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# CINTRA: from an interdisciplinary centre on acoustics towards an intra-inter synergetic network

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### Abstract

Acoustics is an inherently interdisciplinary science that has evolved in a mature discipline field occupied in the study and solution of hot social topics. This is, precisely, the strength and the challenge of the Acoustics in the XXI century. On the other side, nowadays it is out of discussion that universities have a crucial role in knowledge generation with social responsibility towards a more equalitarian society. In this direction, in Argentina new scientific policies promote three fundamental dimensions: a) interdisciplinary and inter-institutional articulations, b) an unified science and technology system, c) coupled with education in all levels and the productive sector. In turn, new paradigms of higher education gives to the research training abilities a central place in the academic curricula. In this complex scenario, a research centre has a key role in the achievement of those main aims. CINTRA, FRC, UTN - UA CONICET, is one of the seven Argentinean laboratories devoted to Acoustics that depends on public universities. In accordance with these lines of thoughts, it is dedicated to interdisciplinary research; young researchers training; education in acoustics and specialized technological service. At present, CINTRA is involved in a collective construction pointing to innovative dynamics encouraging the emergence of synergetic networks where theory and practice are naturally jointed. In this paper, we describe three ongoing programs that articulate research -technological innovation - interdisciplinary researcher training - technological services.

**Keywords:** Collaborative Network; Research Centre; Interdisciplinary Acoustics

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# CINTRA: from an interdisciplinary centre on acoustics towards an intra-inter synergetic network

## 1 Introduction

In this paper we present the institutional profile of the CINTRA (*Centro de Investigación y Transferencia en Acústica*), and three research programs that are in progress that illustrate the new dynamics of collective knowledge construction in which we are involved. This dynamics implicates discovering and promoting internal and external networks that naturally articulate knowledge and practice in three main areas: research and technological innovation, interdisciplinary training of human resources, and high-level technological services.

## 2 Acoustics in the 21st century

The inherently interdisciplinary nature of Acoustic Science is reflected in three dynamically interrelated aspects: 1) in the sub-disciplines involved: musical acoustics, architectural acoustics, electro-acoustic, psychological acoustics, bioacoustics; 2) in the diversity of professionals involved: physicists, psychologists, engineers, computer programmers, architects, audiologists, musicians, biologists, mathematicians, philosophers; 3) in the institutional areas committed: the University, the Public Sector and the Private Enterprise. The excellent opportunity of generating, circulating and exchanging knowledge that enables the multidisciplinary and collaborative work it is both the strength and the challenge of the 21st century Acoustics in the environmental and social global context. Acoustics has become a mature science, which studies topics of great social relevance. It is worth mentioning its applications in biomedicine (ultrasound diagnosis, cochlear implant), environmental issues (acoustic cooler, soundscape); education (software of active and collaborative learning with on-line technology), and the industries of music, communications, information and entertainment (portable devices, ICTs, virtual reality games, visual-auditory motion sensors). In Argentina there are seven laboratories or groups linked to Acoustics that belong to seven Public Universities located in the provinces of Córdoba, Buenos Aires and Rosario. The National development of the discipline in the country has a fragmentary and disjointed characteristic due to geographical, historical and thematic peculiarities addressed by each of the groups. This issue imposes the substantial challenge of achieving a collaborative work of all laboratories and groups in pursuit of strategically positioning the national Acoustic in Latin America and the rest of the world.

## 3 Science and University in Argentina

The value of scientific and technological knowledge and the role and social responsibility of the University in building a fair society are today undeniable truths. In this line, national scientific policies that are being implemented since 2003 under the slogan “Science and Technology (S & T) made in Argentina” are based on three fundamental objectives: to train interdisciplinary and inter-institutional teams; to strengthen the institutions that are part of the S & T system; and to

articulate this system with Education at all levels and with the Industry and Social sectors. In addition, the articulation of teaching and scientific practice, as well as, the training of students in research have a critical place in the new paradigms of Superior Education. In this context of profound changes, a Research Centre in a Public University emerges as a key component in pursuit of the accomplishment of the objectives above mentioned. The CINTRA tightly responds to the new scientific and education paradigms. It is one of the seven Acoustic laboratories recognized in the country that covers the full spectrum of activities: interdisciplinary research; teaching and training of human resources; technological services and other transfer activities to the community. The Centre has become a referent in acoustic issues for many important local, national and Latin American companies. The appreciation of the CINTRA activities by governmental authorities, companies and educational institutions and the above mentioned new working dynamics reinforce the crucial role of the Centre in the context of national Acoustics development.

