Chapter 2

Prolegomena to the perceptual study of sounds

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2.1 The perceptual study of sounds

The study of objects and events in visual field developed through interminable discussions on the nature of perceptual processes and on the methods that can provide well founded knowledge about the matter. Profound theoretical divergences are still on stage, namely between the Helmholtzean view (which cognitivistic, ecological, computer based and neurophysiological approaches after all refer to) and the Gestalt view (supporting the irreducibility of mental facts, like perception, to any machinery inside the brain). In visual field takes also place the question of any distinction between objects and events (some ones assert, some others deny it), since the perception of events (changes in quality, in position, in number) brings to the most intractable problem: that of psychological time.

I think that some echoes of that discussions may be useful for the students of perception of sounds, supposing that in all sensory modalities (vision, audi-

mental level	↑ PERCEPTUAL FACTS	psychology of perception
neural level	neural processes	physiology of perception
physical level	physical stimuli	physics of perception

Figure 2.1: The three levels of perception.

tion, touch *etc.*) the strategies of the perceptual system are the same. Be sure, in auditory field the presence of time is even more apparent, because the unceasingly flow of stimulation sometimes takes the form of an evolving event, and sometimes gives rise to perception or to representation of the source of the stimulus (for example in active touch).

2.2 Perception and psychophysics

Perception is a process that goes through three levels of reality and may be analyzed at three levels, as the scheme of Figure 2.1 shows. By means of this scheme, I try to synthesize some facts well known to perceptionists:

(a) the description of perceptual facts in the sole terms of the stimuli is useless—this is the so called *stimulus error*;

(b) the description of perceptual facts in the sole terms of neural processes is misleading—this is the so called *experience error*;

(c) perceptual facts are linked to neural processes, and – as a rule – to physical stimuli;

(d) there are robust methods to describe perceptual facts at the physical and neural levels;

(e) in order to describe perceptual facts at the perceptual level, there is only a way: to ask experimental subjects for the description [155].

Now, verbal responses of subjects – as well as motor responses subsequent to the tasks – are biased by an endless list of “errors” that begins with individual thresholds, goes through misinterpretations of the task and judgment uncertainties and eventually reaches expectations and motivations. Psychophysics is the discipline that tries to avoid all the more important sources of error, by mean of methods that assign reliable contours to unobservable objects like percepts. In a sense, the experimental subject is a measuring instrument, and we know that a measuring instrument is as much reliable as measures only the quantity for which it has been devised (for instance, the standard meter bar measures the length, and not the temperature that can increase or diminish its length). The development of psychophysics – lasting now since 150 years – shows that the effort to force the experimental subject to report only the facts we want to know is still in progress, by means of a crowd of methods more and more sophisticated. Yet we did not reach methods unconditionally valid.

Let us consider for instance the problem of previous experience. The perception and the recognition of certain sounds takes an obvious advantage from the knowledge the subject owes of that sounds, but there is no mean to weight that knowledge in a certain subject. That is because (a) any attempt to measure the quantity of exposition of the subjects to an already known sound is subdued to their ability of recovering all their past experiences, and (b) the impact of previous experiences is not always linked to their number – see, for example, the case of aversive behaviour, that is elicited by just one harmful episode. Training in experimental sessions, or learning by feedback are surely useful stratagems, but they leave the problem untouched, because their influence is restricted to the experience one can have during the training or the feedback procedures.

To conclude, psychophysical measurements have to be handled with a lot of care. It is sufficient to bring slight variations in procedure – both in tasks or in judgment scales – to turn over results. Someone will point out that this is a commonplace in science, and I agree.

2.3 Geographical and behavioural environment

If we want to attain the point of view of the psychologist, we have to start with the distinction between geographical and behavioural environment [138]. The geographical environment is the physical world, the source of all external stimuli. Living beings do not react to all energy exchanges having place in the physical world, but only to the ones useful or perilous for their survival. It is trivial to refer to ultraviolet rays that are real stimuli for bees, but are inexistent for us, or to ultrasounds, that are real stimuli for dogs, but are inexistent for us. The point is that the behaviour is not determined by potential stimuli physically present in the geographical environment, but by the sole stimuli that a filtering system (sensory system) allows to enter the living being.

