A phenomenological approach to investigate the pre-reflexive contents of consciousness during sound production

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Abstract. This article describes a listening experiment based on elicitation interviews that aims at describing the conscious experience of a subject submitted to a perceptual stimulation. As opposed to traditional listening experiments in which subjects are generally influenced by closed or suggestive questions and limited to predefined, forced choices, elicitation interviews make it possible to get deeper insight into the listener's perception, in particular to the pre-reflexive content of the conscious experiences. Inspired by previous elicitation interviews during which subjects passively listened to sounds, this experience is based on an active task during which the subjects were asked to reproduce a sound with a stylus on a graphic tablet that controlled a synthesis model. The reproduction was followed by an elicitation interview. The trace of the graphic gesture as well as the answers recorded during the interview were then analyzed. Results revealed that the subjects varied their focus towards both the evoked sound source, and intrinsic sound properties and also described their sensations induced by the experience.

Keywords: elicitation interview, auditory perception, sound synthesis, graphic gestures

1 Introduction

When preforming perceptual evaluations of sounds, it is important to be aware of the fact that listeners may focus on different aspects. Gaver [5] distinguished everyday listening from analytical listening. In the case of everyday listening of a simple source, the listener pays attention to the sound producing object, such as its size [9] and the material of which it is composed [7], [1]. In the case of more complex situations reflecting for instance interactions between sound sources, the listener perceives properties related to the event as a whole. Warren and Verbrugge [25] showed that objects that bounce and break can be distinguished by listeners with a high degree of accuracy, while Repp [15] revealed that subjects were able to recognize their own recorded clapping and the hand position from recordings when someone else is clapping. More recently, Thoret et al. [22, 21] showed that subjects were able to recognize biological motions and certain

shapes from friction sounds produced when a person is drawing on a paper.
To favor analytical listening where the listeners focus on intrinsic sound properties linked, for instance, to loudness, pitch, and timbre other approaches have been used. Merer [12] used acousmatic sounds for which the source could not be easily recognized to reveal sound structures responsible for the evocation of movement categories. Other approaches such as sensory analysis during which a group of subjects identify sensory descriptors such as onomatipoeias have been used, for instance to characterize the formantic transition from "ON" to "AN" that characterizes sounds from car motors [16, 19].
Other approaches, such as vocal imitations, that do not specifically focus on everyday or analytical listening have been used to extract relevant features of kitchen sounds [10], and more recently to reveal invariant structures responsible for the evocation of movements and materials [3]. Psycholinguistic analyses have been used to characterize sounds from musical instruments through spontaneous verbalizations. One such study that investigated violinists' preference judgements during a playing task, led to a model that linked auditory and haptic sensations to the timbre, quality, and playability of the instrument [18, 17].
Sound perception is a conscious experience that can be described not only in so-called "third person" protocols (from the point of view of the experimenter within a given paradigm, e.g. a psycho-physical paradigm), but also by protocols aiming at describing the experience from the subjects' perspective (subjective methods) mainly based on the Husserlian phenomenology. Most of the time, spontaneous descriptions of experiences and cognitive processes are poor [14] because the experience does not guarantee immediate access to its background contents [23]. Several kinds of information usually remain undisclosed, masked or "pre-reflexive" as they are called in phenomenological language [14]. Various methods allow to accurately describe the conscious experience in its reflexive and mostly pre-reflexive part. Among them, the elicitation interview (EI) [24, 11] is a disciplined introspection method conceptually based both on neurolinguistic programming (NLP) and Husserlian phenomenology [8]. EI makes it possible to return to the non-reflexive part of the conscious experience of a subject, hereby limiting influences from closed or suggestive questions.
Whereas the qualitative research methods used in sociology, such as Glaser and Strauss' anchored theory (see [17]) or the "repertory grid" method use textual corpora of reflexive descriptions of experiences to extract emerging themes and their variations, EI is essentially interested in the non-reflexive component of the experience. For this reason, whereas in the qualitative methods, the subjects use their autobiographical memory, in the EI, the subjects must relive their experience and activate their "integral memory", in particular corporeal.
We previously described pre-reflexive conscious experiences in passive listening of sounds [13]. In the current work we analyze pre-reflexive content of conscious experiences in an active task consisting in reproducing a sound by drawing on a graphic tablet.