## 4 CINTRA: Interdisciplinary Centre in Acoustics

### 4.1 Brief History

In this century is even more valuable the pioneering and visionary work carried out for more than 45 years by the engineer G. L. Fuchs. He founded and directed for many years the *Centro de Investigaciones Acústicas y Luminotécnicas*, CIAL, in the *Universidad Nacional de Córdoba* (UNC). He was a senior researcher at CONICET and worked tirelessly next to his main collaborators from different disciplines - conforming the Acoustic Group (AG) of CIAL- in promoting Acoustics in Argentina and Latin America.

In May 1999, the AG moved to the *Facultad Regional Córdoba, Universidad Tecnológica Nacional* (FRC, UTN) in order to be located a more appropriate place to develop and promote its technological and scientific work. Only nine months later, it was created [1], due to the scientific and technological relevance of the Group, the institutional project presented and the support of the University authorities. This Centre acquired the category of Associated Unit of the CONICET in June 2004 becoming in a Centre of excellence for interdisciplinary research in Acoustics, scientific and technological production and human resources training.

### 4.2 Mission and Objectives

Mission: To produce and transfer interdisciplinary scientific and technological knowledge in Acoustics according to three main criteria: high quality, strong ethics and respect for the environment. Objectives: a) To generate interdisciplinary knowledge in the field of Acoustics; b) To develop undergraduate and post graduate teaching activities; c) To foster the training of human resources in interdisciplinary research; d) To perform high level technical services and another transfer activities to the community.

#### 4.3 Infrastructure and facilities

The CINTRA building area is distributed on two different places separated by relatively distant areas. In the larger space, there is also the Acoustic Testing Laboratory (*Laboratorio de Ensayos Acústicos*, LEA), which has two acoustic chambers and an audiometric booth to carry out experimental tests and technological services. There are equipment and tools for high-precision acoustic use with traceability to INTI, NIST and DPLA: Class I sound level meters; high-precision microphones for free, diffuse and pressure fields; sound intensity probe to measure sound intensity; measuring amplifiers; target signal acquisition; artificial ear and mastoid; sound sources for acoustic reference and vibration; accelerometers; head and torso simulator; standard and extended range digital audiometers; device to measure otoacoustic emissions and impedancimeter; infrared video cameras; motion-capture sensor; 3D scanner; PC with special hardware capacities for computer developments; ad hoc research tools built at the CINTRA; software development tools for statistics and sound processing analyses.

#### 4.4 Members

42 people have their official work-place in the Centre. Their academic disciplines are: Engineering, Psychology, Medical Sciences and Music. There are members of CONICET; teachers and researchers from UTN and UNC; doctoral and postdoctoral fellows from CONICET, UTN and UNC; undergraduate and graduate trainees from UTN and undergraduate students from UNC. The CINTRA main economic resources come from grants obtained from local and national agencies that promotes S & T and from the Centre's own generated economic and financial resources through the technological services performed.

#### 4.5 Research areas:

- Conservation and promotion of hearing.
- Environmental Acoustics.
- Human echolocation and other phenomena of audio perception-action without visual cues.
- Virtual Acoustics.

#### 4.6 Main topics of interest:

- Unconventional methods for measuring noise
- Sound fields of classrooms and auditoriums
- Soundscape
- Automated measuring of acoustic transducers directivity
- Evolutionary Acoustic Psychology
- Sensorimotor dynamics and Learning

- Spatial and body perception of the music
- Cochleopathy, otoacoustic emissions and recreational habits
- Auralization and synthesis of Head Related Transfer Functions (HRTFs)
- Self-adjusting detection of mechanical failures by acoustic resonance
- Enactive Robotics Hearing
- Audiogames and human-machine interfaces without visual cues
- Technological innovation applied to acoustic problems

#### **4.7 Teaching activities and human resources training**

The CINTRA perform undergraduate and postgraduate teaching activities at the University in different acoustics themes. In addition, it has become a Centre of Excellence for interdisciplinary training of young scientists in acoustics. It is worthy to mention the growing international collaboration for the supervision of highly qualified young researchers in several topics that are relatively little studied in the country.

Currently, 35 undergraduate and graduate students from Engineering, Psychology, Medicine (Speech Therapy) and Music, are carrying out their scientific and technological research projects in the CINTRA. It is noteworthy that in the last 5 years: a) 5 doctoral projects from three different academic disciplines were completed at the UNC (4 with CONICET scholarships): 3 in Psychology, 1 in Medical Sciences (Speech Therapy) and 1 in Engineering. b) Each person in this group has a clear profile as a researcher, one was already part of the CONICET's Researcher Career (CIC), two of them are recently part of the CIC and for the other two their admission is under evaluation.

#### **4.8 High-level technological services (STAN) and other transfer activities**

A group of members of the CINTRA perform part of their working activity in the LEA providing technological services. A remarkable strength of the Laboratory is the area of acoustic measurement tools' calibration, which is responsible for carrying out the calibration of its own tools and external ones with high validity and reliability.