Besides, we face also a rearrangement and disguise of stimuli that are in many ways disrespectful of physical reality. An unceasing research in vision demonstrated that:

1. we see objects that do not exist (anomalous surfaces);
2. we do not see objects that really exist (masking, mimicry, camouflage);
3. we see objects whose existence is impossible (Penrose, Escher);
4. we see two different objects in the same set of stimuli (ambiguous figures);
5. we see the same object from different points of view without moving the object or the observer (Necker's cube, reversible figures);
6. we see objects which exhibit properties different from the physical ones (visual illusions).

For the details on the matter, see Vicario [243]. To sum up, our visual environment is in many ways different from the physical, but we act on the basis of what *we see*, and not on the basis of what *there is*. Even some engineers seem to share this point of view [233].

As a consequence, if our field of researches regards the interaction between sound sources and humans, we have to ascertain (1) what are the acoustic stimuli that are relevant for human behaviour, and (2) what are the properties of the auditory (perceptual, subjective) world.

The task (1) is realized by the physiology of the ear and of the brain if we shed the fact that thresholds undergo considerable variations due to attention, expectations and other strictly psychological factors. The task (2) is to be realized, and in accord with studies in visual domain we are almost sure that the dimensions of auditory, behavioural world are other than the dimensions of the acoustic, physical world. Let us now consider the difference between physical and phenomenal behaviour in the auditory field. A rough exam of facts tells us that:

1. we hear sounds that do not exist (the missing fundamental);

2. we do not hear sounds that really exist (masking);
3. we hear two different objects with the same set of stimuli (reversible rhythms);
4. we hear sounds as produced by physical sources inexistent in the everyday environment (electronic music, and any spectral manipulation of real sounds);
5. as far as I can understand, this class is void, since time is an one-dimensional set;
6. there are a lot of auditory illusions (in tonal domain, see Deutsch [63]).

Since we act on the basis of what *we hear*, and not on the basis of what *there is*, we can conclude that the distinction between physical environment and behavioural environment holds even in auditory field. This fact introduces the problem of the recognition of the source of a sound.

2.4 Hearing the source

There is a problem in the statement that "we hear the source of sound". That could be true in the natural environment: when a violin is playing in front of us, we could say that "we hear a violin". But since we hear a violin also in the reproduction of its sound by means of a hi-fi apparatus, there is to understand why we do not say that "we hear the cone of the loudspeaker". In other words, we do not "hear" the source, but we "represent" it. The obvious explanation that the cone of loudspeaker reproduces very well the acoustic stimulus proceeding from the violin does not work, since *in fact* we fail to identify the actual physical source of the stimulus (the cone of the loudspeaker) and we represent a source (a violin) that is *beyond* the hi-fi apparatus.

The meaning of the fact becomes quite clear when we listen to a vinyl disc that, because of a damage between grooves, at a certain point reproduces the same set of stimuli. When we listen, for example, to a reproduction of a piece of music, we do not hear the loudspeaker or the machine behind it: we perceive the musician, or the orchestra. At the first iteration caused by the damage, we continue to hear the musician or the orchestra, as performing again the same set of tones to obtain a special musical effect (as occurs in final bars of some symphonies). Yet at the third or fourth iteration, we realize that something goes wrong: the musician or the orchestra dissolve, and we have the representation of an apparatus that does not work. There must be something unclear, in the passage from the acoustic stimulus to the verbal report of the listener.

In the visual domain the fact is well known as “pictorial perception” [101]. There are cases in which we perceive only the physical setting that is the tinted surfaces, for example a white wall, or a painting by Mondrian. There are other cases by which we do not see the tinted surfaces, but the represented object, for example an outlined apple, or a photograph, or even a person portrayed by Antonello da Messina. Finally, there are also cases of portrayed objects, architectural elements or even painted landscapes, by which mean we get the impression to be in presence of the “reality” itself: I refer to the *trompe l’oeil* phenomenon. In the auditory domain the problem has not yet been discussed, but it is apparent that we have also perception of a sound without the representation of the source (for example, when we refer to strange noises or timbres of tones, or to cries of unknown animals). That leads to the problem of recognition.

2.5 On recognition

The universal use of the term “recognition” deserves some comments.

1. First of all, it cannot stay in place of “perception”, because we have perception without recognition: we mentioned above the case of sounds that “we don’t know”, but the hearing of enigmatic or puzzling noises is a common experience. On the other hand, we have “recognition” without perception: the photocell of an elevator “recognizes” the presence of a person between the closing doors and stops them, but the electronic apparatus cannot be credited with perception.