2 Material and methods

In this section we describe the interactive device used by the participants, the experimental protocol and the elicitation interview.

2.1 Equipment: The "tablet-synthesizer" device.

Sound synthesis is a powerful tool to create any kind of sounds that either imitate real or virtual situations. Current synthesis models enable high quality re-synthesis of natural sounds that can be generated in real-time. One challenging aspect linked to sound synthesis is the control of the synthesis parameters that is not always intuitive. To meet this challenging control issue, we have developed a synthesizer based on perceptual features linked to the evocation of actions and objects [2, 1]. This device is based on the ecological approach to perception proposed by Gibson [6] which considers that actions and objects are recognized through invariant structures. The sound synthesizer makes it possible to create sounds from verbal labels that describe the action (e.g. hitting, scraping, rolling) and the object (e.g. material, size, shape) associated with the sound. Any combination between actions and objects can hereby be simulated, such as scratching a small metallic bell or hitting a big wooden bar [4]. Unrealistic situations can also be simulated this way, such as rubbing the wind or scratching a wave.
In the present study we decided to use a sound texture that evoked a movement in water, since the timbre of liquid sounds vary strongly with the dynamic action. To create the reference sound that the subjects were asked to reproduce, the synthesized sound was combined with an elliptic movement recorded by the experimenter who drew on a WACOM INTUOS PRO graphic tablet. The experimenter freely chose the eccentricity and the orientation of the ellipse that he/she was asked to draw ten times. To induce a periodic movement, we used a 60 bpm metronome while the experimenter was drawing to help him/her maintain a regular speed. Among the ten repetitions, the three most regular ellipses were selected. The position of the stylus was recorded by a Max/MSP interface at a sampling rate of 129 Hz. We then derived the position to get the velocity profile.

2.2 Experimental protocol

The subjects were first asked to listen to the reference sound which nature and origin they ignored. They were then asked to reproduce this reference sound on the WACOM INTUOS PRO graphic tablet with the gesture that best imitated the reference sound. The subjects produced the sound in real time while they performed the gesture on the graphic tablet.

Participants Ten subjects, 7 women and 3 men (aged from 26 to 70 years) were included in this experiment. Five subjects were experienced musicians practicing

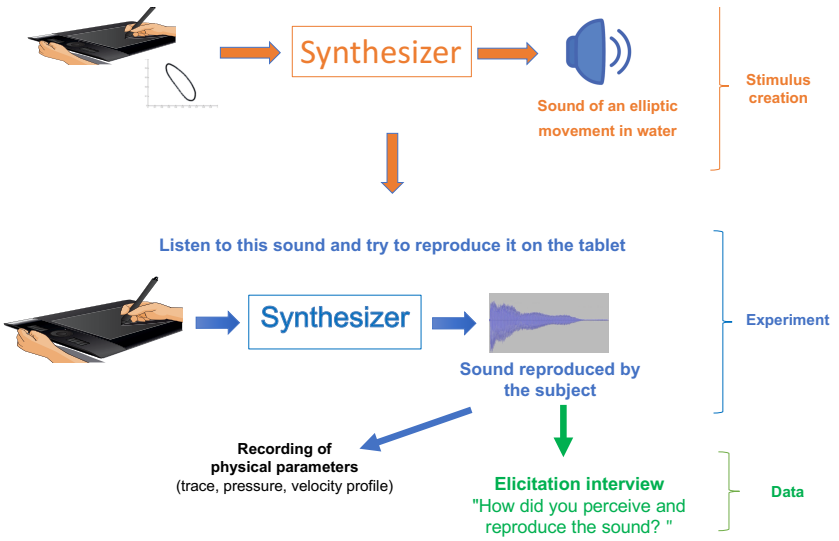


Fig. 1. Experimental protocol

an instrument on a regular basis and the the remaining 5 participants were not musicians. The ten subjects were right handed. Subjects did not have any hearing or neurological problems, such as memory-related problems or attention difficulties. The interview was conducted by one of the three doctors involved in the study: MD, GM, JVD. An audiogram was performed for each subject before the beginning of the experiment to make sure that none of the subjects had hearing impairments.

