RHETORICAL SCHEMES FOR AUDIO COMMUNICATION

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ABSTRACT

The application of rhetorical techniques to the use of non-verbal sound in the interaction between humans and technologies is the core idea of this paper. We present our ideas at a general level and illustrate an exploratory case based on the application of rhetorical schemes to the sonification of computer operating system events. Both cases of musical sounds and everyday sounds are investigated.

This work is intended as a preliminary study aiming at motivating a larger scale and more rigorous research about the potentiality of the use of rhetoric in the domain of Auditory Display (AD) and Sonic Interaction Design (SID).

1. INTRODUCTION

Sound is increasingly present in any occasion of our life. Nowadays, everyday objects and environments can be easily augmented with sonic features by means of embedded loudspeakers, microprocessors, and wireless connection facilities. On the other hand, sound is a powerful and natural means to rapidly convey continuous information about object/animal activities, events and processes occurring in the surrounding environments. Simple but already pervasive examples of artificial sounds currently in use range from cell-phone ring tunes to sounds for computer up to interactive audio monitoring for video games or medical applications. The growth of a shared audio-vocabulary based on iconic audio messages is envisaged as a potential breakthrough in the enhancement of the interaction with machines. The challenging task is to develop robust principles for a semantically effective design of this common audio-vocabulary. A significant effort in this sense was presented in [1]. In that paper, the author states that "sounds are too complicated to be designed in purely analytic manner. We will never have a complete set of rules to determine how specific meanings should be expressed as non-speech sound". However, he investigates "the intuitive interpretation of highly symbolic sounds" and a number of cases and experimental results about audio-video relationships between iconic images and iconic sounds are presented and discussed. While agreeing on the impossibility of defining a complete set of rules, in this paper, we propose a novel methodology aiming at defining useful guidelines for a semantically effective sound design. Our strategy consists in investigating the potentiality of using rhetorical techniques in the process of designing non-verbal sound for human machine communication. We consider both verbal communication techniques, consolidated along the centuries-old tradition of classical rhetoric, and the more recent tradition of musical rhetoric of the 16th-18th centuries, which is by itself a successful example of transposition of verbal rhetorical schemes to another domain: Music.

The general research strategy that we envisage for the future is that of an inter-dependent investigation through three main streams: the identification of a set of rhetorical figures to be adapted to a functional/information domain; the design of AD applications and sonic-based interactive prototypes by employing the selected figures; the validation of the prototypes by means of user tests. The results of these tests will be used as feedback for the validation and redefinition of the rhetoric-based guidelines previously established. In this paper, we concentrate on a basic pilot experiment involving the widely-tested subject of sound design for computer operating system events. A set of common editing commands are sonified by means of sets of earcons and auditory icons either employing or not employing rhetorical figures. The different outcomes for the rhetorical and non-rhetorical cases are presented and discussed. Although we are aware of the difficulty of linking the structural and semantic levels even at such a simple case as that of basic computer operating system tasks, we are strongly convinced that the potentialities of the employment of rhetorical techniques for a robust sonification are extremely promising for a wider range of auditory-based applications.

2. SEMANTIC ASPECTS IN SONIC-BASED INTERACTION

In AD [2] and, more recently, in SID [3][4] applications, the goal is to employ sound as a vehicle of information. Sound perception and experiencing involves semantic aspects that have to be seriously considered. In other words, sound has to be viewed as carrier of semantic contents. All of these aspects have to be taken into account in order to pursue an effective communication process [5], [6].

The main idea of this work is to involve rhetorical techniques [7] in the design process of AD and SID. A similar investigation has already been initiated in the fields of multimedia and web communication [8][9]. Rhetoric schools have developed through the centuries a set of guidelines for organizing communication by exploiting the aesthetics and emotional response of human beings. It seems thoroughly appropriate to involve this fundamental cultural inheritance of western humanities history in the design of communication between humans and machines in general.

Our aim is to investigate how rhetoric could lead to the definition of strong reference guidelines for sound design in augmented and interactive environments. In particular, we will concentrate on the musical rhetoric of the 16th-18th centuries, i.e. on that experience of European music [10] – [16], which

represents a consolidated and successful transposition of rhetoric to non-verbal sound, for the definition of a "language of emotions", the so-called theory of affects.