2. In the second place, we can have recognition at various levels about the same sound. For example, once the stimulus is produced, I can recognize a sound and not a smell; I can recognize a noise and not a tone; I can recognize the noise as that of a car and not of a motorcycle; I can recognize that the noise is that of a VW and not of a BMW; I can recognize that the car is on the point of stopping, and is not passing away; I can recognize that the way of stopping is that of my second son, and not of my wife, and so on. It is plain that a term that does not identify an object or a process, or even a field of possibilities, is useless.

3. There are “false recognitions”: laying in my bed, I can recognize the noise of the rain, but when getting up to close the window, I realize that

the noise was that of the leaves of the trembling poplars ruffled by the wind. Notice that false recognitions are not phenomenally different from true recognitions: they are always “true”, and they become “false” after the comparison with other sense data, by mean of a process that is neither perception nor recognition.

4. There are “ambiguous recognitions”: the same voice may in turn appear as belonging to a man or to a woman, to a woman or to a child.

5. There are “changing recognitions”, in the sense that a noise issued by the same source, when presented again to the perceiver, gives rise to different “recognitions”: the rehearsal of an unknown noise leads to changing verbal reports that reflect a change in individuating the source of the noise. Otherwise, in a reiterate succession of tones to which one tone is added at each iteration, the listener can individuate different already known melodies.

6. It is trivial to note that the same acoustic stimulus gives rise to different “recognitions” when some clones of that stimulus went before and after it: a single shot leads to the recognition of a pistol, whereas a sequence of shots leads to the recognition of a machine gun. Besides, the uncertainty of the temporal limits within which there is integration along stimuli (2, 3, or 4 shots?) in view of the recognition of their source, does not allow to identify the stimulus on which the process of “recognition” is exerted.

7. Sometimes the “recognized” source is immaterial: the acceleration or the slowing down of a rhythm has no physical counterpart, because the intervals between beats are time, that is not a stimulus, but a void container of events. The sounds produced by the way of walking of an individual is a temporal pattern that is not a physical object, and nevertheless the individual (this is the way of walking of my wife) or its expressive content (she is in a hurry) is identified.

8. Again, sounds exhibit expressive contents that, in the case of individuals, are surely immaterial (where is the hurry of my wife?), and, in the case of objects, are quite imaginary (this clock has gone mad).

9. There are recognitions that occur in real time, for instance when we listen to a continuous tone. Yet there are recognitions of very brief sounds that are exerted not on the physical signal, or on the representation of the source, but on the memory trace of the perceived sound. And we do

not know what changes percepts undergo when transformed in memory traces (that could be ascertained for visual objects that are at least stationary, but is surely uncertain for auditory events, since the memory trace of an event is not an event) nor what changes traces undergo when recovered to enter the field of judgment, that is working memory or consciousness.

Be sure, we can put aside all those problems, and continue our research on sounds in artisan way, claiming that they are matter of psychological fancies. But if the psychologist has got involved, his duty is to stress the precariousness of some technical terms and the risk of hasty generalizations.

2.6 On physical models

Working for the "Sounding Object" project, I have been acquainted with two strategies of research: physical models and ecological approach. I did not succeed in understanding well the reasons of both, and I am perplexed about their unconditional fitting with the program.

To the physical model strategy I could object that the hope of finding variations in the physical behaviour of sound sources that have a meaning in the behavioural world of the listener is open to chance.

1. Taken for granted that auditory perception is serviceable to adaptation to the environment, one has to notice that physical models cannot be found in natural environment: perfect cubes, spheres, plates do not exist in it.

2. Stimuli coming from physical sources vary along dimensions like intensity, spectral composition, duration of parts, time intervals among parts of the stimulus, profile of the envelope and so on. Percepts vary along related dimensions, like loudness, timbre, duration, articulation, dynamics and so on. But percepts vary also along other dimensions, like volume, presence, brilliance and so on – not to mention expressive contents – that have no direct counterpart in the physical stimulus.

Considering what is known in the visual domain, it is almost sure that perceptual continua are not congruent with physical continua: the perceptual dimensions of colors are other than the simple variations of wavelength. Giordano (see chapter 5), showed that discrimination between steel and glass materials is strongly influenced by the size of the objects. Small steel objects are

Figure 2.2: "Perceptual transparency".

recognized as being made of glass; large glass objects are recognized as being made of steel.