The elicitation interview In a second step (just after the reproduction of the sound), the subjects were asked to review their experience while listening to and reproducing the sound by means of an elicitation interview, by answering the question "how did you perceive and reproduce the sound?". The EI was conducted by three experienced researchers in phenomenology and EI.
The EI requires a certain number of methodological specificities:

a) The first key of the interview is to lead the subjects to describe their experience, that is to tell what they experienced and not what they thought, believed or imagined to have been their experience [14].

b) The interviewer should lead the subjects to discuss their past experiences by helping them to find the sensory and emotional dimensions.

c) The interview consists in helping the subjects redirect their attention from the content of their experience (the "what"), to its diachronic and synchronic

structure oriented towards the experiential (non-causal) “how”. The diachronic structure of the experience corresponds to the stages of its deployment over time. The synchronic structure of the experiment corresponds to the configuration at a given moment of the sensory registers used, the type of mobilized attention... etc. The aim is to make the subjects relive their experience rather than to remember it.

d) To collect such a description, the interviewer's questions should be “empty of content”, non-inductive and “point” to the structure of the experiment without providing any content. Questions are, for example: “From what did you start? What did you feel ? How did it appear to you? ”, etc. This mode of questioning emphasizes the “how” of the conscious experience and excludes the “why”.

e) The structure of an interview is iterative while guiding the attention of the subject towards a diachronic or synchronic mesh which progressively becomes more detailed each time. The average duration of an interview is about an hour to describe a few seconds of experience (as Stern puts it, “there is a world in a grain of sand” [20]). The interviewer must remain totally neutral. A good harmonization of affects (motor and prosodic affective tuning [20]) is a critical condition for the quality of the interview.

Data collection and analysis. All the EI were recorded, with the subjects' agreement. The physical data (pen movement, speed, pressure etc ...) were collected from the computer connected to the graphic tablet. The records of EI were entirely transcribed. The analysis of verbatim was carried out to extract the descriptive categories (saliencies) from each interview. The choice of descriptive categories for each interview was validated by 7 people in an inter-judge session.

3 Results

The physical data from the tablet were analysed together with the EI. Only the data from the EI, as well as the drawings recorded on the tablet are presented in Tables 1 and 2.

Types of sound listening. The EI enabled to collect the synchronic and diachronic structure from the listening experience of each subject. These data respond to both the ”what” of their experience but also to ”how”, to the proper way of perceiving and reproducing this sound. They give a fine and precise description of an experience that lasted for a few seconds by allowing an awareness of the different processes.
Four descriptive categories (attractors) which are common to all the subjects can be identified. These categories are related to the way the subjects hear a sound while they prepare its reproduction: 1) the direction of listening, 2) the

Table 1. Three types of listening experiences

Types of listening experiences						
Listening focus (LT)	**Main LF used by the subject**	**Nomber of subjects using this LF**	**Main sensory modalities involved**	**Attentional disposition**	**Sound-auditor positon**	**Moment of appearance**
Origin of sound	2, 4 and 5	8/10	Scenes (sea, beach…) perceived by the auditory and visual modalities	Directed attention towards the source. Active search remembrance, familiar scenes evoking the source.	Location of the subject in relation to the scene.	Appears spontaneously first while listening
Acoustic characteristics of sound	1, 7, 8 and 10	8/10	Timbre, intensity, rhythm, height perceived by the auditory modality, but may be associated with other modalities (rhythm with kinesthetic sensitivity)	Attention directed towards the different parts of the sound Active position of the subject in relation to the sound.	Accurate location of the sound, external to the subject....	Appears when subjects focus on the task of reproduction
Effect of the sound	3, 6 and 9	8/10	Dynamics of the sound mainly perceived by kinesthetic sensitivity	Attention less focused, more global Position of the subject rather passive compared to the sound	Blurred boundary between body space and sound Effect of sound throughout the body.	Particular listening modality, generally not described spontaneously rather evoked at the end of EDE.