Everyday sounds are also considered, with a particular attention to the case of cartoons. Specifically, we performed a simple analysis of the morphological, syntactical and semantic aspects of a couple of examples from the cartoon *Coming Out* (1934) by Walt Disney, in order to show how a rhetorically-based analysis can be an effective method for describing and employing everyday sounds in AD applications.

We think that rhetoric is not only able to strengthen the structural coherence of a sonification, but also to build the basis for its semantic effectiveness. All this seems to be coherent with the evidence that music, from one side, and non-verbal sounds for AD applications and interaction between humans (and machines), from the other, have one fundamental common point: they are all structured according to temporal logics.

3. RHETORIC STRATEGIES FOR AUDITORY DISPLAY AND SONIC INTERACTION DESIGN

Within the humanities, rhetoric is defined as the art or technique of persuasion through the use of oral or written language. Ancient Greek and Roman theoreticians stressed the importance of orator's coordination among face, gesture and speech in order to effectively communicate with his audience. Prosody was taken into account as means not only to emphasize emotional contents, but also to clarify the contents of the text. Though Music in the Middle Age belongs to the Quadrivium (altogether with the disciplines of Arithmetic, Geometry and Astronomy), theoreticians like Boetius stress analogies between Music and the literary arts of the Trivium (Grammar, Dialectic, Rhetoric). Music was at this time almost solely vocal; text and music structures were interrelated in order to achieve the greatest variety in vocal sound. In the Baroque era, musical rhetoricians emphasize that even instrumental music (i.e. without singers) can be effectively organized and structured in time both at a micro and at a macro temporal scale in order to achieve a more understandable form. At a micro level, instrumental (non-verbal) sounds build musical figures that we could define as object-figures (like the *exclamatio*, a note unexpectedly played in a very high register or the *anabasis*, a group of notes, whose pitch raises through whole-tone or half-tone steps). At a higher level, these sounds form relation-figures (like the *anaphora*, a regular repetition even transposed of a melodic cell, or the *antithesis*, the contrast between two object-figures following one another). Thanks to the structural analogy between music and verbal speech, rhetoric can, thus, organize the time disposition of the elements both of a discourse and of a musical piece and successfully achieve human communication by correctly addressing the logical and emotional sphere of the listener. Descartes' mechanistic theory stresses that "perceptions or sensations or excitations of the soul ... are caused, maintained, and strengthened by some movement of the spirits" [17], According to this theory, the temporal organization of music with its energy and speed is responsible of awaking one or more passions in the human soul. These passions are determined by the faster or slower speed and the greater or less amplitude of the movements of the soul that produce them [14]. Musical rhetoric becomes, thus, useful for organizing the syntax of a piece, in order to make it semantically effective and able to successfully arousing communication by correctly addressing both the logical and emotional spheres of the listener. For these reasons, even though more recent models of the mind are quite different from that of Descartes, the principles of the baroque musical rhetoric can represent a very useful source of guidelines for the design of effective AD applications. As a matter of fact, they stress that the semantic and structural dimensions have to be strictly interrelated. Up to nowadays, the relationships between semantic and structural dimensions were not clearly and convincingly investigated. On the other side, they represent a challenging and not univocally defined research domain. Even if this work does not have the ambition of providing crucial results in the context of such a general and fundamental debate, it does not exclude the possibility of exploiting possible relationships between structure and semantic contents.

After disappearing from the treatises of the 19th and of the first half of the 20th century, rhetoric enjoyed a renaissance in the second half of the past century, both in musical context [18] and in other domains. The "new rhetoricians" [19] extended the use of rhetoric to the everyday language. After Barthes' studies [20] and Metz's researches [21], the "Groupe μ" from Liège [22] applied rhetorical figures (semiotically defined as deviations from the regularity of the text) not only to the analysis of the poetry, but also to that of images and of the visual world in general, distinguishing even in this case objects-figures ("signes iconiques") from relation-figures ("signes plastiques") (see also [8]). Also, psychology studies [23] explain the psychological mechanisms that make music perception possible and in particular the recognition of small musical events and of the relations among them. These relatively recent researches are directly related to our purposes, since AD applications are often built upon small sonic or musical events (for example, Earcons [24] and Auditory Icons [25]) and are often related to a visual environment with a clear semantic value.