The investigation based on physical models is yet to be continued, because it brings to light unexpected effects. For instance, some manipulations of physical parameters of a unique acoustical signal of a falling body lead to the representation (a) of something like a faint explosion; (b) of the falling body and of the object on which the body is falling; (c) of the falling body, of the plate on which it falls and of the plane that bears the plate on which that body fell.

I consider this phenomenon the best result of the work of the unit of Udine, since it literally reproduces a phenomenon well known in vision, that of "phenomenal scission" or of "double representation". The paradigmatic case is that of "perceptual transparency" [132, 174], where a surface is perceived as the superposition of two surfaces, the upper one being transparent: see Figure 2.2.

Given that the perceptual fact is "a black bar on a white cross… the black bar is transparent", the phenomenal scission concerns the dark gray surface: it represents at the same time the portion of the white cross seen through the transparent bar and the portion of the black bar superposed to the white cross. Notice that on the stimulus display (distal stimulus) there is no white cross (there are 2 irregular white surfaces), there is no black bar (there are 2 irregular black surfaces) and there is an object that we do not mention: the irregular dark gray surface.

The effect is linked to the relations among the reflectance of the involved surfaces (at least four) and some topological and figural characteristics. Other instances of double representation are: scission of homocromatic surfaces, totalization, veiling, anomalous surfaces, amodal completion and figure/ground phenomenon. The common feature of all these phenomena is that they assure the simultaneous perception of objects that mutually occlude themselves when observed from a still point of view [246].

In the auditory domain we face the same problem: in the physical environment there are many objects simultaneously vibrating, so that the sound wave coming to the ear is unique. At this point there is the necessity of extracting from it the signals or the cues that can restore the multiplicity of physical objects, because choices in behaviour depend on a reliable map of objects, distances, obstacles, routes and so on. Take for instance the impact sounds: we perceive at the same time the stroke and the stroke object (a falling ball, the plate on which it falls). Now, which part of the proximal stimulus (the acoustic wave at the eardrum) goes to build the striker, and which part goes to build the stroke object? In my opinion, this is a high priority goal for the research in the field.

2.7 On the ecological approach

Compared with that of physical models, the ecological approach is surely more sensible. Let us disregard all the possible physical sources of sound and noises (for the most referring to objects inexistent in the natural setting, like cubes, spheres or thin plates squared or round in form), and let us concentrate on physical objects actually present in the human environment (stones, trees, running water and so on). After all, the auditory system went to its present structure in order to make human behaviour adaptable to that environment. Nevertheless, even the ecological approach presents some problems.

I see the difficulty of the ecological approach in the neglected distinction between physical environment and behavioural environment. The absence of this distinction is for me an enigma. Gibson [103], which ecological psychologists unceasingly refer to, was a pupil of Koffka, who recognized and imposed the necessity of taking into account, when explaining behaviour, the things as they appear, and not as they are (an attitude entirely shared with ethologists, see Uexküll [247], or Lorenz [158]). Besides, Gibson [101] was the discoverer of the "pictorial perception", that is the most flagrant contradiction with the principles of ecological perception: we see things that are not. It is true that, in the study of sounds, we have to consider sounds that take place in human environment, but this environment is not the physical environment, but the behavioural one. We react to auditory signals as their sources appear, not as their sources are.

In detail, the ecological perspective does not explain errors and illusions and consequent unsuitable behaviours (let us speak of perception as a kind of "behaviour"). As we pointed out before, we hear what does not exist, we do not hear what exists, we hear sources inexistent in the natural environment, et cetera. About errors, illusions and consequent unsuitable behaviours are an unsurmountable obstacle for those that trust in "direct" perception – there is to say that perceptual systems developed in a frame of costs and benefits. We cannot "hear" sounds below 20 Hz, and in this way we are "deaf" to the vibrations produced by physical objects whose size is rather large; at the same time, we cannot hear sounds beyond 20 KHz, and we are therefore deaf to vibrations produced by objects that are rather small. In principle, we could be supplied by an auditory system that can detect signals even below 20 Hz and beyond 20 kHz, but the benefits of this supply (avoiding perils, gain opportunities) could be achieved by unbearable costs (in terms of physiological structures).

