LISTENING, PHONATION, LATERALITY, AND READING EFFECTS OF THE AURELLE THERAPY OF ALFRED TOMATIS ON CHILDREN WITH READING DIFFICULTIES

by Leah Schnitzer

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CURRICULUM STUDIORUM

Leah Schnitzer (née Paltiel) was born December 11, 1927, in Montreal, Quebec. She received the Bachelor of Arts degree in 1949 and Bachelor of Library Science degree in 1950 at McGill University in Montreal. She received the Master of Arts degree in Psychology from Carleton University in Ottawa, Ontario, in 1968. The title of her thesis was <u>Heat Escape Conditioning and Visual Discrimination in the Tiger Salamander (Ambystoma Tigrinum)</u>.

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INTRODUCTION

It may be said that one must have temerity to initiate research in the field of reading remediation because so much has already been done. Still, methods that are effective in ameliorating reading skills and that, in addition, are not detailed and time-consuming to apply continue to elude discovery so that it appears to some observers that important aspects of the reading process must have been overlooked. Common educational practice has been to identify reading errors, such as reversals and inversions, and to attempt their remediation directly, without regard to their source. Similarly, though often based on the hypothesis that neurological dysfunction underlies reading difficulties, perceptual and motor training to rehabilitate deficits in reading and related tasks consists in providing repeated and varied experience with the stimulus units contributing to impaired performance. There has been little systematic theorizing on the reading process per se and, more particularly, on reading as part of a larger language communication process, or on developmental precursors which may be fundamental to it.

As many as forty names have been applied to the problem of difficulties in reading. The prevalent term, dyslexia, which was first used in the late nineteenth century, is now struggling for survival. According to the large Oxford English Dictionary, the etymology of 'dyslexia' is the Greek term 'dys' meaning faulty or defective, plus the Greek word 'legein' which means speaking. Used with respect to its derivation, therefore, dyslexia refers to difficulty with spoken language, with diction, expression, and articulation, that is, to difficulty in selecting words to express ideas and to convey meaning and with the sounds of these spoken words.

Nevertheless, colloquially, the word 'dyslexia' is used by both laymen and specialists to mean disturbance, specifically, in reading. And a review of the literature on learning disabilities quickly reveals that members of the scientific and professional community disagree amongst themselves on a precise definition of dyslexia[1]. Some now maintain that dyslexia is a

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1 Macdonald Critchley, The Dyslexic Child, London, Heinemann, 1970, 137 p.; Jerome Hellmuth, Ed., Learning Disorders, 2 vols., Seattle, Special Child Publications, 1965-1966; Doris J. Johnson and Helmer R. Myklebust, Learning Disabilities, Educational Principles and Practices, New York, Grune & Stratton, 1967, xii-336 p.; John Money, Ed., Reading Disability, Progress and Research Needs in Dyslexia, Baltimore, Johns Hopkins Press, 1962, x-222 p.; Harry Singer and Robert B. Ruddell, Eds., Theoretical Models and Processes of Reading, Newark, Delaware, International Reading Association, 1970, xiii-334 p.; Lester Tarnopol, Ed., Learning Disabilities, Introduction to Educational and Medical Management, Springfield, Illinois, Charles C. Thomas, 1969, xix-389 p.

meaningless term applied to an erroneous concept.

This study was undertaken in an effort to assess the theory of dyslexia proposed by Alfred Tomatis, a medical doctor and specialist in oto-rhinolaryngology. The method used was the Aurelle 'electronic ear' and audio-vocal technique developed by Tomatis and applied and suggested by him as a therapy for children with reading problems. In contrast to previous reports on this method, the present report is of an investigation conducted under experimentally-controlled conditions.

The first part of this thesis presents a brief review of works which epitomize major trends in the recognition and diagnosis of reading difficulties. Following this, the theories of Alfred Tomatis which relate to the present study are reviewed in detail. Then Tomatis' diagnostic technique is described, his treatment procedure is outlined, and reference is made to clinical reports on the effects of the Aurelle apparatus and audio-vocal procedure in the treatment of dyslexic children.

The experimental hypothesis of this investigation is then stated, followed by a description of the experimental design, emphasizing the attempt to adhere to standardized, controlled conditions. Criteria for selecting the sample are discussed and assignment of the subjects to Aurelle and Control groups is described. Materials, procedure, and statistical analyses employed are then specified.

Subsequently, the results obtained in this investigation of the Aurelle technique are presented and discussed. This discussion evaluates the technique, firstly, with reference to the comparison results obtained with the Control group; secondly, in relation to recent findings and contemporary theory and practice in the fields which bear upon this investigation, such as audiology, phonology, and neuro-psychology; and, thirdly, in terms of effects predicted by the theories of Alfred Tomatis and the results he and others claim to have achieved with the 'electronic ear'.

In conclusion, suggestions are made regarding future investigations in this field.

CHAPTER I

REVIEW OF THE LITERATURE

Since the last quarter of the nineteenth century, children with difficulty in acquiring reading skills have been identified, described, studied, and treated. Several hypotheses have been advanced as to the etiology of the disability. Ophthalmologists, who were the first to publish accounts of children unable to recognize written letters or words, took a medical-neurological approach which reached its peak in 1917 with the publication of a monograph by Hinshelwood[1]. The inference of this approach was that a child must have a structurally intact neurological system in order to learn how to read. This led to the assumption that children with reading problems had brain lesions similar to those found in adults who had lost the power to read. A related position held that neurological functioning must be age-adequate and that a reading disorder was the result of a failure to develop the centres in the brain concerned with the visual memory for letters, figures, or words. These explanations, which were associated with the concept of congenital word-blindness, carried the implication that

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1 James Hinshelwood, Congenital Word-Blindness, London, Lewis, 1917, ix-112 p.

cases of extreme disability in reading were probably hereditary and, consequently, rather static and hopeless to treat.

Numerous authors noted the frequent history in so-called word-blind children of retarded speech development and crossed laterality, that is, an increased tendency to sinistrality and ambidexterity. McCready[2] postulated that there were common etiological factors in congenital word-blindness, congenital word-deafness, delay in the acquisition of speech, and stuttering. He speculated that they were the result of variations in the degree of cerebral dominance which was also manifest in weakness of lateralization of handedness shown by many such children. He urged early detection and efforts to correct these conditions. Bronner[3] systematically studied the nature of the perceptual defects associated with reading disability. She attributed the reading disability of one child to faulty visual memory and in another to poor auditory

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2 E.B. McCready, "Defects in the Zone of Language (Word-Deafness and Word-Blindness) and Their Influence in Education and Behavior", American Journal of Psychiatry, Vol. 6, 1926, p. 267-277.

3 Augusta F. Bronner, The Psychology of Special Abilities and Disabilities, Boston, Little, Brown, 1917, vi-269 p.

discrimination and memory, but in many other children she was unable to discover any evidence of perceptual deficits and was at a loss to account for the children's difficulties in learning to read. She speculated as to whether some specific synthesizing ability was required which it was not possible to study with the means at her disposal. Orton[4] found that children with reading difficulties frequently had conflicting laterality of eye and hand. He suggested that word deafness, motor aphasia, alexia, and agraphia, and lesser degrees of these disorders, have common etiological and clinical features, and he regarded them as a disorder of language. He associated language with the development of a hierarchy of complex integrations in the nervous system, culminating in unilateral control by one of the two brain hemispheres, that is, in cerebral dominance. To him, retardation in acquiring reading indicated that there was an intermixture of control in the two brain hemispheres in those areas which subserve the visual or reading part of the language function, and this suggested that there was some interference with the natural process

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4 Samuel Torrey Orton, Reading, Writing, and Speech Problems in Children, A Presentation of Certain Types of Disorders in the Development of the Language Faculty, New York, Norton, 1937, 215 p.

of nervous system growth and development. This theory, which stimulated much research from 1925 on, promoted the point of view that reading disabilities are functional and, therefore, susceptible to treatment.

The multiple causation of reading disabilities has since been reiterated by numerous authors. Major factors that are said to contribute to reading success, namely maturation, vision, hearing, kinesthesis, emotional reactions, and language, suggest that the pre-stages of language and language learning difficulties are embedded in the general development of childhood. These findings are congruent with the developmental views of Werner[5] which he borrowed from embryology and applied to observations of infants and children. Werner emphasized that development involves increasing differentiation and organization. When an infant is stimulated, he responds in a generalized, undifferentiated way with perhaps his entire body. As maturation proceeds, there is increasing differentiation of activity and cognition. Responses become more focused, less diffuse, and less stimulus-bound. With further progression, the increasingly differentiated functions are

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5 Heinz Werner, Comparative Psychology of Mental Development, Rev. Ed., New York, International Universities Press, 1964, xii-564 p.

organized into levels, the earlier being subordinated to the later. The more differentiated adult psyche manifests an integration of the various sequential stages, with the later more differentiated processes ascendant and predominating. Applied to language, Werner and Kaplan[6] state that there is an ontogenetic decline in the physiognomization of verbal forms. However, even at advanced levels, verbal symbols are not entirely divorced from the formative activity of the symbolizer or the listening individual. These authors suggest that, through the dynamic physical features of speech, the most conventionalized units such as words and sentences remain part of and refer back to the articulatory process and bodily postural activity.

The first continuum in the multidimensional phenomenon of language pertains to the phylogenetic development of language. While many species of animals have elaborate systems of communication, none are comparable to human language which can be used to symbolically store learning

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6 Heinz Werner and Bernard Kaplan, Symbol Formation, An Organismic - Developmental Approach to Language and the Expression of Thought, New York, Wiley, 1963, xiii-530 p.

and transmit culture to future generations. Hebb[7] and his coauthors suggest that the advent of word language at about the same age in healthy children throughout the world is determined by the interplay of human heredity and experience. They contend that genetically determined processes of maturation underlying the human capacity for speech and verbal understanding are universally and regularly exposed to a human environment which furnishes language models and opportunity for language interaction.

In ontogenetic development, the normal individual child acquires language. Huizing[8] discusses auditory feedback mechanisms which develop very early and guide motor speech activity in the normal child and in hearing-impaired children and adults. Lenneberg[9] outlines the parallel prelinguistic vocalizations of deaf and hearing infants and the initial words spoken in the first year by normal hearing children living in a language-stimulating

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7 D.O. Hebb, W. E. Lambert, and G. Richard Tucker, "A DMZ in the Language War", Psychology Today, Vol. 6, 1973, p. 55-62.

8 H.C. Huizing, "The Significance of Cybernetic Phenomena in Audiology", Progress in Biocybernetics, Vol. 1, 1964, p. 55-62.

9 Eric H. Lenneberg, Biological Foundations of Language, New York, Wiley, 1967, xvi-489 p.

environment. Psychoanalytic writings[10] have elaborated the concept that, for the cognitive aspects of language to develop normally, the child's affective development must be such that he identifies with persons in his environment. The child must want to "be like" others in his world before he imitates their language. In 1905, Freud[11] described the progressive shifts in body zones most responsive to, and most actively interacting with, the environment and outlined oral, anal, and phallic phases of development. These observations were later combined with the concept of successive, but overlapping, libidinal organizations in each of which different drives dominate. According to Freud[12], the oral-cannibalistic phase, dominated by the drive to incorporate, is followed by the sadistic-anal phase in which the child's strivings to master his body, and all obstacles encountered, are paramount. Toward the end of the oral phase, the child can remember the agent

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10 Lili E. Peller, "Language and Its Prestages", Bulletin of the Philadelphia Association for Psychoanalysis, Vol. 14, 1964, p. 55-76.

11 Sigmund Freud, "Three Essays on the Theory of Sexuality" (1905), The Standard Edition of the Complete Psychological Works of Sigmund Freud, Vol. 7, London, Hogarth Press, 1953, p. 125-243.

12 Sigmund Freud, "The Disposition to Obsessional Neurosis" (1913), Op. Cit., Vol. 12, 1958, p. 311-326.

related most often to the relief of tension and to positive pleasure; he has an image of the mothering person, is attached to her and has rudiments of an image of his own self. Early identification with the mother, which is the beginning of 'object relations' and the matrix from which a more differentiated motivational system develops, normally culminates toward the end of the first year of life. Peller[13] notes that it tends to be followed almost immediately by the learning of language. The unconscious identification upon which imitation is based is achieved by the child on account of a need to survive and to master, to take into himself the powers of the protecting parent in order to combat the feelings of helplessness which give rise to anxiety at the time that ego differentiation is taking place in the anal phase. Successful identification, thus, seems to be the primary condition of the capacity to learn language, according to Peller. In the anal phase, from about 18 months of age on, the child learns to utter an increasing number of words like those uttered around him. Spoken language becomes the foundation of cognitive learning and the behavioral skills

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13 Peller, Op. Cit., p. 55-76.

most directly associated with it. In Freud's framework, the next major motivational reorganization of the personality system is the Oedipal transition during which the child introjects moral standards and prohibitions emanating from the broader culture, particularly as implemented by the father. This phase is followed by the acquisition of written language as the foundation of higher-order cognitive learning and skills.