An example of multimedia products that can be effectively considered from this point of view is that of cartoons. Cartoons are rich in auditory icons and earcons. Moreover, they often observe the principles of simplification and exaggeration of what they represent. These two aspects make cartoons a precious source of indications for an effective connection between non-verbal sounds and their semantic values in AD applications. The principle of reduction and emphasis makes the sound materials of cartoons easy to analyze according to rhetorical figures. They can be analyzed as object-figures (considering their microform, e.g. a single horn-sound or a motor rumble) as well in their connection through rhetorical relation-figures (for example a *paronomasia* that is the varied repetition of an object-figure). Since they refer to the visual level of the story, one can identify further analogies with AD applications, that make analysis of sound design for cartoons a fertile territory for our work.

The long perspective goal of this research is the definition of a robust and general set of rhetoric-based guidelines for sound design in AD and SID applications. These guidelines should provide a sort of toolbox accessible via meaningful parameter spaces, controlling the semantic attributes of non-verbal sound for machine-man communication in interactive contexts. In other words, we aim at showing how it is possible to improve the learnability and usability characteristics of interactive applications by means of a rhetorically designed AD. Indeed, a good administration of the semantic aspects of the system (sonic) feedback is directly related to its understandability. The learnability and memorability issues are crucial. In a relentlessly evolving technology scenario not always (seldom?) the invention and production of new interactive devices and contexts corresponds to an adequate

capacity of acquisition and exploitation of these new means by a large public. These concerns address the problem of the dissemination of technology among people of any age and cultural background. Once more, we believe that the combination of rhetorical strategies with non-verbal sound design would give a significant contribution to making aged people, for example, or, more in general, "non-technological-confident" people more acquainted with and confident in their interaction with machines.

In this paper, the examples and the experimental results are related to simple AD applications such as the sonification of operating system functions (see Sections 5 and 6). At this preliminary stage, only the effectiveness of the communication of functional contents is evaluated. In the future, our aim will be to extend the scope to more complex applications and, in particular, to focus on the sonic aspects of interaction design, i.e. on the design of continuous sonic feedback for continuous interaction.

4. EVERYDAY SOUNDS IN CARTOONS

As an example of rhetoric-based analysis of the sonification of events in cartoons, we considered a classic by Walt Disney: *Coming Out* (1934, duration 6'57"). The subject is a picnic of Mickey Mouse and his friends, during which they have to fight with annoying and kind of "intelligent" mosquitoes.

In the first scene (1'34"), a mosquito flies around Mickey Mouse, which tries without success to catch it. The flying insect stings Mickey's nose twice: the first one in a light way, the second one more violently. A country music is constantly playing during the whole cartoon, while everyday sounds (the object of our analysis) have to be played very loudly in order to be audible. The first time, the mosquito stinging Mickey's nose produces a weak sound (like a plastic cap extracted from a bottle), while the second time a well defined sound is produced (a car horn).

Scene 1: Mickey's nose hit by the mosquito (0'53")	
Object-figure: sound of an opened bottle (plastic cap)	Object-figure: sound of a car horn.
Relation-figure between the two object-figures: *Paronomasia*: - double duration and fundamental frequency equal to half of the one of the second sound, - similar temporal behavior, - different acoustic spectra due to different everyday sounds.	
Relationship audio-video: converging,	

Table 1: Rhetoric analysis of the everyday sounds of the first example of the cartoon *Coming Out* by Walt Disney.

We can classify those sounds as in Table 1. Since they are both recognizable, they can be defined as object-figures (here with their everyday name: no traditional music-rhetoric term could easily be used to identify them). In their succession the sounds build also a relation-figure: the slightly varied repetition (*paronomasia*) at visual level (Mickey's nose stung twice) is sonically stressed by means of two sounds, whose spectrum is quite different. However, the two sounds have a similar temporal behavior and the second sound has double duration and a fundamental frequency that is half of that of the first one (see the sonograms of Figure 1). By comparing the two sounds, it is possible to individuate a *paronomasia* (varied repetition), mimicking the same rhetorical figure at visual level. The relationship between visual and audio level is, thus, converging, as it almost always happens in cartoons (see Table 1).