There is another fact to point out, concerning the "ecological" adaptation of the auditory system to the physical environment. Undoubtedly, there is such adaptation, but the auditory system is a procedure for processing acoustic information that has its roots in the deepest paleontological eres: they even say that cochlea is the transformation of the swimming bladder of fishes. Auditory system developed through the eres, mirroring more and more precisely the physical environment. At this point, the question is: what sort of physical environment is represented by the today human auditory system? According to ethologists, we come to light with a standard toolkit of processing abilities that refer to ecological conditions lost in distant ages, and only after the birth the auditory system specializes in interpreting signals coming from a given environment (forest noises for Amazonians, traffic noises for us). That means that we shall understand better the relation between acoustic stimuli and percepts if we shall investigate gross properties of physical environment that were important also in the past ages. Limiting ourselves to impact sounds, I expect the best results from investigating the sounds produced by concavities (holes) or convexities (bulges out), by hardness or softness of terrain, by rapid or slow running of water – not to mention the sound produced by a source coming nearer or moving away.

Coming back to direct perception so dear to Gibsoneans I ask myself in what sense we can define "direct" the perception of events (in the visual domain the movements, everything in the auditory one, the temporal dimension being unavoidable), while we often have to wait for the end of the signal in order to make use of its preceding part (the case of the discharge of the machine gun is rather simple, but there are also cases by which the succession of auditory events is different from the sequence of acoustic stimuli, see Vicario [246]). It is plain that such a phenomenon requires a sensory storage, a categorization of the signal, a recovery of previous experiences and so on, making direct experience entirely other than "direct". The only way to avoid such a criticism is to suppose that perception of events is "tuned" on physical becoming, that is on a philosophical construct, not on a fact. With such premises, if Gibson's "optical array" can be reduced to the *eidola* of early atomism (V-IV century b.C.), recent calls for the "tuning" of behaviour on physical becoming are just a form of occasionalism (XVI-XVII century a.C.).

2.8 On phenomenology of sounds

"Phenomenology" is a philosophical term [236] that refers to the analysis of the *Erlebnis* (direct experience) by means of nothing but its own contents. The classification of sounds according to their perceptual characteristics (high-/low, loud/soft, brilliant/dull, threatening/reassuring and so on) is phenomenology. To classify sounds according to their spectral composition, or to the mechanical sources that produced them, or to evoked potentials in the ear or in the brain, is no phenomenology at all. As to psychology, the phenomenological attitude is that of Gestalt oriented students, who place the detailed description of percepts (and of all conscious experiences) before the explanations in terms of stimuli, neural correlates, past experience, attention, motivations and so on [170]. In the last decades took place also a method of investigation called *experimental phenomenology*, which we have to be warned about: as I demonstrated [245], experimental phenomenology is nothing but the usual scientific method, this time applied to mental contents.

As far as I know, we lack a well founded phenomenology of sounds, in a way comparable with that of colors [134]. Let us for a moment overlook the most obvious tripartition by noises, tones and speech. If we direct our attention to noises, we find only a long list of nouns (buzzing, squeaking, trampling, blowing, blasting *et cetera*, not to mention the numberless onomatopoëses), without any effort to distinguish the phenomenal dimensions of the noises themselves. It is likely that some nouns refer to different degrees of the same sensation: for instance, whispering and muttering, and that some nouns refer to the same degree of different sensations: for instance, the quiet flowing of the water of a streamlet, or the quiet skimming through a book. I found the sole efforts to create a phenomenology in manuals for police officers or jurists, who need to decide what sorts of noises (and at what loudness level) have to be considered disturbing or harmful.

The only novelty that I found in the field, is that of Fernström and coworkers (see chapter 13), that seems to me sensible and productive. As it is well known, they try to cluster various kinds of noises in a two-dimensional space whose coordinates can be changed at will. In a way, the method is a refinement of the "semantic differential" [190], widely adopted in psychology to measure the meaning of any sort of mental contents. I rely on Fernström's method to achieve a phenomenology of sounds based on their perceptual characteristics, and not on physical or physiological prejudices.

2.9 On expressive sounds

phenomenology of sounds may appear as a huge enterprise, considering the fact that percepts have, besides the characteristics of their own (loud/soft, brilliant/dull et cetera), information about the nature of the source and its probable future behaviour. When we speak of "expressiveness" we refer to the fact that objects and events share not only *primary* qualities (size, form, weight and others, independent from the subject) and *secondary* ones (color, smell, taste and others, rather dependent on the subject) but also *tertiary* qualities (good/bad, threatening/attracting, gloomy/happy and others) not dependent, as a rule, on the subject.