Sociologists have enunciated more fully the conditions of child development within the family. Parsons[14] maintains that the father stands at the principal point of articulation between the family and the wider society. He is, thus, the most important channel through which value patterns of the culture are internalized in the process of socialization. The father constitutes the focus of pressure from the outside world to make the child renounce dependency, and the security of maternal love to which it is fused, and behave more independently, more skilfully,

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14 Talcott Parsons, "The Father Symbol: An Appraisal in the Light of Psychoanalytic and Sociological Theory", Conference on Science, Philosophy, and Religion in Their Relation to the Democratic Way of Life, 13th Symposium, Symbols and Values, An Initial Study, New York, Distributed by Harper, 1954, Appendix III, p. 523-544.

and more responsibly. According to Parsons, this is the main factor in bringing on the Oedipus crisis. Approximately age four is involved when performance capacities have developed which, if they are to grow further, are incompatible with infantile dependency. By selective and contingent reward and punishment of the child's contributions to family functioning, this phase brings about internalization of the values common to the family and shared by the general culture. This process extends the child's reference system outside the family and into the wider society.

Kell and Burow[15] point out that human behavior does not become truly interpersonal until language becomes available as a primary vehicle. While a child may communicate much with the mother non-verbally, communication with others such as the father, siblings, other relatives, and other people, is usually more dependent on the ability to verbalize intelligibly.

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15 Bill L. Kell and Josephine Morse Burow, "Language and Development", Developmental Counseling and Therapy, Boston, Houghton Mifflin, 1970, p. 92-94.

Klein[16] suggests that the upright posture and its associated tonic patterns promote auditory feedback and monitoring of one's own speech which help to sustain reality-oriented thinking. He notes that, by involving a motor apparatus, speech goes beyond conveying thoughts. Through non-verbal voice qualities, speech directly expresses bodily, emotional, or subjective states and drives.

1. Alfred Tomatis on Dyslexia

The theory, apparatus, and therapeutic procedure which form the basis of the present investigation are the conceptualization, invention, and ongoing clinical practice of Alfred Tomatis. His theory of dyslexia integrates many of the concepts mentioned above.

There is one caveat which is mentioned now in the hope that it will be remembered when reading the following pages. This presentation is not of his entire work since Tomatis hypothesizes on language development, audition, etc. from an extremely eclectic approach, much of which is not relevant to this thesis. The discussion that follows

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16 George S. Klein, "On Hearing One's Own Voice: An Aspect of Cognitive Control in Spoken Thought", Perception, Motives, and Personality, New York, Knopf, 1970, p. 322-353.

may appear highly critical of the theories and methods of Tomatis; however, the writer thinks that there is justification for the criticism adduced. It is the writer's opinion that, in relation to complex human problems, Tomatis presents simplistic notions that parody scientific method. In the space of this report, it would be impossible to attempt to synthesize the information from a century of work that fully clarifies how the assertions made by Tomatis deviate from existing knowledge; only the barest outline will be presented below. Nevertheless, verified controlled objective observations and hypotheses arising from them are cited along with the results of our research to support the conclusion that Tomatis engages in unwarranted theorizing based on unsubstantiated hypotheses. The writer trusts that the evidence presented will be compelling despite its brevity and despite limitations in the manner of presentation.

According to Tomatis[17], the etiology of dyslexia lies in the child's continuing instinctual dependence on the mother. In normal development, the desire to communicate and to develop a relationship originates between the

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17 Alfred Tomatis, Dyslexia, Tr. Agatha Sidlauskas, Ottawa, University of Ottawa Press, 1969, xi-102 p.

mother and foetus in utero. "The mother reveals herself to the foetus through all her organic sounds, viscerally, and particularly by her voice"; prenatally, therefore, the normal child "draws upon all the affective substance of the maternal voice" and "integrates the characteristics of the maternal way of speaking"[18]. The latter words are as follows in the original French: "il intègre le support de sa langue maternelle"[19].*

Postnatally[20], the normal infant hears the same voice which he experienced in utero. Though no longer in a liquid medium, he recognizes the inflexions and rhythm and he opens his ear to listen to this communication in the medium of air. The relationship now is richer than before because more meaning is added to the language addressed to the child. Thus, an intimate relationship is established between mother and child[21].

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18 Tomatis, Op. Cit., p. 58-59.

19 Alfred Tomatis, La Dyslexie, Paris, Centre du Langage, 1967, p. 46.

20 Tomatis, Dyslexia, p. 60.

21 Tomatis, Dyslexia, p. 59-60.

* According to Dr. Robert Galambos, there is no evidence that the foetus is able to hear the mother's voice. Personal communication, April 27, 1973.

As the child grows older, however, the teacher is no longer only his mother[22]. She usually yields her place to the father. But to benefit from this new relationship, to integrate the father's information, the child must acquire a language different from neonatal communication. Less emotionally charged, this new language is more normative; it is conventional and social language which represents the father's attitudes. To absorb conventional language requires focused listening to the other, to the father. And to speak, and make oneself understood, requires that one listen to oneself. Thus, the ear takes charge of verbalization. A choice is made between the two ears and, in most cases, the right ear becomes dominant. Auditory control, when established on the right side, induces all laterality to be fixed on the same side: this, in Tomatis' view, is the genesis of laterality.

Besides drawing upon psychoanalytic sources for his affective formulations, Tomatis ascribes the hypothesized developments detailed above to an array of neurophysiological and anatomical notions which he infers from standard textbook descriptions or, in some instances, from observations and measurements he claims to have made in

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22 Tomatis, Dyslexia, p. 61-63.

the laboratory. To begin with, Tomatis[23] declares that the right ear is normally the dominant one in the auditory-phonatory feedback circuit. Input from the right ear, he states, goes directly to the hearing centre in the left hemisphere and, from there, directly to the vocal organs. In contrast, he asserts that input from the left ear goes to the auditory centre of the right hemisphere, then must cross to the left hemisphere auditory centre in a "trans-cerebral transfer" which takes up to one-fifth of a second before travelling down to the vocal organs.* Tomatis asserts further that left-ear dominance produces a "physiological delayed-feedback" which may disrupt speech.**

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23 Alfred Tomatis, "Relations entre l'audition et la phonation",[Annales des Télécommunications, vol. 2, juillet-août 1956], Mimeographed, 21 p.

* As discussed in the next chapter, the evidence is that both hemispheres subserve hearing and research-oriented clinical experience demonstrates that either one or, in rare cases, both hemispheres can subserve speech. An overview of the literature in the anatomy and physiology of the auditory system regarding its function reveals no report of this kind of "transcerebral transfer".

** The literature on speech and hearing contains no reference to this kind of "physiological delayed-feedback". See also J.-E. Fournier, "A propos des théories du Docteur Tomatis", Les Annales d'Oto-Laryngologie, vol. 79, 1962, p. 801-820.

Additionally, Tomatis[24] states that the two recurrent branches of the vagus nerve which transmit motor impulses from the two cerebral hemispheres to the vocal organs are asymmetrical, different in length and, therefore, different in timing; accordingly, Tomatis says the shorter right branch is the first to stimulate a laryngeal vocal response.* Tomatis declares that this time differential, in both cerebral auditory reception and laryngeal motor response, cybernetically favors the right ear and the right side of the larynx and Tomatis declares that for these reasons the right ear is usually dominant.

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24 Tomatis, Dyslexia, p. 60-63; see also William M. Shearer, Illustrated Speech Anatomy, 2d Ed., Springfield, Illinois, Charles C. Thomas, 1968, p. 49 for confirmation that the recurrent branch of the vagus nerve innervates all of the muscles within the larynx except for the cricothyroid muscle which is innervated by another vagus nerve branch, namely the external branch of the superior laryngeal nerve.

* Tomatis' argument is illogical. If, as Tomatis says, all hearing must be processed in the left hemisphere, one would expect that all speech activity would occur via the right recurrent vagus branch. The latter would be the only branch active in motor speech production, not the first!

Regarding the above assumptions, it seems appropriate at this point to refer to another source.

> The cranial nerves which innervate the speech musculature are of different lengths; therefore one would suspect that the neuronal firing order in the mid-brain (where the motor nuclei of the cranial nerves are located) is different from the order of muscular events in speech production. There seems to be a fallacy in this argument. The cranial nerve nuclei in the mid-brain area may or may not have a firing order different from the order of muscular events in speech, due either to the length of the nerves, inertia of the muscles, loci of the nuclei themselves, or all sorts of anticipatory or ex post facto contextual effects in phonological organization.
> . . . .
> It was believed that the motor speech cortex (Broca's Area) which is adjacent to the precentral gyrus (motor cortex) uses cortico-cortical association fibers connected to the latter and thereby 'modulates' the cortico-bulbar pyramidal tract when we are speaking. [...] However, there are reasons for rejecting this assumption. If the production of speech were modulated through this system (the normal cortico-bulbar tract), one would expect to find lateralized articulatory deficits in patients with apraxia of speech or surgical division of the corpus callosum [...] But in fact we do not.[25]

Elsewhere, Tomatis[26] notes that audition regulates the intensity and quality of phonation. The ear, he explains, is the organ of listening and imposes upon phonation

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25 Harry Allen Whitaker, <u>On the Representation of Language in the Human Brain: Problems in the Neurology of Language and the Linguistic Analysis of Aphasia</u>, Los Angeles, ASUCLA Student's Store Book Department, 1969, p. 45, p. 53.

26 Alfred Tomatis, "Cybernetics", <u>Language, The Ideas of Dr. Alfred Tomatis</u>, as Presented by A.E. Sidlauskas, Mimeographed, 1970, p. 29-33.

the phonation of its choice. To speak, man needs his body musculature and the vertical position. Language involves postural, visceral, as well as other controls. Tomatis further illustrates the interaction between hearing, listening, and phonation by stating that, when the tympanum transmits sound, the inferior jaw is lowered and the mouth opens; and when the stapes is activated, the facial expression lights up. The latter, he says, are aspects of the affective and postural involvement of the listener mediated by several cranial nerves (see Appendix 1, Cranial Nerves). For a further comment here, one may refer again to Whitaker who quotes Magoun as follows:

> One can conclude that there are two unrelated central neural mechanisms for vocal expression in vertebrates: one for nonverbal affective communication, widely present in the animal brain stem, and a second for verbal communication, present only in the lateral neocortex of the brain of man.[27]

It is from language, Tomatis states, and for controlling language that the need appeared to structure

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27 Whitaker, Op. Cit., p. 50.

lateralization: "C'est du langage et c'est pour contrôler ce langage qu'est apparue la nécessité de structurer une latéralisation"[28]. Tomatis declares that, with the exception of the viscera, man is symmetrical[29]. "Nothing until now individualizes one cerebral hemisphere from the other. They are identically symmetrical"[30]. "Our language", says Tomatis, "is modeled on our body"[31]. (The translation of the latter two quotations is ours.) "Laterality originates in the visceral part of the organism. Viscerality is asymmetrical and imposes this asymmetry upon the functioning individual [...and on] the cortex"[32]. The vagus nerve, with its visceral afferents to the vocal apparatus, is the pathway through which viscerality is imprinted on phonation and language[33]. This visceral nerve, the vagus, is "the guardian of whatever penetrates the ear"

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28 Alfred Tomatis, L'Oreille et le langage, Paris, Editions du Seuil, 1963, p. 163-164.

29 Id., ibid., p. 150.

30 Id., ibid., p. 153.

31 Id., ibid., p. 180.

32 Tomatis, "Body Image", Language, p. 20.

33 Tomatis, "Embryology", Language, p. 9-10.

since it innervates both the tympanum and the stapes[34]. If incoming sound recalls undesirable memories, neither the tympanum nor the stapes will obey the input.

Thus, according to Tomatis, by carrying visceral information to the larynx and to the ears, by influencing selective listening, and by being involved in an auditory-phonatory circuit preferential to the right ear and left hemisphere, the vagus nerve initiates functional hemispheric differentiation and laterality, that is right-side dominance[35]. "Tout notre être est donc contrôlé par un seul côté, et cela, nous le devons au langage"[36]. ("Our entire being is thus controlled by only one side, and this we owe to language"; our translation). Elsewhere, Tomatis says "This fixation on the right side of the purely auditory controls induces the whole laterality to be crystalized on the same side. Here [...] is the genesis of laterality"[37]. Contrast this view with that of Magoun

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34 Tomatis, "Neurology", Language, p. 13; and Tomatis, "Cybernetics", Language, p. 31. See also Appendix 1, Cranial Nerves, which shows that the auricular branch of the vagus nerve innervates the external ear and external auditory meatus and extends, with the facial nerve, to the mastoid region; however, the function subserved is that of cutaneous sensibility, not hearing.

