Recent spectral procedures as potential attributes of source sound variation in cue-based localization studies

Leonardo Aldrovandi

PUCSP – Pontifícia Universidade Católica de São Paulo
Rua Albuquerque Lins 646, ap. 1
01230-000 – São Paulo – SP

Email: leoaldrovandi@ig.com.br

Abstract: Recent psychophysical studies of cue-based sound localization have, to the most part, considered clearcut characteristics of source sound stimulus, such as bandwidth and general spectral characteristics (flat and randomized intensity components in noise, presence and absence of transient onset, narrow and broad frequency bands, choice of noise (mainly pink and white) or simple and Gaussian tones. This article suggests that other source sound characterizations and procedures should begin to come into play in such studies. Even though the avoidance of complex sound input is generally taken as a guarantee of more reliable analysis, as it reduces the scope of a sound's mutable temporal and spatial structure to avoid analytical confusion, recent music's conceptual groundings such as "harmonicity" and degree of temporal periodicity, regulated in different possible forms at source sounds, may bring new directions for experiments to come, as they rely on more subtle or more "realistic" levels of sonic changes.

General Remarks

Recent psychophysical studies of cue-based sound localization have, to the most part, considered clearcut characteristics of source sound stimulus, such as bandwidth and general spectral characteristics (flat and randomized intensity components in noise, presence and absence of transient onset, narrow and broad frequency bands, choice of noise (mainly pink and white) or simple and Gaussian tones. This is due most likely to the prudent "Cartesian" attempt of controlling experimental grounds departing from the simplest, purest, more isolated and unambiguous initial stimulus, avoiding complex material that could lead to tautological analysis and misreading interpretations. In most localization studies where source sound is changed apart from source position characteristics, emphasis is given to the analysis of cue-based salience according to the change of these general sound attributes. This article suggests the hypothesis that other source sound characterizations and procedures should begin to come into play in such studies. Promoting a complex sound-based variation paradigm, that is, where cue measurement studies confront or depend also on different varying spectral procedures and attributes of single sounds, may lead to the revelation of other directions for cue-based localization discussions. Even though the avoidance of complex sound input is generally taken as a guarantee of more reliable analysis, once it reduces the scope of a sound's mutable temporal and spatial structure to avoid confusion while relating sound attributes and real/apparent position interpretations, recent music's conceptual

groundings on timbre, such as harmonicity or degree of temporal periodicity, once regulated in different possible forms at source sounds, may bring new directions for experiments to come, as they rely on more subtle or more "realistic" levels of sonic changes. The hypothesis holds that a more controlled and gradual change in the sound's internal spatial and temporal attributes may indicate something about how and in what conditions we alter its apparent localization in actual space, with these alterations put as functions of the sound's own dynamical characteristics. Various significant trends from such possible efforts may be developed. The article presents the hypothesis and suggests two well-known procedures.

1. Source sound variation in most experiments

Ambient and individual listening characteristics have been key issues in localization studies, that is, respectively, the transformation of sound as it travels from the source to the listener and listener individual characteristics (individual HRTFS, head movement, pinnae and shoulder natural reflections, dispersions, filtering, etc). But varying characteristics of source sound itself through a wider range of procedures have been less common in experimental groundings and discussions about sound localization. Change in sound is well documented, for instance, in general frequency range, bandwidth changes and noise treatments in various types of experimental contexts. Many studies reveal how different cues (binaural and monaural) are more or less prominent with such sonic changes. For example, it is generally agreed that monaural spectral cues are mainly active in the higher frequency ranges, as well as ILD (intensity level binaural difference).

2. Little use of complex sound material

Clearcut manipulations and the use of simple source sounds have the purpose of avoiding conflicting situations where temporal and spatial attributes of complex sounds would confuse the analysis of results. Blauert puts it well:

"In theory, sound fields of any desired complexity may be used in auditory experiments. Because complicated fields present great difficulties in analysis, however, most experiments employ sound fields of the simplest possible temporal and spatial structure, though these are chosen so as to allow the furthest possible extrapolation of measured results to more complex fields." (1995, p. 22)

To rely on the argument that the simplest should necessarily come first, as an ideal experimental point of departure, could be a prudent Cartesian belief about the method. But it may also entail habitual scientific attitudes or, more importantly, a distance between "simple as ideal and eternal start" and world or "realistic" complex experience. Furthermore, the assumption that "the simplest" will explain complexity in the future is a deductive inference. Complex material may reveal relationships itself and may allow different methods of procedure.

3. Hypothesis about other procedures

Without entering any endless epistemological discussion on the method, the purpose of this paper is solely to expose the hypothesis about the validity of new procedures of sonic treatment as experimental basis for localization studies. These treatments may include the gradual manipulation of temporality (for example: periodicity, variable periodicity) and spatial content (for example, harmonicity, inharmonicity) of complex sounds, now

possible with more accessible technological means, in order to confront them with apparent/real localization experiments.