*STAN, CONICET:* Calibration of Acoustic Instruments; Hearing Protectors Testing; Acoustic Engineering Consulting; Acoustics Training Programs; Customs Acoustic Testing; Environmental and Occupational Noise Testing; Automotive Noise Testing.

*Featured Clients:* 3M, Holcim, Honeywell, Mercedes Benz, Iveco, Fiat, Renault, Volkswagen, MSA, MWM, Alladio, CONAE, CNEA, Fravida, Cámara Argentina de la Industria del Juguete.

Besides, other transfer activities were implemented through: a) several programs of articulation with other Argentinean Acoustic Laboratories and high-schools b) essential and sustained participation, from the 90s, in the development of norms (IRAM) and other municipal, provincial and national regulations; c) different activities of scientific dissemination in a variety of public and private domains.



## 5 CINTRA: new dynamics of collective work

In this last section we briefly describe three programs in progress, each of which has its own particularities, that illustrate the new dynamics of the collective work in which we are involved. The first two are long-standing programs that articulate (a) applied research, research in technology and pedagogical innovation and transfer; (b) applied research, research in technology and international collaborative network for the supervision of young researchers on current topics that are relatively little studied in the country. The third one (c) is an early stage project that belongs to the recently established Technological Innovation Program, which articulates research and technological development, STAN and the integral training of the UTN research students.

### 5.1 Early hearing impairment in adolescents and young adults induced by social or recreational noise

*Applied research:* longitudinal and transverse descriptive studies are conducted in order to establish relationships between audiological, psychosocial and acoustic dimensions and their evolution in time. *Audiological research:* study of the sub-clinical manifestations of hearing with objective assessment of the cochlear protection mechanism that is regulated by the medial olivocochlear system, in order to identify hearing vulnerability and detect an early predisposition to premature deterioration of hearing. *Psychosocial Research:* study of recreational music listening habits and the relation to the noise levels preferred by adolescents and young people. *Acoustic research:* study of noise immission levels in closed recreational areas and of real noise levels for personal music players' users, using novel measurement techniques based on sound pressure and its distribution in the frequency range. *Research and technological development:* it is performed ad hoc developments that fulfill requirements of national and international standards regarding testing environments, measurement techniques and equipment optimization. The following aspects are addressed, among others: audiometer and noise measurement tools calibration; design and construction of special fixed and mobile audiometric booths for audiological studies and measurements of acoustic sources located close to the ear (e.g. personal music players); implementation of special systems for the measurement of noise immission in recreational activities and of new methods for the measurement of acoustic sources located close to the ear. *Academic extension activities:* transfer and extension activities for the community are performed in order to help to mitigate early hearing deterioration induced by recreational noise and to contribute to the protection and awareness of the damaging effects of high-level noise exposure through the implementation of the following intervention strategies (from 2008 to date): participatory workshops promoting awareness aimed at adolescents (especially in technical schools) in order to train them as leaders in Hearing Health Promotion; intensive awareness seminars aimed at the entire education community; courses for the training of trainers aimed at teachers who are responsible for the transmission of healthy lifestyles through daily teaching and learning of values; training courses for "Promotion of Hearing Health in Schools" (STAN N°1316 CONICET) aimed at teachers from municipal schools in the city of Cordoba, Argentina; Manual of good hearing practices aimed at the wider community, which warns about risks due to bad habits that can induce hearing loss and provides guidance for

building healthier sound environments [2]. The progress achieved in this project is integrated into a Psycho-Acoustic-Auditory Screening destined to detect levels of noise immission and its components in the frequency range that can affect hearing, and to analyze health-risk behaviors and early prediction of hearing vulnerability in relation to these noise exposures. This will contribute to: a) the co-creation of healthy recreational environments, b) the prevention of hearing loss induced by recreational noise, and c) continue with more actions promoting hearing health. We are currently working on the following projections of the three dimensions above mentioned: the study of speech discrimination under sound competition and its relation to the functioning of the medial olivocochlear system in pathological and normal-hearing people; the development of a digital audiometer prototype to evaluate conventional hearing thresholds and other auditory functions and validation of an assessment tool for auditory perception under sound competition; the participation in specific scientific events in order to link scientists with the school community and with the general public.