35 Tomatis, "Body Image", Language, p. 20.

36 Tomatis, L'Oreille et le langage, p. 164.

37 Tomatis, Dyslexia, p. 63.

(as quoted by Whitaker[38]) who concluded that the mechanism for language is present only in the lateral neocortex of the brain of man.

Summarizing, Tomatis[39] states that the child learns to control auditory, phonatory, visceral, and cerebral structures in order to gain the father's attention, and this results in functional hemispheric differentiation and body organization. To enlarge his experience and relationships, to share the father's knowledge, the child becomes actively involved in the listening process and listens with his total self. And, in order to respond effectively and to maintain the relationship, he uses self-listening to regulate his spoken thought and his vocal mechanisms which control such speech qualities as intensity, tempo, and timbre. Thus, it is the ear which puts the child in communication not only with his father, the representative of the surrounding world, but with himself. The next step is to open himself to relationships with a wider world

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38 Whitaker, Op. Cit., p. 50.

39 Tomatis, Dyslexia, p. 56-64.

beyond his family. Opportunities soon confront him in school and, later, in public and social relations.

Any abnormality in the elaboration of these relational structures will have repercussions on the development of language. "Written language which specifically interests us", writes Tomatis, "since we are engaged in studying reading disability, does not differ essentially from language in general"[40]. ("Précisons que le langage écrit qui nous intéresse plus particulièrement dans notre propos puisqu'il s'agit d'étudier les troubles de la lecture, ne diffère pas essentiellement du langage en général", are his words in French). Written signs, in themselves, are nothing but coded sounds to be reproduced[41]. The process of reading involves reinvesting written signs with sound so they may serve as a means of expression and interpersonal communication. "To read is to gather through the ear what somebody else has written; it is [...] to tell to

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40 Tomatis, Dyslexia, p. 65; Tomatis, La Dyslexie, p. 50.

41 Tomatis, Dyslexia, p. 51. See Whitaker, Op. Cit., vii-169 p. for an alternative view and, specifically, p. 29-32 for a summary of the principal cortical and subcortical structures which have been identified as part of the language system in the brain.

ourselves what somebody else has decided to tell in writing"[42]. It is to consent to be informed[43]. Thus, the auditory attitude is even more involved in written than in oral communication.

Tomatis describes dyslexia as nothing else but a disorder of listening[44]. The dyslexic's perturbed relationship with the external world is manifested in the abnormal functioning of the ear[45]. As the door of communication with the world of sound, the ear is either opened or closed to verbal communication. All impairments of relationships result in dysfunctions in listening which prevent maturation of one or more of the processes which the ear must acquire in order to structure language. These "impairments of relationships carry over into impaired deciphering of graphic signs"[46]. Another outcome is that, without the wish to communicate and to apprehend and understand the accumulated knowledge within one's environment, one may

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42 Tomatis, <u>Dyslexia</u>, p. 66.

43 <u>Id</u>., <u>ibid</u>., p. 65.

44 <u>Id</u>., <u>ibid</u>., p. 3.

45 <u>Id</u>., <u>ibid</u>., p. 44-45.

46 <u>Id</u>., <u>ibid</u>., p. 65.

master the mechanics of reading yet fail to integrate the linguistic meanings[47].

In the case where the relationship between mother and child does not take place in utero, language may not develop or is sometimes totally missing[48]. On the other hand, if the relationship with the mother evolves only to the point of enabling the child to cling fixedly to the mother, language will be poorly elaborated and will not acquire normal linguistic structures. Such children are dyslexic long before they are exposed to the written word. Disabilities in learning to read also occur when the encounter with the father is difficult[49]. If contact with the father can only be made remotely, the child will be driven back, closer to the mother. This will lead to an emotional rejection of others and will progressively eliminate the desire for an independent existence, and, instead, foster a need to live only through the mother herself. "With such an attitude, the child will never take the trouble to read a book, will refuse to grow up, and

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47 Id., ibid., p. 69.

48 Id., ibid., p. 67.

49 Id., ibid., p. 41-42; Tomatis, La Dyslexie, p. 34-35.

will never find the written word attractive"[50]. Since the affective process and interpersonal relationships have not been elaborated, the postural attitude is in opposition to listening and neural controls are not established due to failures in feedback[51]. Consequently, laterality is either mixed or is crystalized on the left side, in opposition to what it should be. Behavior is negativistic, especially in a learning situation. Tomatis warns of the consequences if the whole integration does not follow the ideal programming which he has designed:

> Toute intégration ne suivant pas l'idéale programmation que nous avons brossée quelques lignes plus haut, risque-t-elle de ne pas utiliser convenablement le support nerveux qui lui permettra d'enregistrer plus tard les informations.[52]

That is, any integration that does not follow the ideal programming which we have sketched a few lines above risks being unable to properly utilize the nervous support which will later permit the registering of information. (The translation is ours).*

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50 Tomatis, Dyslexia, p. 42.

51 Id., ibid., p. 67.

52 Tomatis, La Dyslexie, p. 50-51.

* For a different translation, see Tomatis, Dyslexia, P. 66-67.

> Le Dyslexique n'est pas seulement en peine devant la lettre, il l'est dans tout le déchiffrage de l'univers. Il lit mal tout ce qu'il doit intégrer; tout ce qu'il appréhende est entaché d'erreurs.[53]

Here, Tomatis says that the dyslexic is not only at a loss when confronting letters, he is so in all deciphering of the universe. The dyslexic misreads everything that he must integrate; he misapprehends everything. (The translation is ours).

2. Audio-Psycho-Phonologic Diagnosis

The usual techniques for detecting dyslexia are considered inadequate by Tomatis whose method seeks to reveal the dyslexic "in his functional attitude" ("La posture fonctionnelle"[54]) which he adopts in his interpersonal life. Oddly, despite earlier statements quoted above, he now says that dyslexia may be "admirablement compensée par des possibilités sous-jacentes qui masquent les difficultés. Mais ces dernières n'en existent pas moins". (That is, in our translation, dyslexia may be admirably compensated by some underlying possibilities which mask the

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53 Tomatis, La Dyslexie, p. 36.

54 Tomatis, Dyslexia, p. 70; Tomatis, La Dyslexie, p. 54.

difficulties. But the latter exist nonetheless[55]). For Tomatis, listening and lateralization are the two essential points upon which the diagnosis is based[56].

When seated facing the assessor, the non-dyslexic child adopts a posture of listening[57]. He pays attention to the conversation. The normal listening posture consists of mobilizing the right side of the facial musculature: the right ear appears to be outstretched, the lower jaw relaxes, the child sometimes repeats the investigator's words silently with his lips. At the same time, the right hand and, specifically, the right thumb and index finger, are slightly mobile and involved though the body, in general, is immobile. Thus, the body seems immobilized except for the areas related to language and in proximity, cortically, to motor speech areas. The verbal flow is smooth and lively, conveying the semantic meaning desired while reflecting the underlying affective context.

The dyslexic, on the contrary, shows psychomotor disorganization in the elaboration of the mechanisms of

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55 Tomatis, La Dyslexie, p. 53; see also Tomatis, Dyslexia, p. 69.

56 Tomatis, Dyslexia, p. 80.

57 Tomatis, "Audio-Psycho-Phonologic Diagnosis", Dyslexia, p. 69-82; Tomatis, "Bilan Audio-Psycho-Phonologique", La Dyslexie, p. 53-62.

listening and of speech. Seated in front of the investigator, the dyslexic turns one ear and then the other to the investigator or remains indifferent to the other's conversation. The left side of the face is mobilized, the left ear seems outstretched, while the right side of the face is uninvolved. The jaw is stiff, contracted, and body movement is uncoordinated, synkinetic, agitated. On the other hand, in some cases the face is lifeless and quite immobile, there is no motor activity or synkinesis, and the child barely opens his mouth so the voice is almost nonexistent. Generally, the voice of the dyslexic is dull, flat, unmodulated, and lifeless, without affective tone. Language is poor and there is, frequently, difficulty with ideation and expression.

The above observations are described as "preliminary examinations"[58]. To check these clinical observations, the child is then given more precise, quantifiable tests. An electro-encephalogram and an electro-myogram of facial musculature are used to record motility and synkinesia as estimates of energy loss during listening and speaking. It should be noted that Tomatis has not published any graphic or numerical results of these EEG and EMG tracings. In

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58 Tomatis, Dyslexia, p. 75.

reporting a case, he merely mentions overt behavioral signs, then says "L'ensemble de l'examen général permet de mettre en évidence une insuffisance motrice gauche"[59], which means that the whole general examination allows an inadequate left motricity to be made conspicuous. No reference to EEG or EMG tests is made, either, in the clinical cases reported by Beller[60].

Phonograms and sonograms are used to ascertain the energy and harmonics of the voice and, somehow, the method is not revealed, to calculate "la recherche de la structuration de l'oreille directrice"[61] which may mean the pursuit of or attempt at structuration (organization?) by the directing ear. (The language and concepts of this section, and of some others, are beyond our understanding). "Spatialisation en phonation"[62] reveals to Tomatis how the subject himself localizes his own voice. His voice must be fixed on the directing ear in order to benefit from rapid regulation in phonic emission.

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59 Tomatis, L'Oreille et le langage, p. 168.

60 Isi Beller, Rôle de l'oreille dans le traitement de la dyslexie, Paris, Copedith (no date), p. 39-95.

61 Tomatis, La Dyslexie, p. 58; see also Tomatis, Dyslexia, p. 76.

62 Tomatis, La Dyslexie, p. 59; see also Tomatis, Dyslexia, p. 77, where this is translated by Agatha Sidlauskas as '"specialization" in phonation'.

"Un examen plus complet et classique, celui de la latéralité"[63], which means a more complete and standard examination, that of laterality, (the translation is ours), is used to disclose more elements which complement the child's structural organization. Tomatis states that, in his tests of motility, he considers the spontaneous and automatic aspect, then the conscious or praxic; in tests of 'sensory laterality' first he considers the automatic, then the conscious or gnosic aspect[64].

After listing the various tests of motility, namely the EEG, EMG, sonograms, and laterality, Tomatis sums up with the following statement:

> Il se dégage des tests pratiqués, une désorganisation qui peut être mise en évidence à l'aide d'un graphique très significatif dans son aspect général. On note en effet, le plus souvent, un tracé en "zig-zag" témoin du manque de latéralisation.[65]

The above quotation states that, from the tests applied, there emerges a disorganization which can be made conspicuous with the help of a graph very significant in its

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63 Tomatis, La Dyslexie, p. 58; see also Tomatis, Dyslexia, p. 76.

64 Tomatis, Dyslexia, p. 76-77.

65 Tomatis, La Dyslexie, p. 58; see also Tomatis, Dyslexia, p. 76.

general aspect. Indeed, one observes most often a "zig-zag" line, evidence of the lack of lateralization. (The translation is ours).

The next step is "a thorough examination of audition" ("examen très approfondi de l'audition"[66]). One would assume, especially since he nowhere states otherwise, that being an oto-rhinolaryngologist he administers and interprets audiometric tests according to methods that are professionally acceptable internationally. However, this is not the case. (See Appendix 4, Audiometric Tests). Standard audiometric tests entail psychophysical methods which have long been recognized as testing perception not basic sensory response[67]. However, Tomatis appears to think that his method tests auditory perception and that standard methods do not[68]. (See Appendix 4, especially 4d).

An examination of vision is also administered. Completing all the aforementioned tests which Tomatis describes as "propres à notre spécialité" ("within our medical

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66 Tomatis, Dyslexia, p. 77; Tomatis, La Dyslexie, p. 58.

67 Joseph B. Sidowski, Ed., Experimental Methods and Instrumentation in Psychology, New York, McGraw-Hill, 1966, Chapters 5, 6, 8.

68 Alfred Tomatis, On the Subject of Audiometrics, Notes Taken From a Tape, Discussion of Points Raised by A.E. Sidlauskas, Paris, June 1971, Mimeographed, 11 p.

competence"[69]) is a psychological test battery. The latter includes an intelligence test and an examination to determine temporo-spatial organization and psychomotricity. Examinations of affectivity are used for a last word as to the reasons which brought about the abnormal listening and lateralization structure. It should be noted that Tomatis[70] himself reports very few individual case histories, almost no individual numerical results for any test, no group results except in sweeping general claims, and the only specific psychological technique he demonstrates having used is the projective, drawings. He implies use of the Wechsler Intelligence Scale for Children by referring to Verbal and Performance IQ scores. His colleagues are almost equally unscientific. For example, Beller[71] reports ten case histories: in some he specifies Terman, Wechsler, or just gives an IQ score without naming the test; he reports reading and spelling errors but only once gives test names; his list of laterality tests varies from case to case; he describes the subjects' affectivity and only once

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69 Tomatis, La Dyslexie, p. 59; Tomatis, Dyslexia, p. 78.