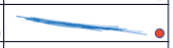
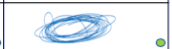
sensory listening modalities, 3) the attentional disposition 4) the reproduction strategies. The first three descriptive categories which correspond to three types of listening are in line with categories identified in our previous work [13]. The fourth is specific to this study. Each of the 3 types of listening can be analyzed from a) the main sensory modalities used, b) the attentional disposition of the subject, c) the position of the subject with respect to the sound and d) the moment this type of listening occurs. Each subject has a preferred type of listening (in this experiment), but this does not mean that he or she does not use other types of listening in a less marked way. This part of the analysis is presented in Table 1.

The first type of listening is turned to the source of the sound and involves attention directed to the origin of the sound with an active search for familiar scenes associated with the source. In this type of listening the imagination is very active. The subject is thus projected into an imaginary scene evoked by the sound heard which is integrated into the scene, and a given context in the visual modality. This listening structure appears spontaneously and early in the diachronic description of the experience. This type of listening, characterized as everyday listening by Gaver [5], represents the main listening mode of three subjects but is, for 8 out of 10 subjects, associated with the other types of listening.

The second type of listening, characterized as analytic listening by Gaver, is directed to the characteristics of the sound. This way of perceiving sounds appears when subjects focus on the reproduction task. This time the sound is brought back to its different components (rhythm, pitch, timbre, intensity), and the subjects focus on the sound itself and not on the causality. This is the main listening type for four subjects, but 8 out of 10 subjects used it in the experiment.

The third level of listening is a particular listening modality that is usually not spontaneously described in our daily lives and rather evoked at the end of the diachronic description of the listening experience. This is a way of listening that focuses on the effect of the sound, specifically the dynamics, the movement it induces relative to the whole body. It is an "internal" or "embodied" listening modality in which the boundaries between the sound and the corporal space become porous. Subjects adopt a more passive position related to the sound, in a way they are "impregnated by the sound". This is the main listening modality of three out of ten subjects, but 8 out of 10 subjects used it in the experiment. Finally, we did not find any difference between musicians and non-musicians with respect to the type of listening.

Table 2. Reproduction task and type of listening. The colored circles indicate the coherency between the representation of the sound and the imaginary content or the reproduction gesture (green = good, orange = medium, red = poor)

Listening focus (LF)	Subjects	Representation of sound	Imaginary content	Recorded trace (movement)
Origin of sound	2	Wave	Wave	
	4	Wave with bubbles	Wave	
	5	Waves with bubbles	Wave	
Acoustic characteristics of sound	1	Something perfectly rounded	Ellipse	
	7	Dynamics of the sound	Sinusoids	
	8	Rhythm	Rhythm	
	10	Wave	Wave	
Effect of the sound	3	Oscillation, oval shape	Hourglass	
	6	Dynamics of the sound	Kind of Ellipse	
	9	Pulsations of the sound	Kind of spindle	

Reproduction strategies. An original result of this study is that the representation of the sound and the imaginary content of the drawing gesture to perform depends on the major mode of listening for each subject (Table 2). Subjects with a predominant listening based on the origin of the sound (i.e. everyday listening) imagined waves. Subjects with a predominant listening based on the acoustic characteristics of the sound (i.e. analytic listening) rather considered the physical parameters with a coherent imaginary content with these parameters. Subjects with a predominant listening based on the sound effect rather felt oscillations and movements and evoked the elliptic shape in their imaginary content. Surprisingly, the actual realization of the trace is not closely coherent with the imaginary content of the gesture and it seems that it does not depend

on the preferential manner in which the sound is listened to. We did not find any relation between the type of listening and the age or gender of the subjects or between musicians and non-musicians.