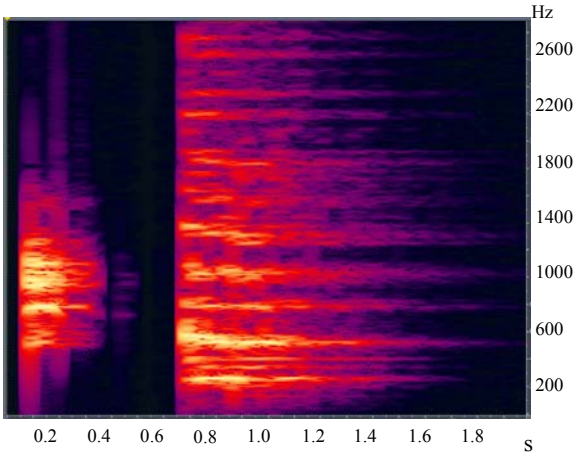

Figure 1: Sonograms of the bottle cap and the car horn sounds.

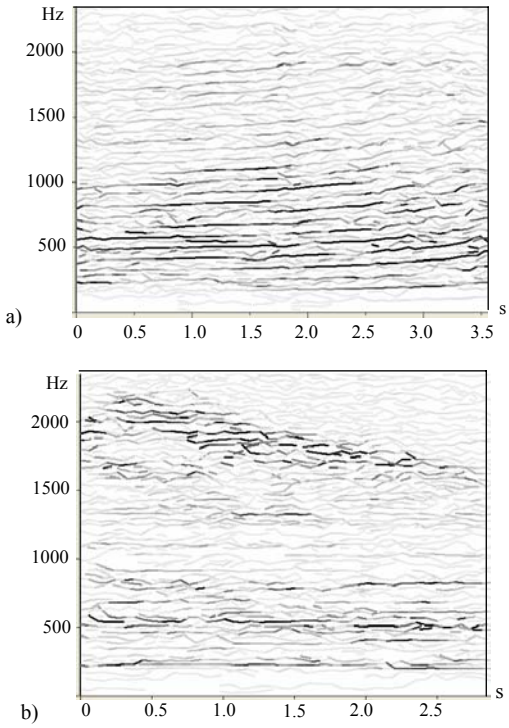

Figure 2: Sonograms of a) the motor scooter and b) the horse whinny sounds

Similar object-figures as well as the same relation-figure can be identified in another scene of the cartoon, where Mickey's friend Horace Horsecollar, hanging on a hammock, is hit in its bottom by the mosquito.

Before it hits Horace, the mosquito, while taking a run in order to gain speed, produces the sound of a motor-scooter. From the point of view of the object-figure the motor-glissando can be interpreted as an *anabasis* (i.e. a sound whose pitch is rising). Horace reacts to the mosquito's hit jumping very high and then falling, as a horse could not realistically do; this action is sonified by a horse whinny in form of a fast rising glissando and a relatively long descent that underlines Horace's jump and subsequent fall. This can be identified with the *object-figures* of the *exclamatio* (very high and quickly reached pitch) and of the *catabasis* (falling pitch). By comparing the *anabasis* of the mosquito with the *exclamatio-catabasis* of Horatio, a *relation-figure* of *antithesis* (opposition) comes out. In fact, the two *object-figures* are opposite and almost complementary in the pitch direction and in their spectrum, as it is possible to see in Figure 2a-b, representing the sonograms of the two sounds.

Scene 2: the mosquito stings Horace's bottom (1'24")	
Object-figure: sound of a motor-scooter with raising glissando (*anabasis*). *Climax:* tension is increasing.	Object-figure: horse whinny in form of a very high pitch, reached through a quickly raising glissando (*exclamatio*), followed by a long descending glissando (*catabasis*). *Anticlimax*: decreasing tension *Hyperbole*: exaggeration of the consequence of mosquito's hit (Horace's jump) with comic effect.
Relation-figure between the two object-figures: *Antithesis* -raising vs. falling glissando, -complementary pitch direction and acoustic spectra due to the different everyday sound.	
Relationship audio-video: converging, since the *antithesis* at the sonic level reflects the opposition of the characters in the cartoon.	