70 Tomatis, L'Oreille et le langage, p. 168-185.

71 Beller, Op. Cit., p. 39-95.

mentions a technique that may have been used in assessing it, namely the Rorschach; the only tests reported consistently and graphed in each case are the audiometric tests, but the method of administering and interpreting them is nowhere specified.

From all this investigation, the degree of dyslexia is estimated.* Tomatis asserts, as already described, that dyslexia is a product of disturbed relationships and is manifested in auditory disorganization and fixation in a defective posture for lateralization[72]. Dyslexia identified according to his method is labelled High, Medium, or Benign in degree, according to the precocity of onset. However, it is important to note that although Tomatis[73] states that he is specifically interested in written language and reading disabilities, he makes no direct assessment of reading difficulties. He does not administer a test of reading, the crucial test of dyslexia. Nevertheless, Beller[74] describes numerous reading errors, and

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72 Tomatis, Dyslexia, p. 78.

73 Tomatis, La Dyslexie, p. 50; Tomatis, Dyslexia, p. 65.

74 Beller, Op. Cit., p. 39-95.

* One would like to see evidence that this comprehensive battery is, in practice, administered by Tomatis and his associates.

Le Gall[75] refers to the comparison of reading before and after treatment and states that, after fifty half-hour sessions with the Aurelle apparatus, subjects are cured of dyslexia.

3. Audio-Psycho-Phonologic Treatment

The therapy proposed and utilized by Tomatis[76] consists in teaching the child to use his ear as an apparatus capable of listening. This means creating or developing the wish to communicate by training the ear to listen. The treatment for children up to age fifteen takes forty sessions of twenty minutes to a half-hour per session[77]. Elsewhere, Tomatis[78] states that treatment lasts about a trimester in benign cases and one year in severe cases. Preferably, half-hour treatment sessions should be given three times a week, but, for reasons of convenience, two

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75 André Le Gall, The Adjustment of Certain Psychological and Psycho-Pedagogical Deficiencies with the Tomatis Effect Apparatus, (no place), 1961, Mimeographed, p. 26.

76 Tomatis, "Audio-Psycho-Phonologic Treatment", Dyslexia, p. 83-96.

77 Alfred Tomatis, L'Oreille électronique, Cours à l'Université d'Ottawa, Centre d'Etude de L'Enfant, October 7, 1970, Mimeographed, p. 2.

78 Tomatis, Dyslexia, p. 85-86.

half-hour sessions divided by a rest period may be given twice a week, and even three sessions daily may be given for a three-week period. Le Gall[79], who claims that "not one case of dyslexia with intellectual integrity (I.Q. 100) has, to our knowledge, persisted after re-education with the Tomatis Effect apparatus", goes on to describe two typical cases out of about sixty. One, an eleven year-old with a Wechsler IQ of 100, "very pronounced dyslexia" ("dyslexie très marquée"), with "considerable dysortography" [sic] ("dysorthographie assez importante"), after forty half-hour sessions reads easily, fast, without any noticeable hindrance; "the inversions have completely disappeared" and "dysortography [sic] is very much reduced". The other, a fourteen year-old with a Wechsler IQ "110/115", "severe dyslexia and dysortography" [sic], after fifty half-hour sessions shows "hardly more difficulties" in reading ("lecture: elle n'accroche presque plus"). Note that both are older children, and older children generally have a reading disability of long-standing, and both were diagnosed

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79 Le Gall, Op. Cit., p. 32-33; André Le Gall, Le Redressement de certaines déficiences psychologiques et psycho-pédagogiques par l'appareil à effet Tomatis, Paris, Centre du Langage, 1961, p. 34-35.

as severe dyslexics. Beller[80] reports similar improvements after fewer than forty Aurelle sessions and even in children with IQ's well below 100.

The therapeutic process involves the use of the "electronic ear"[81]. A microphone is placed in front of the child, about six inches from the child's lips, and earphones are placed on his ears. Transmitted to the child is material filtered and recorded on magnetic tape which is modified further by filters, amplifiers, and speakers built into the Aurelle machine that attenuate the lower frequencies and boost the high frequencies. One hundred per cent transmission is delivered to the right ear while transmission to the left ear is gradually reduced to ten per cent. It is asserted that the procedure promotes right-ear dominance in listening and, consequently, under the control of the right ear, a 'right voice'[82] which issues forth with more intensity, more harmonics, and more rhythm than a dyslateralized or left voice. "In the progress of the therapy, the most remarkable signs will be

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80 Beller, Op. Cit., p. 57-59.

81 Tomatis, L'Oreille électronique, 52 p.; Tomatis, Dyslexia, p. 83-96.

82 Tomatis, L'Oreille électronique, p. 4-5.

reflected in the modification of the voice"[83]. It is claimed that the therapy trains the right ear to be efficient in listening and self-listening, (recalling Tomatis' theory that the right ear should be dominant for listening because it transmits auditory information more quickly to the left auditory brain centre and because the right recurrent vagus branch transmits visceral afferent information and cortical motor responses more quickly to the vocal apparatus), and that it leads to laterality or overall right-sidedness. Although Tomatis[84] asserts that the Aurelle apparatus and procedure have numerous and varied applications, our interest in this study is in the improvement in reading that he claims follows upon modifications in listening, phonation, and laterality.

The auditory training procedure consists of three components[85]. The first phase, preferably, utilizes the filtered maternal voice heard as though 'in utero'. This intrauterine reconditioning is regulated, generally, at

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83 Tomatis, Dyslexia, p. 94.

84 Tomatis, L'Oreille électronique, 52 p.; Tomatis, L'Oreille et le langage, 184 p.

85 Tomatis, Dyslexia, p. 86-90.

30 dB above the average threshold ("à 30 db de moyenne"[86]). This phase is terminated when the child recognizes and identifies the maternal voice. However, if the mother's voice is unavailable or inconvenient to record, this component can be eliminated[87]. Instead, one begins with the second component, with recorded music as the first part of each treatment session. This is followed by the third component, recorded words which are heard and repeated by the child. A clear, expressive voice is recorded, speaking words or phrases with pauses in between to allow the child time to repeat what was heard. Theoretically, on the observable behavioral level, verbal communication coming from an "other" must now be accepted by the child and the child is required to respond and to communicate. This, it is asserted, gradually adjusts the "sickness of relation"[88]. A last phase in the training under the electronic ear consists in requiring the child to read[89].

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86 Alfred Tomatis, La Surdité, Paris, Centre du Langage, 1965, p. 28.

87 Tomatis, L'Oreille électronique, p. 23; Beller, Op. Cit., p. 45, 57, 69, etc.

88 Tomatis, Dyslexia, p. 95.

89 Tomatis, L'Oreille électronique, p. 24.

The third component just referred to is not unlike a language-laboratory procedure. The innovation Tomatis has made is, firstly, that he filters both the music and verbal material. The filtering is done at one of several frequency levels, each of which attenuates an increasing range of the lower frequencies extending well into what is generally considered as the high-frequency range; the result is that the auditory input, in the Tomatis procedure, consists only of high or very high frequencies. In the verbal component, the filtering at some levels, according to his procedure, markedly diminishes word recognition, i.e., the intelligibility of speech[90]. Thus, the child must listen extremely attentively to the "other" in order to be able to hear and repeat correctly what was said. As to intensity, for which the Aurelle apparatus[91] has several controls, Tomatis says that intensity must reach 60-80 dB in order to affect the dynamics of the human ear. The subject immediately speaks with the same intensity: "le sujet parle immédiatement avec la même intensité"[92].

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90 J.C.R. Licklider and George A. Miller, "The Perception of Speech", S.S. Stevens, Ed., Handbook of Experimental Psychology, New York, Wiley, 1951, p. 1040-1074.

91 Tomatis, L'Oreille électronique, p. 17-31.

92 Id., ibid., p. 23.

(In discussing stutterers[93], he says that 80 to 100 dB are sometimes necessary to awaken their acoustic sensation). To quote Le Gall, "under the combined influence of the intensity and high-pitched nature of the sounds, [the stapes] may move between the positions corresponding to the maximum and minimum frequencies of the sounds perceived"[94]. Earlier, on the same page, Le Gall states that, according to Tomatis,

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93 Tomatis, L'Oreille et le langage, p. 145.

94 Le Gall, Adjustment, p. 16.

> A conditioning of the ear by the compulsory and repeated hearing of sounds which have until then not been heard or have been otherwise heard, gives rise to a definite modification of hearing and speech.* The basis and the support of this conditioning must be the mobility of the ligament and of the muscle** which [connect the stapes and the oval window and] control the opening and shutting of the oval window. It is probably at this stage of the passage of the sound vibrations that are registered the habits which will give rise to the conditioning.[94]

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94 Le Gall, Adjustment, p. 16.

* See Chapter III re the Lombard effect, namely, that when acoustic stimulation is raised to a high level of intensity, a feedback mechanism occurs resulting in a rise in vocal intensity. Also, see Shearer, Op. Cit., p. 45, who notes that for singing or voice disorders involving monotone or improper pitch, a wider pitch range can usually be attained through vocal training exercises including a great deal of oral reading. He states that these oral readings should be pitched at constant levels above, and also below, the person's habitual speaking level. And the more often this is done, the easier and more natural these new voices will become.

** It is important to note that the reflex contraction of the stapedius muscle referred to here is elicited at a threshold of 65-90 dB SPL (Sound Pressure Level), depending upon the acoustic stimulation presented (bands of white noise, complex tones, or individual pure tones). As the acoustic stimulation rises in intensity, the stapedius muscle reflex increasingly attenuates the sound. This would seem to contradict Le Gall's statements. See Gordon Flottorp, Gisle Djupesland, and Finn Winther, "The Acoustic Stapedius Reflex in Relation to Critical Bandwidth", Journal of the Acoustical Society of America, Vol. 49, 1971, p. 457-461.

Moreover, Le Gall[95] states that the varied mobility of the stapes is the only possible explanation for the great variety of sensations and, through them, perceptions which distinguish various ears.* To stretch the musculature of the stapes is in reality what he is attempting, says Tomatis; the "Tomatis method is a type of physiotherapy"[96].

The second innovation in the Tomatis procedure is that input is transmitted one hundred per cent to the right ear and in diminishing amounts to the left ear. The purpose of this is to bring about auditory lateralization, that is right ear dominance, and its chain of consequences, according to the theory.

Finally, the Aurelle apparatus provides cybernetic feedback. Each time the dyslexic repeats words and phrases, he is forced to hear his voice modified, in the way of a listener who "hears well". "This procedure is conducive to the child becoming aware of the controls of

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95 Le Gall, Adjustment, p. 6.

96 Tomatis, L'Oreille électronique, p. 35; A.E. Sidlauskas, "Tomatis Effect", Workshop on Treatment Approaches to Children with Reading Disabilities, American Orthopsychiatric Association, New York, 1969, p. 10.

* Note that this statement makes no reference to the sensory receptors of the inner ear or to the auditory neural pathways.

his voice, of his body"[97]. The object of the program is to normalize the diverse "structures"[98] described above.

Although Tomatis[99] states that the child, his parents, and teacher should be informed of his progress and that parents should be encouraged to establish the "dialogue" with the child, he also says that no educational means serve any purpose until the child is disposed to listen. In Le Gall's words:

> The object of the treatment has nearly always been to lower the audiometric register of the low-pitched sounds and to raise that of the high-pitched sounds in various proportions which are indicated to the operator on examination of the initial audiogram and of the following audiograms during the treatment. This adjustment alone produces the psycho-pedagogical effects which we have described.[100]

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97 Tomatis, Dyslexia, p. 89-90.

98 Tomatis, Dyslexia, p. 86; Tomatis, La Dyslexie, p. 65.

99 Tomatis, Dyslexia, p. 91-92; Tomatis, La Dyslexie, p. 69-70.

100 Le Gall, Adjustment, p. 31. It should be noted that, if Le Gall were using correct terminology, he would have said that the object of the treatment is to elevate the threshold of the low-pitched sounds and to lower the threshold of the high-pitched sounds. However, he is referring here to the shape of the curve (see Tomatis, L'Oreille et le langage, p. 101) and not to numerical (dB) values.