4 Discussion and conclusion

The phenomenological analysis of the pre-reflexive contents of the consciousness in a reproduction task of a sound using a sound-based graphic tablet makes it possible to confirm the main types of listening previously described by Gaver [5] or Petitmengin et al. [13]. The fact of having a reproduction task to be accomplished modifies, with respect to an isolated passive listening, the diachronic and synchronic content of this experience (the moment of appearance of the experiential content, in particular).

In this preliminary work involving a small population of subjects, we did not find differences in listening and sound reproduction based on age, gender, or musical experience. It would be interesting to increase the number of subjects to assess whether differences appear according to these factors. However, we can not perform EI on large populations because of the considerable time required for data processing. We (GM, JVD) are currently testing faster and more efficient data processing methods to increase the number of subjects involved in this type of study. When comparing our current and previous studies [13], several differences must be reported. The initial study focused on describing the modalities of listening to the sound, as such, and without any task required at the end of the listening. The study aimed to highlight the descriptive categories of the non-reflexive part of the sound listening experiences and to define the general structure of such an experience. For this reason, various sounds were used (sounds from nature, sounds from everyday life, abstract sounds). Some individual differences linked to the way subjects listened to sounds were observed, but the constitution of subgroups of subjects did not appear. In our current study, only one sound is proposed with an associated reproduction task. If the same types of non-reflexive experiences can be observed, the task to be done changes the type of intentionality [8] and attentional focus. The task to be performed involves motor strategies, whereas in passive listening such strategies are absent. Moreover, the tablet-synthesizer device constrains the motor strategy and probably the associated imaginary processes.

This study also made it possible to highlight the fact that even if each subject possesses a preferential type (focus) of listening, other types of listening are also mobilized to find the resources for carrying out the reproduction task. This entanglement of available perceptual dispositions opens a new field of research on the co-presence of pre-reflexive complex processes involved. Another unexpected result is that, on the one hand, since we find a correct coherence between the preferential type of listening and both the representation of the sound in the consciousness and the imaginary content attached to the act of reproduction, on the other hand, it clearly appears in Table 2 that the actual traces recorded on the tablet no longer display the same coherences and do not appear as closely corre-

lated to the imaginary content attached to the act of reproduction. This relative dissociation suggests that in the entire audio-motor loop, cognitive and motor processes generating the drawings are not entirely constrained by the imaginary processes associated with the sound. Two hypotheses could explain this relative dissociation: 1) the audio-motor loop would have a relative autonomy compared to the construction of the motor act of reproduction and would not modify the motor control. The imaginary content would then be an epiphenomenon more or less independent but generated by the sound heard, 2) the imaginary content aroused by the sound would modulate more or less the driving act of reproduction, according to the personality of the subject, his/her interests and the context of the experimentation. This exploratory and multidisciplinary work seems to provide an early proof of concept of the use of introspective methods in acoustics and audition in order to refine synthesis models and sound control towards an approach more and more turned towards the human experience.

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References

1. Aramaki, M., Besson, M., Kronland-Martinet, R., Ystad, S.: Controlling the perceived material in an impact sound synthesizer. IEEE Transactions on Audio, Speech, and Language Processing 19(2), 301–314 (2011)
2. Aramaki, M., Gondre, C., Kronland-Martinet, R., Voinier, T., Ystad, S.: Imagine the sounds : an intuitive control of an impact sound synthesizer. In: Ystad, Aramaki, Kronland-Martinet, Jensen (eds.) Auditory Display, Lecture Notes in Computer Science, vol. 5954, pp. 408–421. Springer-Verlag Berlin Heidelberg (2010)
3. Bordonné, T., Dias-Alves, M., Aramaki, M., Ystad, S., Kronland-Martinet, R.: Assessing sound perception through vocal imitations of sounds that evoke movements and materials. In: Aramaki, Davies, Kronland-Martinet, Ystad (eds.) Music Technology with Swing, Lecture Notes in Computer Science, vol. 11265, pp. 402–412. Springer Nature Switzerland (2018)
4. Conan, S., Thoret, E., Aramaki, M., Derrien, O., Gondre, C., Ystad, S., Kronland-Martinet, R.: An intuitive synthesizer of continuous-interaction sounds: Rubbing, scratching, and rolling. Computer Music Journal 38(4), 24–37 (2014)
5. Gaver, W.W.: What in the world do we hear? an ecological approach to auditory event perception. Ecological Psychology 5(1), 1–29 (1993)
6. Gibson, J.J.: The ecological approach to visual perception: classic edition. Psychology Press (2014)
7. Giordano, B.L., McAdams, S.: Material identification of real impact sounds: Effects of size variation in steel, wood, and plexiglass plates. Journal of the Acoustical Society of America 119(2), 1171–1181 (2006)
8. Husserl, E.: Ides directrices pour une phénoménologie. Gallimard (1985)
9. Lakatos, S., McAdams, S., Chaigne, A.: The representation of auditory source characteristics : simple geometric form. Perception and Psychophysics 59, 1180–1190 (1997)