Table 2: Rhetoric analysis of the everyday sounds of the second example of the cartoon *Coming Out* by Walt Disney.

Also, the relationship between the running mosquito and the final hit can be identified through the rhetorical figure of the *climax* (increasing tension): the velocity of the mosquito becomes higher and higher until it produces an unexpected and comic consequence. Horace's jump sonification by means of an *exclamatio* and a *catabasis* (that, due to its falling pitch, generates also the rhetorical figure of the *anticlimax*, i.e. the resolution of the previously accumulated tension) makes the spectator laughing because of the exaggerated consequence of the mosquito's hit. The figure of exaggeration, often used in cartoons for its comic effect, is also an important one in the rhetorical context, denoted as *hyperbole* (see Table 2).

We now ask ourselves, how a rhetorically-based description of everyday sounds can become a useful tool to be employed for the design and creation of AD applications. In Section 5, we try to give an answer to this point, as well as to the issues discussed in Section 3, by means of a number of elementary examples.

5. A RHETORIC-BASED SONIFICATION OF COMPUTER OPERATING SYSTEM EVENTS.

From an experimental point of view, we concentrated on the well-defined case of the sonification of three computer operating system functions. Both the case of earcons based on musical rhetoric and of auditory icons based on audiovisual rhetoric of cartoon sounds are considered. For each of these functions, we produced one example of earcon and one example of auditory icon, in which we employed very simple and evident realizations of rhetoric figures. Additionally, we realized an equal number of counter-examples. In order to create the earcon counter-examples (non-rhetorically-based), we considered only the melodic aspect, while leaving unaltered the rhythmic features and the implicit harmonic structure. Rhythmic alterations were not considered in order to avoid the risk of destroying the similarity within the pair of earcons, necessary to make the comparison between the rhetorical and non-rhetorical versions meaningful. Harmonic variations, on the other side, are considered to have a too high degree of complexity for this early stage of our study.

In this simplified frame, we used three different rhetoric figures based on the repetition, associated according to heuristic principles to three different computer functions, namely "copy", "undo" and "redo". As described in Figure 3a, we adopted the *anaphora* figure to sonify the "copy" function. The rhetorical figure is obtained by the repetition of the first part in both the semi-phrases. Kircher [11] says: "The *anaphora* or *repetitio* occurs when a period is repeated more times, so that the sentence acquires a stronger energy"[1]. The repetition is missing in the counter-example of Figure 3b. The ending on the tonic G give a sense on conclusion of the action in both of the earcons. However, the feeling of having created a copy of a certain object is stressed by the presence of the *anaphora*.

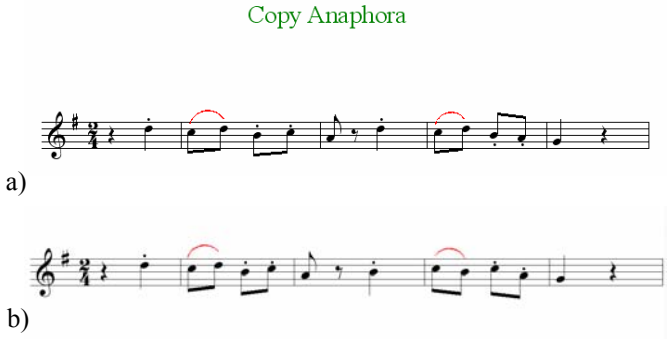

Figure 3 a) *The Anaphora figure is employed to emphasize the "copy" function.* b) *A similar earcon used to test the effect of the lack of the rhetorical figure.*

[1] The translation from Latin and German of the quotations of the rhetoric treatises are by the first author.

In a similar way, the other two examples lay on rhetoric figures based on an iteration of melodic cells. Figure 4 represents an earcon based on an *epanalepsis* figure, adopted in order to give the feeling that the final state is the same as the state prior to the last action (the "undo" function). The *epanalepsis* requires, in fact, the repetition of the initial element at the very end of the structure, mimicking the return to the original situation. This rhetoric figure occurs "when the same expression that appear at the beginning of a sentence, ends the sentence itself" [13]. The repetition is missing in the counter-example of Figure 4 b.