4. Basic Hypothesis

This study was undertaken as an exploratory study to assess the Aurelle technique under experimental conditions. Its aim was a preliminary assessment of the Aurelle therapy as a treatment for children with reading difficulties. The experimental hypothesis may be stated as follows: subjects administered the Aurelle therapy will show a significant post-treatment effect in right-ear preference in listening, in phonation, in over-all right-side preference or laterality, and in reading scores on a standard reading test, as compared to subjects given the same material and audio-vocal treatment for the same number of sessions and the same duration of time in a language-laboratory type of procedure without the Aurelle modifications of filtering and reduced left-ear input.

CHAPTER II

EXPERIMENTAL DESIGN

1. Subjects

In mid-April 1971, the investigator made an oral announcement of the proposed study at the meeting of the local branch of the Association For Children With Learning Disabilities (ACLD). It was announced that children, aged eight and nine, of average or above-average intelligence who were having reading problems were being sought for a program to be conducted throughout July and August. It was pointed out that the remedial technique to be used, although in use clinically at the University of Ottawa Child Study Centre and elsewhere, has always been employed simultaneously with other treatment and educational techniques, so that its specific remedial benefit was unknown. It was mentioned that the planned summer program would use only the one technique in an experimental effort to ascertain its effects. Any individuals who inquired about the program, either at the meeting or later on, were also given this information. It was specified, too, that children with detectable sensory or brain damage and hyperactive children on medication would not be included in the study.

A written announcement of the study (see Appendix 2, Summer Clinic for Poor Readers) appeared shortly thereafter in the Bulletin of the local branch of the ACLD. On the mailing list to receive the Bulletin are the names of school principals and teachers of remedial reading in both the Separate schools and the non-Catholic schools of Ottawa, Hull, Vanier, and Nepean. Thus, the entire spectrum of elementary schools in the Ottawa area was quickly informed of the program. Names of seventy-one children were soon assembled. Initial screening, e.g., by telephone, reduced the possible subject population to thirty-five. Of the original population of seventy-one, some were clearly unwilling or unable to participate for the duration of the study and some were taking medication for cerebral dysfunction.

a) Screening tools

The remaining thirty-five children were given the following pre-training, individual screening tests*:-

Wechsler Intelligence Scale for Children[1] (WISC)
Wide Range Achievement Test[2] (WRAT) Reading**
Bender Visual Motor Gestalt Test[3]
Draw a House-Tree-Person-Your Family[4]

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1 David Wechsler, Wechsler Intelligence Scale for Children, New York, Psychological Corporation, 1949, v-114p.

2 J.F. Jastak, et al., Wide Range Achievement Test, Reading, Spelling, Arithmetic from Pre-School to College, Rev. Ed., Wilmington, Delaware, Guidance Associates, 1965, 4 p.; Manual of Instructions, 56p.

3 Lauretta Bender, A Visual Motor Gestalt Test and Its Clinical Use, New York, American Orthopsychiatric Association, 1938, xi-176p.

4 Florence L. Goodenough, Measurement of Intelligence by Drawings, Chicago, World Book, 1926, xi-177p.

* Unless otherwise indicated, all tests were administered by the writer. The assessment of the screening tests was done by Prof. Agatha E. Sidlauskas together with the writer. It must be mentioned that the writer attempted to assess the "listening posture" described by Tomatis (see Chapter I). With each child, signs of a deficient "listening posture" were recorded when observed. However, to the writer, very few such signs were detectable. It is important to note, too, that at least until the time of this writing, the "listening posture" has not been part of the procedure in assessing dyslexia at the Child Study Centre.

** This test was administered again as a retest after the completion of training.

Ten Tasks:	Laterality**
3 eye preference (tube, carton, kaleidoscope)	
4 hand preference (write, cut with scissors, toss and catch ball)	
2 foot preference (hop on one foot, kick ball)	
1 ear preference (dichotic digits) A score of 10 = right dominance; less than 10 = mixed laterality.	
Audiological Examination*:	
Bone Conduction (standard method[5])§	
Air Conduction (standard method[5])¶	Hearing Sensitivity**
Selectivity Test[6] (Tomatis' test)¶	Selectivity**
Dichotic Digits[7]¶	Verbal Listening**

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5 Lloyd L. Price, "Pure-tone Audiometry", Darrell E. Rose, Ed., Audiological Assessment, Englewood Cliffs, New Jersey, Prentice-Hall, 1971, p. 167-205. (See also Appendix 4a, 4b)

6 See Appendix 4c, Selectivity Test.

7 D.E. Broadbent, "The Role of Auditory Localization in Attention and Memory Span", Journal of Experimental Psychology, Vol. 47, 1954, p. 191-196.

* These tests were administered in a floating IAC (International Acoustics Corporation) booth, using an audiometer MAICO 2400.

** These tests were administered again as retests after the completion of training.

§¶ The writer gratefully acknowledges, respectively, the technical assistance of Pat Kramer, audiologist, and of Gabriel Mancini, assistant, Department of Child Psychology and Child Study Centre, University of Ottawa.

Immediately prior to the first session, the subjects' voices were recorded saying the phrase "Hello. Here I am. My name is.... "* This was converted later to sonograms.

Phonation**

Regarding the WRAT, the standard score is comparable to the IQ of standard tests. "The WRAT standard score has a mean of 100 and a standard deviation of 15. It is statistically comparable to IQ's obtained from the Wechsler scales (WAIS and WISC)...."[8] The authors of the WRAT point out that the standard score is useful in research to report improvement or decline in achievement as a result of remedial work. The standard score represents the rate of learning and these scores are uniform and strictly comparable within the scale. For other purposes, the WRAT also provides grade ratings, which indicate the level of achievement reached, and percentile ranks.

On the basis of the screening battery outlined above, twenty children were selected for the study. The criteria for selection were an average IQ and reading retardation relative to the IQ. The reasons for eliminating

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8 Jastak, WRAT Manual, p. 12.

* The writer gratefully acknowledges the assistance of Jack Watters, technician, Child Study Centre, University of Ottawa.

** This test was administered again as a retest after the completion of training.

fifteen children were, in some cases, no evidence of reading retardation according to our tests, in other cases clear evidence of perceptual-motor dysfunction, and, in two cases because it was decided for administrative reasons to limit the sample to twenty subjects.

b) Assignment to groups

The twenty children, five girls and fifteen boys, were matched, primarily, by IQ, age, and sex, and, secondarily, by pre-training scores on several dependent variables, namely, reading, laterality, and dichotic listening. All twenty children were within the normal range of hearing on both air and bone conduction tests. A boy dropped out before the start of training and, in his place, a girl was asked to join the study. Instead of placing this girl in the group from which the boy had dropped out and, thus, balancing the groups as to number and sex, this girl, erroneously, was randomly assigned. Then the two groups, comprising eleven and nine subjects, respectively, were randomly assigned to the two treatment conditions, Aurelle and Control. In the course of training, two more children dropped out, another boy and a girl, both from the Control group. Thus, eighteen children completed the study, eleven $\underline{S}_s$ in the Aurelle group (seven boys and four girls), and seven $\underline{S}_s$ in the Control group (six boys and one girl).

2. Materials

a) Apparatus: Aurelle

The equipment used was the Aurelle 'electronic ear' assembled by Alfred Tomatis (see Figure 1). It consists of an electronic circuit containing some or all of the components described below. (Tomatis[9] is not explicit about the composition of the Aurelle apparatus. However, he describes studies in which he has used the Aurelle _plus_ the following):-

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9 (Alfred Tomatis), _Experimentation en vue de la démonstration de l'effet Tomatis et de ses conséquences_, (no place, no date), Mimeographed, 32 p.; Alfred Tomatis, _L'Oreille électronique_, Ottawa, Centre d'Etude de l'Enfant, 1970, Mimeographed, p. 2-31.

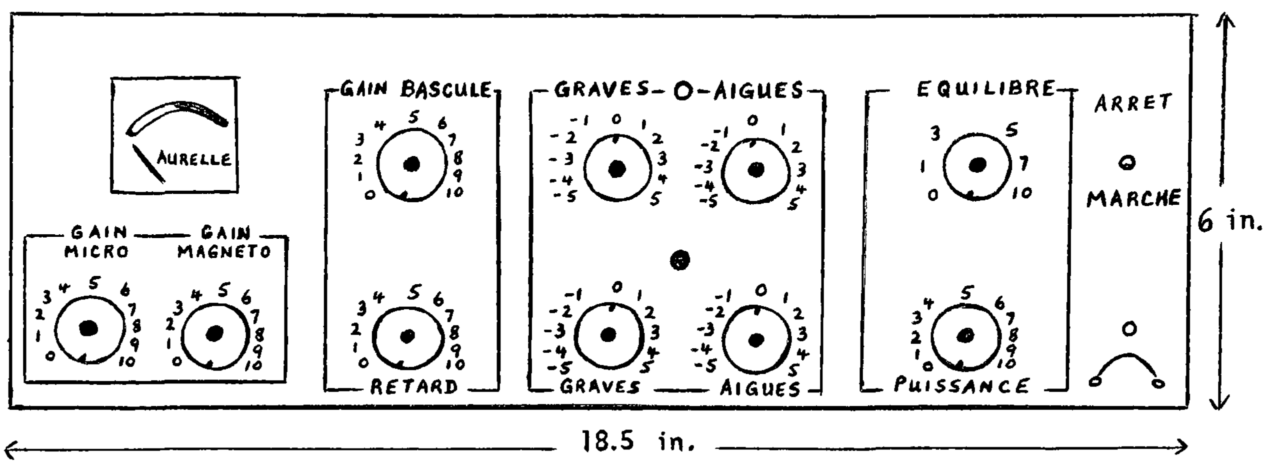

Fig. 1. Aurelle apparatus, 18.5 in. X 6 in. X 14.5 in. (See Tomatis, Experimentation, 32 p.; Tomatis, L'Oreille électronique, p. 2-31.)

a sonometer, SSG 6, from the Laboratoire Electro-Acoustique L.E.A., which serves as a pre-amplifier to the frequency analyser. This equipment has ranges at the following intensity levels: 24-54 dB, 44-74 dB, 64-94 dB, 84-114 dB, 104-134 dB;

a frequency analyser (Pimonow system), AF 10 S L.E.A., 100 cps-15,000 cps;

an ultra low-frequency band-pass filter, Model 330 M, which permits obtaining a rejection band whose yield drops to -24 dB or to a sharp null frequency;

a variable rejection filter, Model 360 A, whose response curves are identical to those of the ultra low-frequency filter but the zones utilized are the reverse;

a high-fidelity power amplifier;

a generator (audio-generator Heathkit, Heath Company) which permits the control of frequencies and intensity;

a magnetic recorder SAREG, unwinding at 38 cm and verified linear until 12,000 cps.

Tomatis[10] states that the Aurelle is equipped with two

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10 Tomatis, Experimentation, p. 2.

potentiometers fixed, respectively, at 1 kHz and 2 kHz which permit the attenuation of low-frequency sounds (i.e., 100 cps-1000 cps) and the boosting of high-frequency sounds (i.e., 2 kHz-13kHz). The attenuation and amplification together operate within a range of 35 dB.

By adjusting the appropriate control dials, one is able to modify or leave unaltered the frequencies of recorded material and of material sung or spoken by the subject into a microphone, and to modify or leave unaltered the subject's hearing, via earphones, of this material. The Aurelle contains a 'bascule' which, with the 'retard' or delay mechanism, acts like a seesaw in the shifts between the subject's real hearing and the hearing imposed. The bascule lamp lights up when the subject is speaking with sufficient intensity; the bascule can be adjusted to require the subject to speak more loudly in order to illuminate the lamp[11]. An attenuator, called the 'équilibre', controls two parallel speakers. The équilibre can be set so that the subject hears through both earphones equally, or one hundred per cent volume at one earphone and only a fraction of the volume at the other earphone; this is done to train auditory lateralization. The 'magneto' and 'micro'

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11 Tomatis, L'Oreille électronique, p. 28-29.

dials, respectively, control the intensities of the recorded material and the material emitted into the microphone. Another dial, 'puissance', controls the overall power output. Regarding the latter, Tomatis[12] states that the subject himself must find a comfortable intensity level and that an adult can often regulate this himself, but that a child must often be helped to find the zone of comfort.

b) Player/recorder

For the duration of the study, four Aurelle units with their individual player/recorders were permanently housed in a bank of steel shelving in a control room. The control room was identical in dimensions and otherwise to the four individual training rooms (see Figure 2), opening off the same hallway. However, besides the Aurelle and player/recorder units, the control room contained a work table, cabinets for the technician and experimenter, tapes, and other supplies. Each Aurelle and player/recorder unit transmitted from the control room to one of the four training rooms.

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12 Tomatis, L'Oreille électronique, p. 30.