We could formulate some primal and general questions concerning these possible procedures:

1. How does periodic content of timbre relate to the capacity of localization, if at all? And in what directions and distances this would hold any pattern, given the specific sound transformation procedure and sound attributes?

2. How does harmonic content relate to the above localization matters?

3. How are they related to a priori knowledge or recognition of subjects?

4. How does perceptual data vary and set convincing relationships with these sound manipulations?

5. How should we actually cross-integrate degrees of harmonicity and periodicity in order to analyze them in relation to localization?

In sum, how should an experiment with such variables proceed to achieve reasonable analytical interpretations?

On several monaural spectral cue experiments, a priori knowledge has been proven to be relevant. Altering sound procedure characteristics may help indicate new arguments on the matter.

More specific questions may also appear. For example, does harmonicity and periodicity at higher rates and directly associated (for instance, as in pop music) have any direct relation to perception at front, since most music is experienced at front? Would this indicate the influence of a priori or cultural determinations or would it have other reasons?

These tools control the behavior of the inner structure of sound. Thus, observations taken from finer controls of energy distribution in sound may relate to how we perceive it in space. A brief description of these two examples of procedures chosen here should then be given.

4. Harmonicity and Periodicity:

We may think of two well-known compositional procedures that could be applied to sonic material in scientific experiments. If we consider them in a rougher way, one is related to inner harmonic regularity and the other to inner time regularity of sound.

Let us say that harmonicity would be a degree of controllable harmonic content and displacement in sound. Its equivalent in time would be periodicity, defining a degree of controllable periodic content in sound. In music composition, examples by composers such as Gérard Grisey are often given. In *Les Espaces Acoustiques*, one may find processes such as the one that goes from periodicity to non-periodicity in a gradual and linear manner (See Baillet, 2000).

These concepts allow finer control over the manipulation of transitional states of sound, what may be considered noise-to-sound and sound-to-noise transitions. The possibility of controlling linearly these transitions and, to some degree, intermediate states of these poles of regularity and irregularity, may allow a better comprehension about the relationship between sonic properties and localization. Usually, experiments do not consider change in different parts of the signal spectrum relative to each other, relying at most in dynamic envelopes and flat/randomized noise spectrum components. These controls may establish, for instance, new grounds for broadband frequency

experiments and show how temporal and intensity articulation may relate to the ability of localization.

In good part of the literature, it has been said that broadband frequency ranges as more localizable, as in experiments focused on the median plane (where no binaural cues would be, ideally, activated), and thus, where spectral characteristics of sound itself become necessarily prominent in localization.

It has also been proven that changes in spectrum content affect the direction of auditory events (Blauert, pg. 98). This was reported to be true in an experiment in which the intensity of higher harmonics in a 4 harmonic sound was varied. Another experiment has shown that adding a few harmonics may alter how we locate sound in elevation, since we tend to associate higher frequency content with higher positions and low frequency content with lower positions. All that goes without mentioning the well-know relationship between sound spectrum filtering and distance perception.

These examples are very few, considering all the efforts up to now: the relationship between spectrum content and localization is well recognized. Thus, it seems very plausible that different sound procedures for varying spectrum content may bring new meanings and trends to come.

.5. Postlude words:

From this general exposition, more specific questions become unlimited. These considerations may well be in the mind of scientists, but are probably part of a risky shot to be taken. Once dealing with complex sound material and such procedures, interpretation of results may remain too speculative. But they also may bring new trends on the subject. The arguments presented are just “trigger-thoughts”, suggestions raised in the hope that, once interested in conducting experiments on such direction, scientists come to develop “lineaments of gratified desire”, as William Blake sings.

References

BAILLET, J. (2000). Gérard Grisey: Fondements d’une écriture. Paris: L’Itinéraire.

BLAUERT, J. (1995). Spatial Hearing. Cambridge, MA: MIT Press.

DESCARTES, R. (1965). Discours de la Méthode. Paris: Garnier-Flammarion.

WIGHTMAN, F., D. KISTLER (1993). “Sound Localization”. Human Psychophysics. New York: Spring-Verlag, pg 155-191.

WIGHTMAN, F., D. KISTLER (1992). “The dominant role of low-frequency interaural time differences in sound localization”. Journal of the Acoustical Society of America, 91, pgs. 1648-1661.

WIGHTMAN, F., D. KISTLER, E. WENZEL (1991). “Localization with non individualized virtual acoustic display cues”. New York: Preprint, ACM Press.

WIGHTMAN, F., D. KISTLER (1997). “Factors Affecting the Relative Salience of Sound Localization Cues”. Binaural and Spatial Hearing in Real and Virtual Environments, pgs. 1-23. Mahwah, New Jersey: Lawrence Erlbaum.

WIGHTMAN, F., R. JENISON (1995). “Auditory Spatial Layout”. Perception of Space and Motion, pgs. 365-400. New York: Academic Press.