, rather than favoring interpretations of relations, these representations become ultimately abstract and emancipated from their referent. The practical experiences were gradually detached from the text's semantic content and oriented towards an aesthetic exploration of the expressive qualities of its visualizations and sonifications.

Regarding *mechanics (data and mapping processes)*, the starting point was a selection of three main sections of the dissertation, as chapters of a different structural and semantic nature; an aspect that gives rise to different visualization and sonification approaches. Following the general steps proposed by Song (2006), and inspired by simple textual analysis and visual mapping techniques, as seen in *Writing Without Words* by Stefanie Posavec (2008), we begin with an analysis of relations between textual elements that are mapped to graphic elements, which in turn are the starting point for algorithmic sonifications that are later combined with these visualizations.

In terms of *experience (surface and dynamics)*, we opted for the use of elementary figures and sounds, seeking to minimize aspects that are accessory to the audio-visual reading of the text. As static representations they reflect the structure, correlation and recurrence of key elements of the dissertation, *in abstacto*. Presented as transient sequences, these images are accompanied by a similarly minimal aesthetic of simple sounds that, when combined, produced more complex textures.

4.2. DEVELOPMENT AND RESULTS

The presented work results from a closed system of correspondences, between text, graphic symbols and sound parameters. Its development involved analyzing and extract-

ing themes and keywords from each section of the text and defining graphic symbols, while similarly considering the tables and diagrams resulting from the analysis of the artifacts studied, as abstract graphic notations for sonification. This set of visual representations pertains to the structure, recurrence and spatial configuration of textual elements in each section of the dissertation.

We then defined their corresponding sound parameters by exploring frequency and amplitude modulation and sound filtering techniques. The visualizations and sonifications were thus combined, resulting in two graphic scores that are presented sequentially and a third sequence combining the diagrams, each with its associated sound, that the user can activate or deactivate.

The visualizations are presented both as static images of a whole section of the dissertation and also combined with the sonifications, where the temporal sequence becomes an abstract narrative of this study. These were integrated in an online platform[5] that contextualizes the project and its methodology, and provides the source files for download.

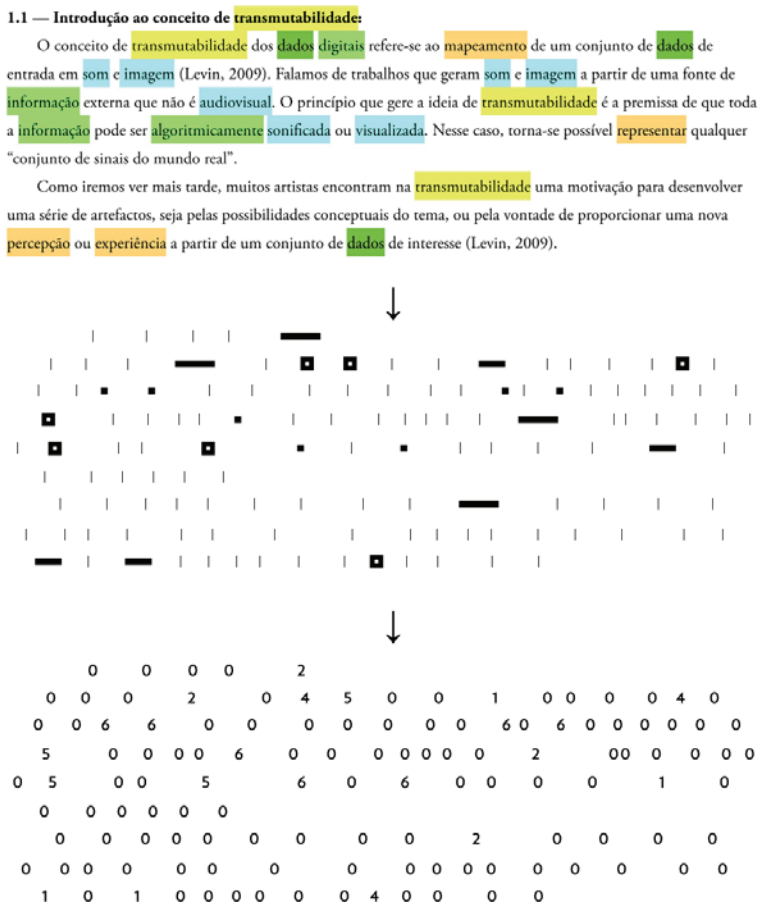


Fig. 4 Mapping process

5 *http://tinyurl.com/ovj7y7j*

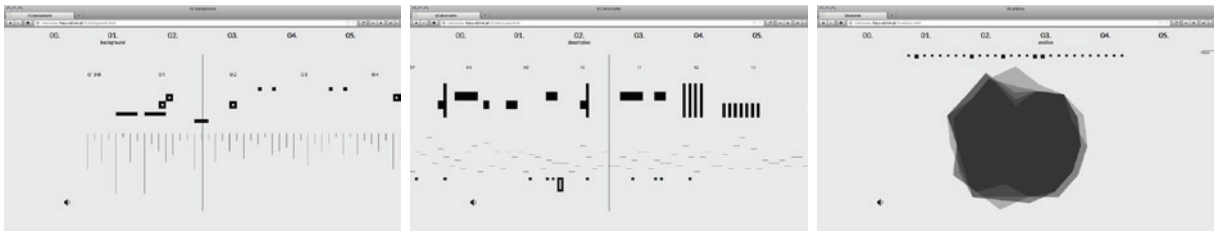


Fig. 5 Resulting audiovisual sequences – screenshot

Consequently, rather than promoting change, the static and transient outputs and the closed non-variable nature of this work highlight a diversity of possible derivations, reinterpretations and subjective approaches to the same referent, therefore promoting a contemplative experience.

This project can then be understood as an open process, where the produced visualizations and sonifications provide a starting point for further explorations of the creative and expressive potential of transmutability, namely through other data and mapping processes. While this study focused on devising an expression adequate to its specific source information or content, further developments contemplate the expansion of this methodology to more complex algorithmic mappings or dynamic results.

5. CONCLUSION AND FUTURE WORK

This study focused on the creative exploration of the concept of transmutability. In order to address this topic we acknowledged its multiplicity by discussing its associated concepts and by examining practices that creatively explore the premise of the mutability of digital data. In line with this idea, this study underlines the theme's expressive potential by developing a project based on the dissertation's contents. In this manner, this work sought to contribute to a deeper understanding the notion of transmutability and how it becomes significant and meaningful in the ways it emphasizes data as content, its representation and perception, and the procedures for its reconfiguration.

The notion of transmutability not only implies the development of visual and auditory renderings of data, but is above all, an exploration of expressive audiovisual languages, which, by means of technology, allow a new perception or aesthetic experience of data. These ideas are evidenced by the examples analyzed and guide this practical exploration of the topic.

The interest in data is often connoted with complex and intangible phenomena or with the abstract nature and inherent malleability of digital data, while the processes for its reconfiguration evoke the computational medium's potential for proposing new aesthetic experiences, and allowing the audience to contemplate or interact with the data that permeate our world. This study then sought to reveal how transmutability becomes relevant as an artistic argument, when approaching our contemporary condition of immersion in digital data.

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