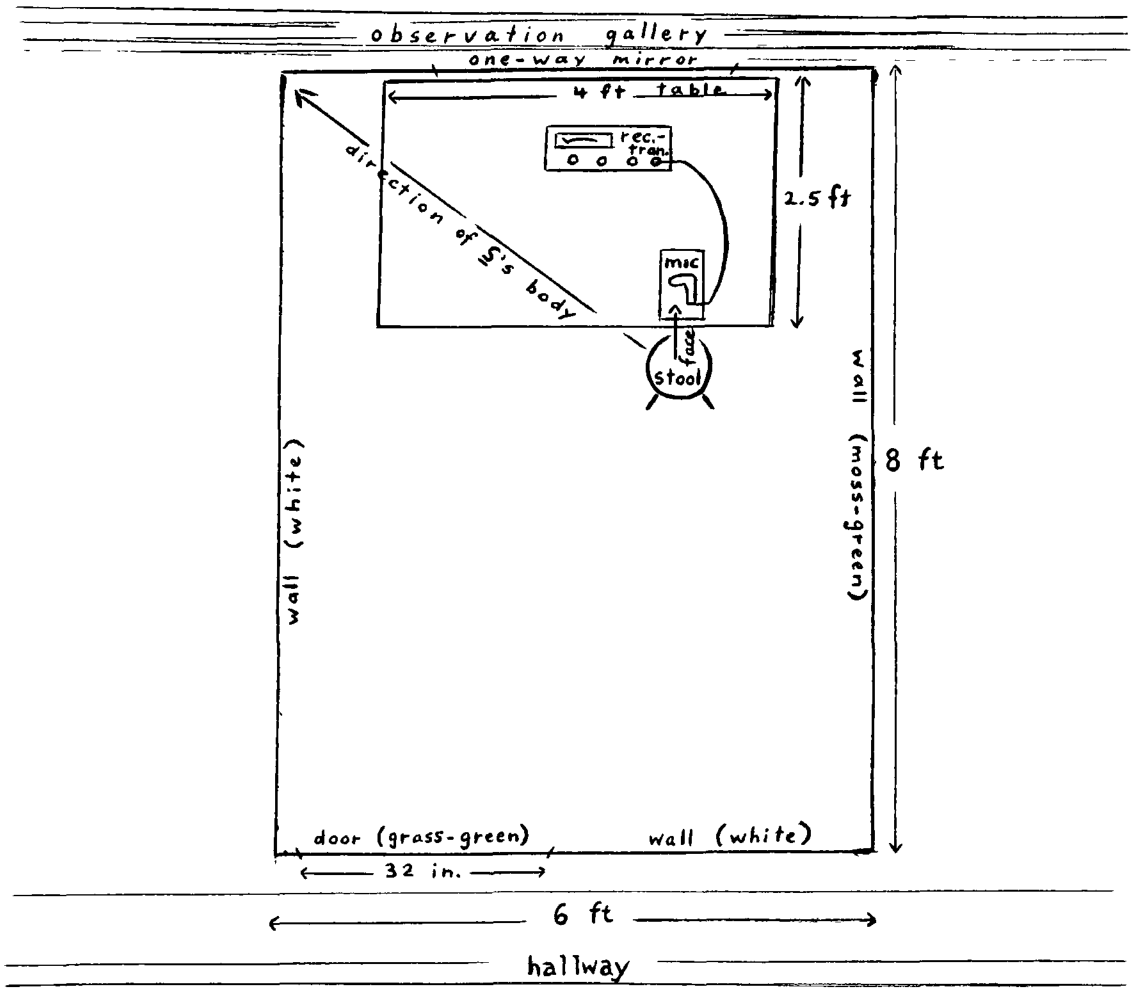

Fig. 2. Training room, 6 ft. X 8 ft. X 7.5 ft. high. One-way mirror, 3 ft. X 14 in., centred 2 ft. down from ceiling. Fluorescent light fixture, 2 ft. square, centred on ceiling. White ceiling, three white walls and one moss-green wall. Wall-to-wall carpeting of green/brown tweed in training rooms and hallway.

Each training room was private, sound-proofed, and carpeted. In each room, there was a stool, 13.5 inches in diameter and of adjustable height, and a table 4 ft. long by 2.5 ft. wide and 26 in. high.

c) Receiver/transmitter

The receiver/transmitter (see Figure 3) was placed on the table in each training room. During a training session, both the microphone and earphones were plugged into it. On the receiver/transmitter, a small white light bulb which flashes on intermittently and a numerical gauge with a needle indicator, the volume-unit (VU) meter, both signify intensity: with the Aurelle apparatus in operation, sufficient intensity of the recorded material and emitted voice activates the light as well as the needle indicator. If, however, the Aurelle apparatus is set at 'zero', the light bulb is inoperative and, then, only the needle indicator signifies the volume of the recorded material, transmitted by the player/recorder, and of the voice emitted into the microphone.

d) Earphones

These were Type 50 Q, DR-80C, LEM, Zec. Zmic.

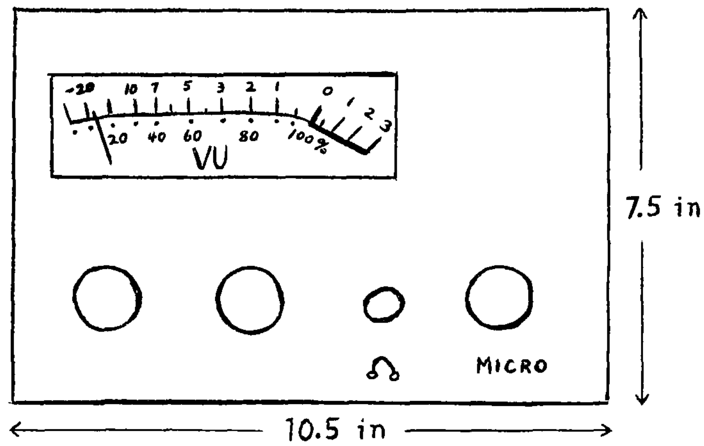

Fig. 3. Receiver/transmitter 10.5 in. X 7.5 in. X 4 in. Earphones and microphone plug into this apparatus. Manufacturer: Multi-Vox 10A - 125V.

e) Microphone

This was microphone LEM 409, 50 QE 2-5. These were table-top microphones, 7 in. high at a horizontal level, which could be tilted to 8 in. and more. The microphones were set on a sponge base, one-inch thick.

f) Tapes

The music and verbal material were recorded, using one of the player/recorders, on Ampex Low Noise tapes No. 444 (Ampex Corporation, Redwood City, California, U.S.A.). These were seven-inch reels, ¼ in. X 1800 ft., 1 mil polyester. One direction recording, at recording speed 7½ ips, provided forty-five minutes of playing time.

The first twenty minutes of recorded material consisted of music. Twelve minutes of music was taped from the first, and eight minutes of music was taped from the second of the following commercial recordings:-

(1) Angel record No. 35948. Herbert von Karajan, The Berlin Philharmonic Orchestra, Chorus of Gesellschaft der Musikfreunde, Vienna, and The Philharmonia Orchestra.

Georg Friedrich Handel, The Water Music Suite: Allegro, Air, Bourrée and Hornpipe, Andante espressivo and Allegro deciso.

Wolfgang Amadeus Mozart, Eine Kleine Nachtmusik; Serenade No. 13 in G, K. 525, Allegro, Romanze, Minuet and Rondo, Three German Dances; Ave, Verum Corpus.

(2) Columbia LP Masterworks (ML 4550). Isaac Stern, violin, with Sir Thomas Beecham conducting The Royal Philharmonic Orchestra.

Jan Sibelius, Concerto in D Minor for Violin and Orchestra, Opus 47.

Jan Sibelius, Four Historic Scenes: Festivo, Opus 25; At the Drawbridge, Opus 66; Love Song, Opus 66; The Chase, Opus 66.

The last twenty-five minutes of recorded material consisted of words.* When the music ended, a voice was heard, first giving the subjects the following instructions:-

> Have your body facing the corner.
> Turn your head toward the microphone.
> Remember to sit up straight.
> Speak with your lips well forward.

Then the word list began (see Appendix 3). Prior to each session during the first week, the posture and lip position were demonstrated to each S individually by the technician.* That week, each S's posture and lip movements were checked and corrected. Thereafter, the Ss were monitored unobtrusively at each session, and posture and lip movements were demonstrated once weekly.

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* The writer gratefully acknowledges the assistance, respectively, of Maxine Smith, receptionist at the Child Study Centre, University of Ottawa, and of Jack Watters, technician at the Child Study Centre, University of Ottawa, who was trained in Paris by Tomatis.

Following the instructions, the voice continued, speaking words selected by the E from primary-school readers and story-books used at the Child Study Centre school and ranked for grades 1-6. Words which appear on the WRAT reading and spelling subtests were not included. After each word or phrase, there was a pause averaging one second, long enough for the subject to repeat the word. The word list totalled about 650 words or short phrases (see Appendix 3).

Thus, with the above-detailed music and verbal material, the tapes consisted of the following:-

(1) four tapes, marked B, which were unfiltered, unaltered.

(2) four tapes each, totalling twelve tapes, marked A, AA, AAA which were filtered, respectively, at

A	-	960 cps
AA	-	1920 cps
AAA	-	3840 cps

That is, in the music and words, the frequencies below these levels were reduced, attenuated, and thus filtered out. However, the instructions were not filtered.

g) Word lists

Mimeographed word lists, double-spaced, in three columns, duplicated the words on tape. (See Appendix 3). These lists were used in the last sessions.

h) Coloring-books, coloring-paper, crayons, colored pencils, erasers, cardboard and wooden jigsaw puzzles.

The subjects were given individual coloring-books, marked with their own name. Other materials were shared. These supplies were kept in the control room when not being used.

i) Lifesaver candies

A candy was offered to each S about twice a week, immediately following a session.

3. Procedure

The two groups were randomly assigned to differential treatments of the auditory input.

The Aurelle group was administered the following:-

1) filtered tapes and auditory lateralization

Tape	Frequencies	Sessions	Left Ear	Right Ear
A	960 cps+	2	70%	100%
"	"	2	50%	100%
"	"	2	30%	100%
"	"	3	10%	100%
AA	1920 cps+	5	10%	100%
AAA	3840 cps+	16	10%	100%
		30		

2) Aurelle-apparatus modifications for the English-language ear[13], *i.e.*, (see Figure 1)

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13 (Alfred Tomatis), *L'Intégration des langues vivantes*, Paris, Centre du Langage, (no date), p. 45.

	graves (low)	aigues (high frequencies)
upper dial	- 5	+ 5
lower dial	+ 5	- 5

The gain bascule was set between 4 and 5; retard was set at zero. Gain micro was adjusted individually; gain magneto was adjusted individually but, generally, was set at about 7 so as to drive the needle indicator to the white-red border line on the VU meter; puissance was set from 7 to 9, depending on the S's comfort.*

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* At the start of this study and following its termination, the writer requested that the tapes and these Aurelle settings be measured re Sound Pressure Level (SPL) at the headphones. The technical officer of the Child Study Centre repeatedly cited technical difficulties for refusing this request. Approximately eight months later, in April 1972, the technical officer measured the Aurelle settings re SPL at the headphones and issued a memo stating that settings above 3 on puissance are of high intensity and should be used with caution. (See Appendix 15, Memo Re Electronic Ear). However, it should be noted that during a week-long visit to the Child Study Centre in August, 1971, while this study was under way, Tomatis himself checked and approved of the settings and of the recorded material being used, to which he listened via headphones.

The Control group was administered the following:- 1) unfiltered tapes, marked B, and one hundred per cent input to both the left and right ears for thirty sessions. 2) a language-laboratory procedure of input and feedback; no Aurelle-apparatus modifications, no filtering or amplifying of selected frequency bands. The gain bascule, retard, graves and aigues were set at zero; équilibre was set at 10; gain micro was adjusted individually, gain magneto was adjusted individually but, generally, was set at about 7, and puissance was set between 7 to 9, according to the S's comfort (see Figure 1).

a) Training sessions

All Ss were assigned to a permanent attendance hour and a permanent training room for the duration of the study. Five periods were scheduled each day, beginning at 8:15 am, 9:15 am, 10:15 am, 11:15 am, and 1:15 pm. Each session lasted forty-five minutes. The fifteen minutes between periods allowed the E and technician time to rewind and change tapes on the players, reset the apparatus, tidy the training rooms, and allowed for the occasional late attendance. Usually, sessions were held five days weekly, Monday through Friday. The training program began on Tuesday, July 6, 1971, and ended on Thursday, September 2, 1971. Most of the children took holidays with their families at some point during the summer. But the eighteen Ss who completed the training program and retests each received a total of thirty training sessions, of forty-five minutes per session. That is, twenty-two and one-half hours of training were completed per subject.

b) Training procedure

During the twenty minutes of music, the Ss were allowed to draw, color, or do puzzles. When the music ended, the Ss pushed the play materials aside, placed the microphone in position for the verbal portion, and placed their body as instructed. The E checked that these were all done correctly.