10. Lemaitre, G., Dessein, A., Susini, P., Aura, K.: Vocal imitations and the identification of sound events. Ecological Psychology 4(23), 267–307 (2011)
11. Maurel, M.: The explicitation interview: example and applications. Journal of Consciousness Studies 16, 20–57 (2009)
12. Merer, A., Aramaki, M., Ystad, S., Kronland-Martinet, R.: Perceptual characterization of motion evoked by sounds for synthesis control purposes. ACM Trans. Appl. Percept. 10(1), 1–24 (2013)
13. Petitmengin, C., Bitbol, M., Nissou, J., Pachoud, B., Curallucci, H., Cermolaccce, M., Vion-Dury, J.: Listening from within. Journal of Consciousness Studies 16, 252–284 (2009)
14. Petitmengin, C., Bitbol, M., Ollagnier-Beldame, M.: Vers une science de l'expérience vécue. Intellectica - Rev Assoc Pour Rech Sur Sci Cogn ARCo. 64, 53–76 (2015)
15. Repp, B.H.: The sound of two hands clapping: An exploratory study. The Journal of the Acoustical Society of America 81(4), 1100–1109 (1987)
16. Roussarie, V., Richard, F., Bezat, M.C.: Validation of auditory attributes using analysis synthesis method. In: Congrés Francais d'Acoustique/DAGA. Strasbourg (2004)
17. Saitis, C., Fritz, C., Scavone, G., Guastavino, C., Dubois, D.: A psycholinguistic analysis of preference verbal descriptors by experienced musicians. Journal of the Acoustical Society of America 141(4), 2746–2757 (2017)
18. Saitis, C., Giordano, B., Fritz, C., Scavone, G.: Perceptual evaluation of violins. a quantitative analysis of preference judgments by experienced players. Journal of the Acoustical Society of America 132(6), 4002–4012 (2012)
19. Sciabica, J., Olivero, A., Roussarie, V., Ystad, S., Kronland-Martinet, R.: Dissimilarity test modelling by time-frequency representation applied to engine sound. In: Audio Engineering Society Conference: 45th International Conference: Applications of Time- Frequency Processing in Audio (2012)
20. Stern, D.: The Present Moment in Psychotherapy and Everyday Life. W. W. Norton & Company (2010)
21. Thoret, E., Aramaki, M., Bringoux, L., Ystad, S., Kronland-Martinet, R.: Seeing circles and drawing ellipses: when sound biases reproduction of visual motion. PLoS ONE 11(4) (2016)
22. Thoret, E., Aramaki, M., Kronland-Martinet, R., Velay, J.L., Ystad, S.: From sound to shape: auditory perception of drawing movements. Journal of Experimental Psychology: Human Perception and Performance 40(3), 983 (2014)
23. Vermersch, P.: Conscience directe et conscience rflchie. Intellectica 31, 269–311 (2000)
24. Vermersch, P.: Describing the practice of introsopection. Journal of Consciousness Studies 16, 20–57 (2009)
25. Warren, W.H., Verbrugge, R.R.: Auditory perception of breaking and bouncing events: a case study in ecological acoustics. Journal of Experimental Psychology : Human Perception and Performance 10(5), 704–712 (1984)