Figure 5 depicts the use of an *epizeuxis* in order to stress the recovering of an action that had already been performed and then canceled. The "redo" function is rendered by the repetition present at the beginning of the earcon as a confirmation of something that was already there. An *epizeuxis* is such "when the same word is repeated one after the other at the beginning of a sentence" [13]. Once more, the repetition is missing in the counter-example of Figure 5b.

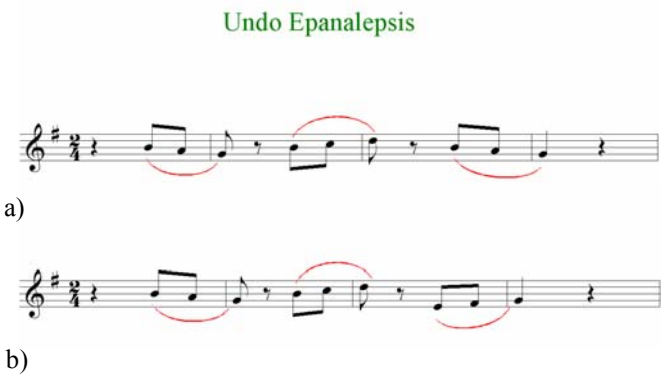

Figure 4 a) *The Epalepsis figure is employed to emphasize the "undo" function.* b) *A similar earcon used to test the effect of the lack of the rhetorical figure.*

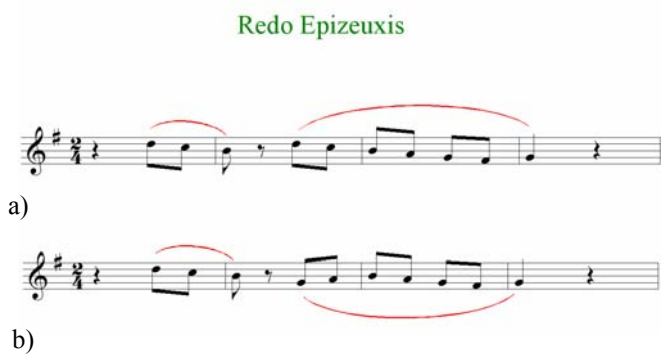

Figure 5 a) *The Epizeuxis figure is employed to emphasize the "redo" function.* b) *A similar earcon used to test the effect of the lack of the rhetorical figure.*

In order to produce an equivalent set of examples for the case of Auditory icons, we employed the cartoon sounds analyzed in Section 4. The "copy" function was sonified by means of the "readymade" *Paronomasia* of Mickey's nose hit by the mosquito (see Table 1). For the other two functions, we manipulated the motor-like sound of the attacking mosquito in the second example of the cartoon (see Table 2). More in detail, we altered and varied the *anabasis* of the motor-mosquito sound, in order to obtain:

1) An *epanalepsis* for the undo function. The sound was transformed in pitch and duration and a reversed version of the sound (descending glissando) was joined to the first sound in order to obtain an effect of wide-sense *epanalepsis*: the beginning is equal to the end.
2) An *epizeuxis* for the redo function. The sound was transformed in pitch and duration and the first part of the sound was repeated twice at the beginning of the icon in order to obtain an effect of wide-sense *epizeuxis*.

The counter-examples are simply provided by the same sounds deprived of the rhetorical structure, i.e. from the different form of repetitions present in the rhetorically-based examples. In the next section we discuss some preliminary results collected in listening experiments by using the described icons in the rhetorical and non-rhetorical versions, respectively.

6. PRELIMINARY ASSESSMENT

The application of rhetoric figures to the above described examples appeared to remarkably reinforce the information conveyed through non-verbal sound. In order to show this we performed two experiments.