Tertiary qualities are often defined as *physiognomic*, that is "informing on the nature" of the object or of the event. In a sense, they are added to perceptual features: for instance, when listening to a sound we can say: "this is a violin", and we can also add: "this is a good violin". Indeed, objects and events present a special sort of expressive features that are *Aufforderungscharaktere* (a term translated by Gibson as *affordances*), that is information about their manageability; for instance, a door handle has a form that asks for grasping it. In general, events are far more expressive than objects: the way a man moves his hands when speaking carries a lot of information (it is defined as "non verbal communication"); the way a speaker modulates dynamics and phases of his utterances is another important communicative factor (defined as "supersegmental").

There is evidence that expressiveness in perception is not a matter of computer like processing of signals, covert thinking or previous experiences. Expressive features of objects and events are immediately manifest as form, color, size and so on. Gestalt theorists stress this fact, producing numberless instances, at least for the visual domain.

The role of expressive features seems that of guiding the behaviour in an environment where motor responses have to be performed in suitable way and in the least time: In the visual domain we perceive that a beam is threatening to fall, or that the movements of the animal in front of us presages an aggression. From the interactive behaviour of two persons we immediately realize which is the dominant and which the obedient one. Expressive features are the foundation of social behaviour.

In the visual domain, movements are far more expressive than objects, since to the spatial features (form, color, size) the evolution of these features in time is added. With even stronger reason, that seems to hold in the auditory domain, where there is no stimulus unless it goes on for a suitable time. As a consequence, research on expressiveness in the auditory domain should rather concern the profile of variations than the spectral composition of sounds. A lengthy experience in the perception of expressions in movements starting from the study of Heider and Simmel [119], and the theoretical and experimental contributions of Michotte [176] provides a lot of recipes for the perception of various mechanical or intentional contents. Rightly famous is the method of Johansson [126] for the recognition of locomotions.

Having worked in the field, I ask myself whether we should continue in finding stimulus conditions for all the sorts of expressive contents, or make an effort to establish the rules underlying all those phenomena. For instance, I remember the gross taxonomy made by Kanizsa and myself [133] concerning movements, and I think that it could be transposed to sounds. So we should have: (A) a first class of "natural" sounds, that is those produced by physical processes; (B) a second class of "mechanical" sounds, for the most repetitive or cyclic patterns of noise; (C) a third class of "intentional" sounds, that are those produced by living beings during their motion in the environment or during their interaction with other living beings.

Perhaps there is a simpler way for attacking the problem of expressive sounds. A careful exam of hundreds of "sounds effects", devised for adding the soundtrack to movies, persuaded me that the first and simplest categorization of sound and noises is that of "animate" versus "inanimate". For instance, cyclic noises, or noises that vary in regular manner are perceived as coming from "natural" sources or mechanical devices; while irregular, unsteady or aperiodic noises are easily attributed to the presence of a living being acting in the environment.

2.10 Some findings and suggestions

The preceding points have been the theoretical framework for the research carried on by the unit of Udine in the “Sounding Object” project. From that framework, there emerged some findings and suggestions that I briefly summarize.

The awareness that phenomenal scission of the acoustical stimulus is the central point for understanding the multiplicity of sounding objects on the auditory scene, enabled us to imagine and to perform the experiments reported by Burro, Giordano and Grassi in this book.

The analysis of results of the aforesaid experiments makes me foresee that sooner or later we shall face the two major problems of auditory perception: (a) the formation of auditory events in the flow of phenomenal time and (b) the non deterministic and non computable relations among features of the already formed auditory events (on this point, see Vicario [242]). I hope that the knowledge of the identical matter of fact in visual field, as to the perception of objects, movements and changes, will assist us in seeing more clearly the problems of auditory perception.

The expressive value of sounds and noises came immediately on the foreground. Observations performed on noises produced by dragging objects on sandpaper, as well as produced by drills under stress, showed that expressiveness does not appear in steady sounds, and that even the recognition of their source is impaired.

The filling up of vessels by dropping water seems to give rise to two frequencies shifted in opposite direction, presumably that of the growing water column and that of diminishing air column above the surface of the water. The perception that the vessel is filling up, or that it is near to be full to the brim, depends on the slope of shifting fundamental frequency. I argue that before investigating expressiveness, it should be ascertained the conditions of the perception of change. We performed a couple of formal experiments on the perception of acceleration and slowing down of rhythms. We found confirmation of an already suspected fact [244]: the threshold for the perception of an acceleration is lower than the threshold for slowing down. The fact could be interpreted as higher sensitivity for approaching sources (incoming opportunity or peril) than for those going away (less attainable opportunities or ceasing peril).