## **5.2 Enactive Sensorimotor Learning in Human-Environment-Robot interaction**

Enactive perspectives argue that perception is intimately related to action. In a strong sense, perception is based on the regularities that govern the ongoing coupling between the agent's action and the subsequent sensory changes, known as sensorimotor contingencies [3]. The interaction of the agent with his environment and/or with other agents constitutes a complex and autonomous dynamic system. The agent must be able to regulate his behavior adaptively according to the dynamic changes (disruptions) that occur in the agent himself, in the environment or in the other interacting agents, which implies a continuous process of sensorimotor learning [4]. Sensory substitution refers to the phenomenon by which environmental information that is typically acquired through one sensory modality can be acquired through another modality. For instance, visual information can be provided by auditory or tactile stimulation. This kind of phenomenon is seen as a paradigmatic situation that enables the study of how an agent learn new sensorimotor contingencies. A sensory substitution device (SSD), a technological system that transduce the characteristics of stimuli from one sensory modality to another, is a powerful research tool that allows the emulation of disruptive situations that constrains the user to adapt his sensorimotor contingencies in order to re-establish an appropriate interaction with the environment. The study of the role of interaction in the construction of intelligent behavior, that is, to perform actions in order to give meaning to each interaction (sensemaking), it is a topic of great relevance and interest [5]. In this context, social interaction is defined as a continuous process of reciprocity and interdependence, where the sensorimotor contingencies are redefined. Robotics is achieving promising progresses based on enactive perspectives in relation to autonomy and adaptive behavior of robotic agents. One of its main challenges is the development of control models that implement successful sensorimotor coupling which is useful to interact with other agents located in real environments. Such models implies, on one hand, the development of a new computer architecture specifically designed to implement sensorimotor dynamics observed in human studies. On the other hand, the use of stochastic estimation techniques that define an appropriate framework to address the problem of motion control, guided by information from the sensorimotor flow. We are developing an interdisciplinary program of international scientific collaboration with three European teams

(Laboratoire d'analyse et d'architecture des systemes, LAAS; Institut des Systèmes Intelligents et de Robotique, ISIR; and Fundación Vasca para la Ciencia, Ikerbasque). The main goal is to make theoretical and empirical contributions on processes of sensorimotor learning in the absence of visual cues for both, humans and robots. Specifically we aim: a) to characterize sensorimotor patterns emergence in localization and objects recognition tasks using SSDs and also to analyze its evolution in tasks that involve interaction between agents; b) to develop an enactive model of (audio) perception-action in robots with parallel computing architecture; c) to build an experimental platform to study real agents' interactions (human and/or robot), by integrating methods and tools developed by the groups implicated. We will fulfill these goals through an extensive young researchers international exchange program. This program involves the promotion of collaborative scientific production, the training of new researchers, educational activities and transfer to the community. It is worthy to mention that the senior researchers from the European institutions are supervising doctoral and postdoctoral projects of several CINTRA members. We expect that these activities will strengthen and consolidate the current international cooperation and will promote the generation of new major projects related to this relevant topic.

### 5.3 Environmental Noise Remote Acquisition Station

Measurements of sound pressure levels (SPL) that are performed to evaluate noise levels at work and in open spaces require the presence "in situ" of a sound level meter (SLM) and of an operator for each measurement location. In some cases, these measurements are made periodically at the same locations, so the procedure could be optimized with an autonomous remotely controllable SLM. The high cost of such SLM in the current market makes it a non-viable option, especially when several remote stations are necessary to simultaneously test at different locations. The expertise achieved in the CINTRA throughout the past years, both in building scientific instrumentation tools and in performing high level technological services, and new technological advances available in the market (MEMS microphones, embedded systems with high processing capacity, small size, low power consumption and wireless communication capacity and software development tools), has allowed us to propose the implementation of a reliable and thrifty solution for the remote acquisition of environmental noise levels. This project, which cuts across different areas of the CINTRA, emerges naturally in the LEA, - which has extensive experience in acoustic measurements in general and in environmental noise measurements in particular, following national and international standards – because of the working dynamics implemented and the requirements of several important clients. It will take place in three stages. For the first stage, currently in progress, preliminary studies are conducted on the requirements and functionalities of the system and cost estimation. In the second stage, different working teams will be built according to Centre human resources skills and to the specific requirements of the actual remote station construction. It is noteworthy that the participation of undergraduate and graduate students from different disciplines in the team has a twofold purpose: one, to achieve their integral basic training in technological research and two, to acquire scientific background by working with well-established research teams. In the third stage, we will implement the validated prototype according to current standards in real environments.



## 6 (Un)conclusion

In this paper we present the institutional profile of the CINTRA. At present, we are involved in new dynamics of collective work that were illustrated through three research programs in progress. This type of collaborative network articulates knowledge, practices and resources around relevant thematic axes. The results obtained thus far show a very promising scenario and encourages us to propose a similar model of collaborative work -in which it naturally fade away frontiers among disciplines, areas and research lines- thus, achieving the integration of Acoustics Laboratories and Groups in the country in order to promote a fairer position of Latin American Acoustics in the word context.

### Notes

- [1] Founder members: M. R. Serra (Engineering – CONICET); C. E. Biassoni (Psychology – CONICET); A. M. Verzini (Psychology – CONICET); O. A. Ramos (Engineering – CONICET); C. Arias (Psychology – CONICET); C. Frassoni (Engineering – FRC, UTN); A. H. Ortiz Skarp (CONICET).
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