Until the end of the 19th training session, each S listened to the recorded words and repeated the words. Beginning with the twentieth session, when the music ended each S was given a mimeographed list of the words (see Appendix 3). Pointing to each word in succession, the S now silently read the words he was listening to and then spoke the words aloud. Thus, multisensory training and intersensory integration were attempted, using audition, vision, and kinesthesis. Obviously, this training was gross since no training was given in the specific visual or auditory stimulus properties or in specific motor patterns.*

From the twentieth session until the thirtieth, that is the last session, the word list was read as follows:-

Session	20:	whole list	
	21:	whole list	
	22:	pages 1-2	
	23:	pages 3-4	
	24:	pages 5-6	
	25:	pages 7-9	
	26:	pages 1-4	
	27:	pages 5-9	
	28:	whole list	
	29:	whole list	) Verbal part of tape
	30:	whole list	) turned off; i.e., no prompts.

Before and during the training program, parents were strictly instructed to provide their children with no other remedial reading or remedial education until this program was over. In addition, parents were instructed not to apply pressure on their children regarding success in the program. After the program was under way, parents were questioned occasionally as to whether they had observed any changes in their child's behavior since the start of the program. No particular changes or observations were

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* Tomatis' procedure is identical to the procedure used in this study except that Tomatis does not require the subject to point to the words.

suggested by the E who was attempting to record changes which parents might notice spontaneously and which might correspond to and corroborate those reported by Tomatis and his colleagues, for example increased activity and improved mood[14].

On the day after the S's thirtieth training session, the S was individually retested on the following: the air conduction hearing test, administered according to the standard method; dichotic digits, *i.e.*, listening to verbal material; Tomatis' test of auditory selectivity; phonatory output repeating the phrase originally recorded; hand-foot-eye-ear preference, *i.e.* laterality; and the WRAT reading subtest. (It should be noted that Tomatis tapes the voice "in a quiet room"* which is not soundproof. For this study, the pre-training voice tape was made with the S standing in a quiet hallway. However, ambient noise and noise from the recorder were registered. Post-training, the voices were recorded in a soundproof room using a

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14 Alfred Tomatis, *Dyslexia*, Tr. Agatha Sidlauskas, Ottawa, University Press, 1969, p. 88-89; André Le Gall, *The Adjustment of Certain Psychological and Psycho-Pedagogical Deficiencies with the Tomatis Effect Apparatus*, (no place), 1961, Mimeographed, p. 29.

* This was reported by students who visited Tomatis' clinic in Paris.

quieter recorder). The last S was retested on September 3, 1971.

All Ss were reassembled on a Saturday morning, October 2, 1971, for individual hearing retests of bone conduction, standard method of administration. Earlier scheduled retesting of bone conduction had been postponed due to the need to re-calibrate the audiometer.

4. Statistical Analyses

a) Analyses of variance, covariance, and t-tests

1) A two-factor (AXB) analysis of variance, with group (Aurelle and Control) and trials (Test, Retest) as the experimental variables, was performed on the laterality scores. Laterality gave a maximum score of ten, totalling right-sidedness on ten preference tasks. (See the raw data in Appendix 7, Laterality Test and Retest).

2) A one-factor (group, Aurelle and Control) analysis of covariance was performed on WRAT reading difference scores, i.e. on the difference between reading standard scores before and after training. The three covariates were age, sex, and I.Q. (See the data in Appendix 6, Some Characteristics of Treatment Groups, under columns listing WRAT reading scores).

3) A two-factor (AXB) analysis of variance, with group (Aurelle and Control) and trials (Test, Retest) as

the experimental variables, was performed on the WRAT reading scores (standard scores). (See the data in Appendix 6, Some Characteristics of Treatment Groups).

4) A four-factor (AXBXCXD) analysis of variance, with group (Aurelle and Control), frequencies (nine pairs, namely 8k-6k, 6-4k, 4-3k, 3-2k, 2-1.5k, 1.5-1k, 1k-500 cps, 500-250 cps, 250-125 cps), ear (Right, Left), and trials (Test, Retest) as the experimental variables, was performed on the number of correct responses on auditory selectivity. (See the data in Appendix 9, Auditory Selectivity on Test and Retest).

5) A three-factor (AXBXC) analysis of variance, with group (Aurelle and Control), frequency (250 cps, 500 cps, 1k, 1.5, 2, 3, 4, and 8k), and ear (Right, Left) as the experimental variables, was performed on Air Conduction intensity (dB) difference scores to determine the effects on hearing thresholds. (See the data in Appendix 8, Hearing Thresholds on Test and Retest).

6) A four-factor (AXBXCXD) analysis of variance, with group (Aurelle and Control), frequency (250 cps, 500, 1k, 1.5, 2, 3, 4k), ear (Right, Left), and trials (Test, Retest) as the experimental variables, was performed on Bone Conduction intensity (dB) scores. (See the data in Appendix 8, Hearing Thresholds on Test and Retest). Although these data were analysed statistically, it should

be noted that the results cannot be considered reliable since the audiometer was re-calibrated before the retest.

7) A four-factor (AXBXCXD) analysis of variance, with group (Aurelle and Control), trial block (six 10-Trial Blocks), ear (Right, Left), and test (Before, After) as the experimental variables, was performed on the number of correct responses on Dichotic Digits. (See Appendix 13, Dichotic Digits in Six Trial Blocks). Paired comparison *t*-tests were done on the mean correct scores obtained on dichotic digits in six trial blocks per ear per group before and after treatment.

b) Nonparametric tests

1) A Mann-Whitney *U* test was done on the audiogram ratings done "blind" by Tomatis. The audiograms were coded so that the group and *S* were not identified, but pre- and post- treatment audiograms were indicated. The pre-treatment baseline rating was zero for each subject; a rating of zero to three indicated the amount of change within a *S* after treatment. (See Appendix 10, Audiogram Ratings by Alfred Tomatis).

2) A Mann-Whitney *U* test was done on the sonogram ratings done "blind" by Tomatis. The sonograms were coded so that the group and the *S*'s identity were not indicated, but the pre- and post-treatment sonograms were marked as such. The pre-treatment baseline rating was zero for all

subjects; a rating of zero to three indicated the amount of change within a S following treatment. (See Appendix 11, Sonogram Ratings by Alfred Tomatis).

CHAPTER III

RESULTS AND DISCUSSION

The group means and standard deviations for the variables along which the subjects were matched prior to training are presented in Table I. *T*-tests were done between the group means and the results are included in Table I: these *t*-values show that, prior to training, the two groups were adequately matched and belonged to the same population.

TABLE I

MEANS, STANDARD DEVIATIONS, AND *t*-VALUES FOR MATCHING VARIABLES PRE-TREATMENT

GROUP		IQ WISC	AGE in months	SEX M=1 F=2	READING WRAT	LATERALITY Max.=+10 (RT.)	DICHOTIC LISTENING RT.EAR	DICHOTIC LISTENING LEFT EAR
AURELLE	$\bar{X}$	104.6	109.7	1.4	86.8	7.7	142.4	132.3
	SD	8.3	9.2	0.5	7.0	1.8	28.0	28.8
CONTROL	$\bar{X}$	101.0	103.9	1.1	88.6	7.0	154.3	105.3
	SD	8.6	4.8	0.4	3.6	0.8	38.5	41.9
	t	0.85	1.58	1.32	0.66	1.00	-0.71	1.55

$t_{crit.}$ (df=16, p=.05) = 1.75

After training, subjects were retested on the dependent variables, namely, laterality, reading, auditory selectivity, air conduction hearing thresholds, bone conduction hearing thresholds, dichotic listening, and phonatory output. The statistical analyses of group results on the dependent variables are reported and discussed below. These are followed by observations on individual performance. Subsequently, there is a general theoretical discussion with regard to the results and observations.

1. Group Performance

1) The laterality test consisted of ten tasks (3 eye, 4 hand, 2 foot, 1 ear). Each task was scored in terms of sidedness or lateral preference, i.e. +1 = right preference, -1 = left preference, 0 = mixed. Thus, for ten tasks, a maximum score of +10 = right sidedness or right dominance; a score of less than +10 = mixed laterality.

The means and standard deviations of the laterality scores for both groups pre- and post- treatment, and the results of *t*-tests between group means, are presented in Table II. Neither difference was statistically significant.

TABLE II

LATERALITY SCORES (MAXIMUM = +10: RIGHT SIDEDNESS)

GROUP		PRE-TREATMENT TEST	POST-TREATMENT RETEST
AURELLE	$\bar{X}$	7.7	8.0
	SD	1.8	1.5
CONTROL	$\bar{X}$	7.0	7.6
	SD	0.8	1.4
	t	1.00	0.55

A two-factor (AXB) analysis of variance, with group (Aurelle and Control) and trials (Test, Retest) as the experimental variables, was performed on the laterality scores. There were no significant main effects or interaction effects. This result is contrary to the experimental hypothesis which stated that subjects administered the Aurelle therapy would show a significant post-treatment effect in over-all right-side preference or laterality. (See the raw data in Appendix 7, Laterality Test and Retest, and the summary of the analysis of variance in Appendix XIV, Table I).

2) The reading scores consisted of standard scores derived from raw scores on the reading subtest of the Wide Range Achievement Test (WRAT). The means and standard deviations of these reading standard scores for both groups pre- and post-treatment are presented in Table III. The

t-tests showed no significant differences between groups.

TABLE III

READING SCORES (WRAT STANDARD SCORES)

GROUP		PRE-TREATMENT TEST	POST-TREATMENT RETEST
AURELLE	$\bar{X}$	86.8	89.9
	SD	7.0	10.5
CONTROL	$\bar{X}$	88.6	89.0
	SD	3.6	4.9
	t	0.66	0.22

As an additional check that the groups were adequately matched, Pearson product-moment correlations were computed between pre-treatment reading standard scores and IQ scores, age, and sex. These correlations are presented in Table IV.

TABLE IV

PEARSON CORRELATIONS PRE-TREATMENT

	WRAT READING SCORES AURELLE GROUP	CONTROL GROUP
IQ (WISC)	.33	.01
AGE	.10	.25
SEX	.36	.68*

* $p < .05$

Since some of the coefficients in Table IV, above, exceed .30, showing a slight or moderate correlation, statistical control of the concomitant variables was applied by performing a one-factor (group, Aurelle and Control) analysis of covariance on the WRAT reading difference scores, i.e. on the difference between reading standard scores before and after treatment. The covariates were IQ, age, and sex. The analysis of covariance yielded no significant main effect and was not significantly different from the analysis of variance reported below. This result is contrary to the experimental hypothesis which stated that subjects administered the Aurelle therapy would show a significant post-treatment effect on reading scores on a standard reading test. (See the raw data in Appendix 6, Some Characteristics of Treatment Groups, under columns listing WRAT reading scores).

3) Since some of the coefficients presented in Table IV, above, do not exceed .30, a two-factor (AXB) analysis of variance, with group (Aurelle and Control) and trials (Test, Retest) as the experimental variables, was performed on the WRAT reading scores (standard scores). Like the analysis of covariance, the analysis of variance yielded no significant main effect and no interaction effect. This result is contrary to the experimental hypothesis which stated that subjects administered the

Aurelle therapy would show a significant post-treatment effect on reading scores on a standard reading test. (See the data in Appendix 6, Some Characteristics of Treatment Groups, and the summary of the analysis of variance in Appendix XIV, Table II).

4) The auditory selectivity test consisted of nine pairs of tones presented successively to each ear in descending frequencies, i.e. 8k-6k, 6-4, 4-3, 3-2, 2-1.5, 1.5-1k, 1k-500 cps, 500-250, 250-125 cps. The subject was asked to tell which of the two tones was higher. A score of 1 indicated an incorrect response; a score of 2 was given for a correct response.

The means and standard deviations of the auditory selectivity scores for both groups pre- and post-treatment, and the results of *t*-tests between group means, are presented in Table V. None of these differences was significant.

TABLE V

AUDITORY SELECTIVITY SCORES PRE- AND POST-TREATMENT (MAXIMUM CORRECT = 2)

GROUP		RIGHT EAR PRE	RIGHT EAR POST	LEFT EAR PRE	LEFT EAR POST
AURELLE	$\bar{X}$	1.94	1.87	1.90	1.84
	SD	0.3	0.4	0.3	0.4
CONTROL	$\bar{X}$	1.96	1.93	1.97	1.91
	SD	0.4	0.4	0.4	0.4
	t	-0.11	-0.3	-0.39	-0.35

A four-factor (AXBXCXD) analysis of variance, with group (Aurelle and Control), frequencies (nine pairs of tones), ear (Right, Left), and trials (Test, Retest) as the experimental variables, was performed on the number of correct responses on auditory selectivity. There were no significant main effects or interaction effects. This result is contrary to the experimental hypothesis which stated that subjects administered the Aurelle therapy would show a significant post-treatment effect on the number of correct responses on auditory selectivity. (See the data in Appendix 9, Auditory Selectivity on Test and Retest, and the summary of the analysis of variance in Appendix XIV, Table III).