In a first experiment, 8 users were asked to express a preference between the two earcons of each of the pairs corresponding to the three functions described in Section 5. They knew what kind of action they were performing and the action was graphically represented on the computer by simple figures (an ellipse that was duplicated for -copy-, an ellipse that was cancelled after being created for -undo- and an ellipse that was recreated after being created and erased for -redo-). The subjects could freely perform the three actions (one at a time) on a computer, choosing either one or the other corresponding earcon. They could repeat the action as many times as they wanted with any of the two earcons. Obviously, they were not informed about the criteria used for the composition of the pairs of earcons. On the other hand, they were asked to express their judgment according to their confidence in the fact that the specific function was successfully accomplished. All of the users had at least a fair musical listening culture and some of them were also amateur players. The rhetorically designed icons covered more than 85% of the preferences. In this experiment, the degree of effectiveness in terms of "feeling comfortable about the successful accomplishment of a computer-operation" was extremely promising. Indeed, the earcons, as they are, are unsatisfactory to the extent that they are not concise enough. A shortening of the earcons would involve a more subtle distinction between rhetoric and non-rhetoric versions and the lost of the self-evident properties of the earcons discussed here. In a sense, the examples we adopted here were intended to be almost self-explanatory.

In a second experiment, we considered a more ambitious assessment procedure. This time, the material included the 6 earcons and also the 6 auditory icons. The goal was to test the possibility of inferring the effectiveness of the sound-function assignment of the heuristically designed icons as a result of a free classification by the users. Twelve subjects, different from those of the first experiment, were asked to listen to three series of three sounds. Before the listening test, they were told that:

1) The three sounds of each of the series had a correspondence one-to-one with three operating-system functions: copy, undo and redo;

2) They were going to listen to a first series of non-musical sounds and then to two series of musical motives;

3) They could listen to the sounds of a series how many times they wanted before passing to the following series;

4) For each series, their task was to write down a one-to-one correspondence between the three sounds and the three operating system functions in a 3X3 matrix.

The listening materials were presented in the following way:

a) The series of three auditory icons described in Section 5;

b) The series of the three non-rhetorical earcons of Figure 3b, Figure 4b and Figure 5b;

c) The series of the three rhetorically designed earcons of Figure 3a, Figure 4a and Figure 5a.

The results of the test gave an encouraging result, since the percentage of associations of the rhetoric-based icons was above chance. Actually, we hoped to receive a higher percentage of successful identifications. On the other side, when discussing after the test with the subjects and explaining the background of the experiment and the intentionality of the icon-design, almost everybody agreed that the design was a good and meaningful one. Therefore, when passing from an unconscious level to a conscious one, the rhetorical figures were recognized as effective ones. This is a good point at least in terms of learning aspects: even if the rhetorical figures are not self-evident on their own at an unconscious level, after a verbal explanation, they become a strong identifying element that can be extremely helpful for memorization tasks. Also, these are preliminary results on a restricted set of sounds and functions. We are going to consider the feedback received from these first experiments in order to carefully refine the designed experiment, especially in terms of sound design in order to obtain better results also at an a-priori (unconscious) level. This would be a first step towards the definition of effective guidelines for a rhetorically-based AD design. As an example of feedback gained form this experiment, we report also the following: it emerged that often the mistaken identification consisted in an inverse attribution of the icons corresponding to the functions redo and undo. These two functions can, of course, have some overlap in our mental representation at an abstract level. This matter would require a deeper investigation at a more general semiological and psychological level. However, we will take these as hints for a redesign of the icons.

Also, we plan to perform larger and more quantitative experiment, similar to the latter one, by submitting matrices of AD icons vs. functions to subjects. These should associate each icon to one of all of the available functions. If our heuristic rhetoric-based association were "correct", the expected result would be that the non-rhetoric icons would be associated to the different functions according to a uniform distribution (lack of peculiarity with respect to any function). In contrast, the rhetoric-based earcons would be associated to the different functions according to non-uniform distributions with peaks in correspondence of the "correct" earcon. Also more advanced evaluation techniques [26], [27] will be considered in the future.

7. CONCLUSIONS AND FUTURE DEVELOPMENTS

While aiming at consolidating and deeply investigating the potential application of rhetoric principles to the case of auditory icons and earcons, our goal is also an extension of this study to any kind of musical and non-verbal sound employed for representing information or for supplying sonic feedback in interactive contexts. Also, we intend to collect more experimental results and enlarge the scope of AD cases, considering in particular interactive contexts. These results will be the starting point for the definition and progressive refinement of rhetorically-based guidelines for the design of new sounds for AD and SID applications.

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