5) The air conduction hearing test consisted of eight frequencies presented to each ear individually via earphones. The intensity of the stimulus, measured in decibels (dB) relative to audiometer zero, to which the subject responded on 50 per cent of the stimulus presentations was recorded as the threshold or score for that frequency.

The means and standard deviations of the air conduction intensity (dB) scores for both groups pre- and post-treatment are presented in Table VI.

TABLE VI

AIR CONDUCTION HEARING THRESHOLDS ON TEST AND RETEST

SCORES = INTENSITY IN DECIBELS (dB) RE AUDIOMETER ZERO

		250 cps				500				1k				1.5				2				3				4				8k			
		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.	
GROUP		T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
AURELLE	X̄	9.5	9.1	9.1	8.2	9.5	7.7	10.9	7.7	5.9	5.0	8.2	5.0	7.3	5.0	5.0	3.6	6.8	4.1	6.8	4.1	7.3	7.3	6.8	5.0	9.1	6.8	8.6	5.9	11.4	6.8	15.0	9.5
	SD	2.7	4.9	3.8	3.4	3.5	5.2	3.8	4.1	3.0	5.5	6.0	3.9	4.7	3.2	3.9	4.5	2.5	3.0	5.1	4.4	4.1	4.1	6.0	5.0	4.9	2.5	6.0	5.4	7.1	4.6	11.0	6.5
CONTROL	X̄	12.1	10.7	11.4	9.3	14.3	12.1	13.6	12.1	10.7	8.6	7.9	6.4	7.9	7.9	5.7	5.7	8.6	7.9	7.1	5.7	9.3	9.3	6.4	4.3	9.3	10.0	7.9	5.7	13.6	12.9	15.0	13.6
	SD	4.9	5.3	7.5	6.1	5.3	7.6	3.8	9.5	10.2	6.9	3.9	8.0	7.0	3.9	4.5	6.1	5.6	4.9	5.7	9.3	5.3	7.9	5.6	4.5	3.5	9.1	6.4	6.1	5.6	8.6	8.7	5.6

A three-factor (AXBXC) analysis of variance, with group (Aurelle and Control), frequency (250 cps, 500 cps, 1k, 1.5, 2, 3, 4, and 8k), and ear (Right, Left) as the experimental variables, was performed on the air conduction intensity (dB) difference scores. The analysis yielded no significant main effects or interaction effects. Regardless of the Aurelle effects on listening, this result indicates that, in this study, the Aurelle treatment had no significant effect on hearing by air conduction. (See the data in Appendix 8, Hearing Thresholds on Test and Retest, and the summary of the analysis of variance in Appendix XIV, Table IV).

6) The bone conduction hearing test consisted of seven frequencies presented to each ear individually via bone-conduction vibrator placed on the mastoid process of the temporal bone; masking noise was delivered to the ear not under test. The intensity of the stimulus, measured in decibels (dB) re audiometer zero, to which the subject responded on 50 per cent of the stimulus presentations was recorded as the threshold or score for that frequency.

The means and standard deviations of the bone conduction intensity (dB) scores for both groups pre- and post-treatment are presented in Table VII.

TABLE VII

BONE CONDUCTION HEARING THRESHOLDS ON TEST AND RETEST

SCORES = INTENSITY IN DECIBELS (dB) RE AUDIOMETER ZERO

		250 cps				500				1k				1.5				2				3				4k			
		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.		RT.		L.	
GROUP		T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
AURELLE	$\bar{X}$	7.7	7.7	8.6	6.8	8.6	4.5	10.0	5.5	8.2	5.0	9.1	5.9	8.2	5.5	5.9	4.1	3.6	5.0	6.8	5.0	8.6	5.0	10.0	6.8	10.5	5.5	10.5	4.5
	SD	3.4	4.1	5.5	3.4	5.5	4.2	5.9	2.7	4.6	3.9	3.8	3.8	5.1	4.7	3.0	4.4	3.9	4.5	5.1	3.9	3.9	2.2	3.2	4.0	5.2	3.5	4.7	3.5
CONTROL	$\bar{X}$	6.6	3.6	4.4	5.7	5.1	1.4	4.4	5.0	4.4	4.3	5.1	5.0	4.4	4.3	3.0	2.9	3.7	3.6	2.3	4.3	5.9	8.6	4.4	2.1	7.3	5.0	4.4	5.0
	SD	8.7	3.8	7.6	3.5	7.9	2.4	7.6	5.0	7.6	4.5	6.7	5.0	7.6	3.5	6.0	3.9	6.6	3.8	6.7	5.3	7.0	5.6	7.0	2.7	8.8	7.1	7.6	6.5

A four-factor (AXBXCXD) analysis of variance, with group (Aurelle and Control), frequency (250 cps, 500, 1k, 1.5, 2, 3, 4k), ear (Right, Left), and trials (Test, Retest) as the experimental variables, was performed on bone conduction intensity (dB) scores. The analysis yielded no significant treatment effect but there were some other significant effects. However, as already mentioned, the bone conduction results in this study cannot be considered reliable since the audiometer was re-calibrated prior to the bone conduction retest. (See the data in Appendix 8, Hearing Thresholds on Test and Retest, and the summary of the analysis of variance in Appendix XIV, Table V).

7) The pre-treatment audiograms were given a baseline rating of zero. Following treatment, the pre- and post-treatment audiograms were compared by Tomatis and he rated the post-treatment audiograms on a scale of zero to three, indicating the amount of change within a subject following treatment. (See the data in Appendix 10, Audiogram Ratings by Alfred Tomatis).

The means and standard deviations of the audiogram ratings post-treatment for both groups are presented in Table VIII.

TABLE VIII

AUDIOGRAM RATINGS

DIFFERENCE PRE- AND POST-TREATMENT

GROUP		
AURELLE	$\bar{X}$	1.27
	SD	.75
CONTROL	$\bar{X}$	1.00
	SD	.93

A nonparametric test, the Mann-Whitney *U* test, was done on the audiogram ratings. The result was non-significant (U=33, n_1=7, n_2=11, p=.30). This result is contrary to Tomatis' theory which predicts a significant modification in the hearing curves following Aurelle treatment. However, this study employed standard methods of testing hearing sensitivity. It is probable that the presentation of high-frequency sound at considerable intensity predominantly to the right ear, which constitutes the Aurelle treatment, conduces to eliciting the hearing curves Tomatis describes as the musical ear[1] or the beautiful ear[2] only when the

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1 Alfred Tomatis, *L'Oreille et le langage*, Paris, Editions du Seuil, 1963, p. 101.

2 Alfred Tomatis, *On the Subject of Audiometrics,* Paris, 1971, Mimeographed, p. 5.

curves are obtained by Tomatis' method of testing.

8) The dichotic listening test consisted of a series of 4 digit stimuli presented to the right ear and, simultaneously, another series of 4 different digits presented to the left ear. Sixty of these 4-pair trials were administered successively. Subjects were instructed to recall as many of the numbers as they could remember, in any order. The numbers reported were scored correct and given one point each if they corresponded to the numbers presented, with no correction factor applied for guessing.

The maximum number of digits correct per ear was 240. (See the raw data in Appendix 12, Dichotic Digits, Total Correct). The means and standard deviations of the total dichotic listening scores for both groups pre- and post-treatment, and the results of *t*-tests between group means, are presented in Table IX. None of these differences was significant.

TABLE IX

DICHOTIC DIGITS PRE- AND POST-TREATMENT

MAXIMUM CORRECT = 240

GROUP		RIGHT EAR PRE	RIGHT EAR POST	LEFT EAR PRE	LEFT EAR POST
AURELLE	$\bar{X}$	142.4	144.1	132.3	139.3
	SD	28.0	31.2	28.8	30.3
CONTROL	$\bar{X}$	154.3	172.6	105.3	111.1
	SD	38.5	44.4	41.9	37.3
	t	-.71	-1.5	1.55	1.65

For detailed statistical analysis, the total dichotic scores were divided into six trial blocks comprising ten trials of 4 digit-pairs per trial block. Forty was the maximum number correct per ear per trial block. (See the data in Appendix 13, Dichotic Digits in Six Trial Blocks).

The mean correct score for right and left ear responses in six trial blocks for each group is plotted in Figures 4 and 5. Figure 4 indicates that the Control group showed right-ear superiority across trial blocks before and after training. The number of left-ear responses increased slightly after training. The pattern of right-ear responding across trial blocks was maintained on retest;

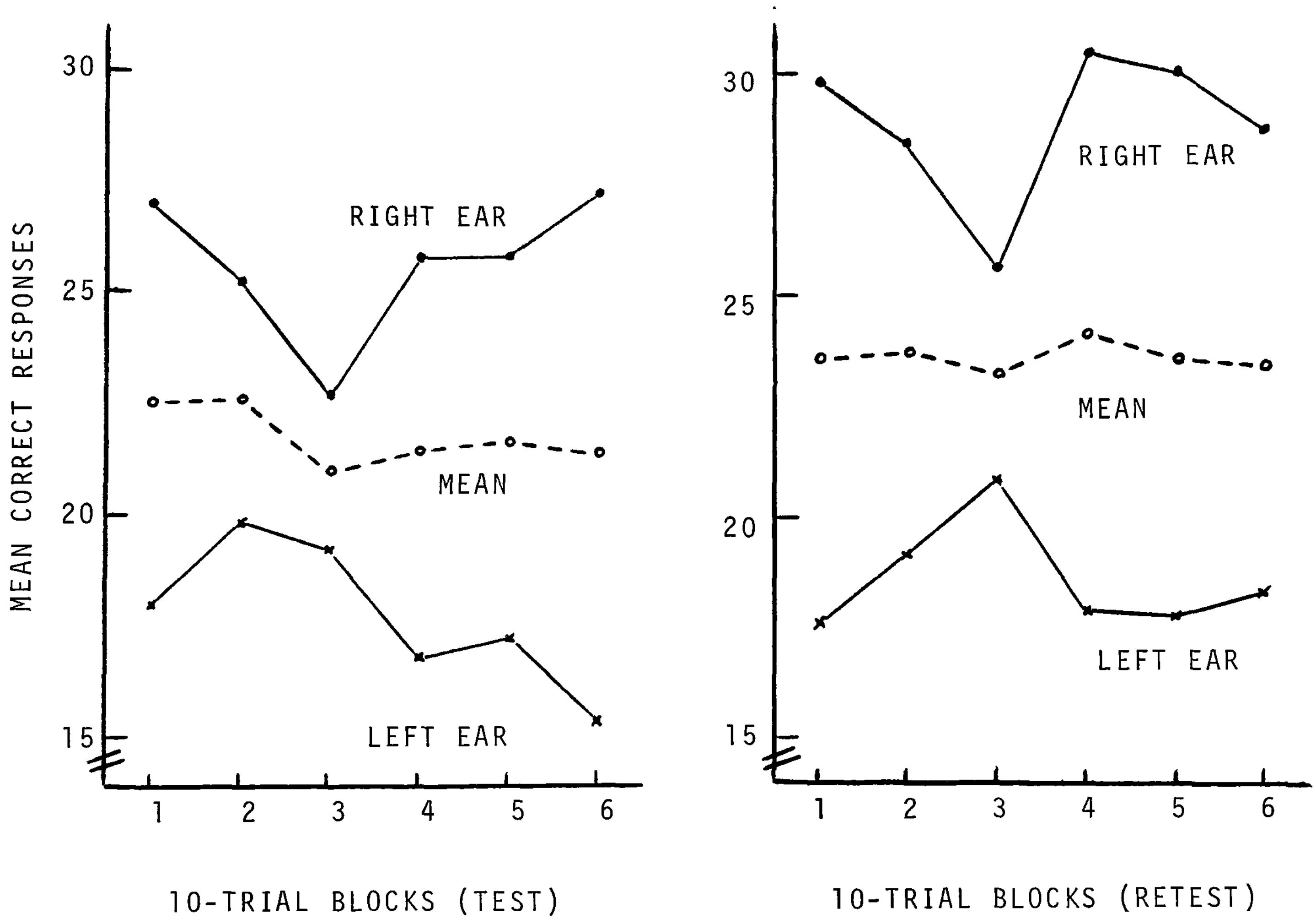

Fig. 4. Control group mean correct responses on dichotic digits per trial block on test and retest.

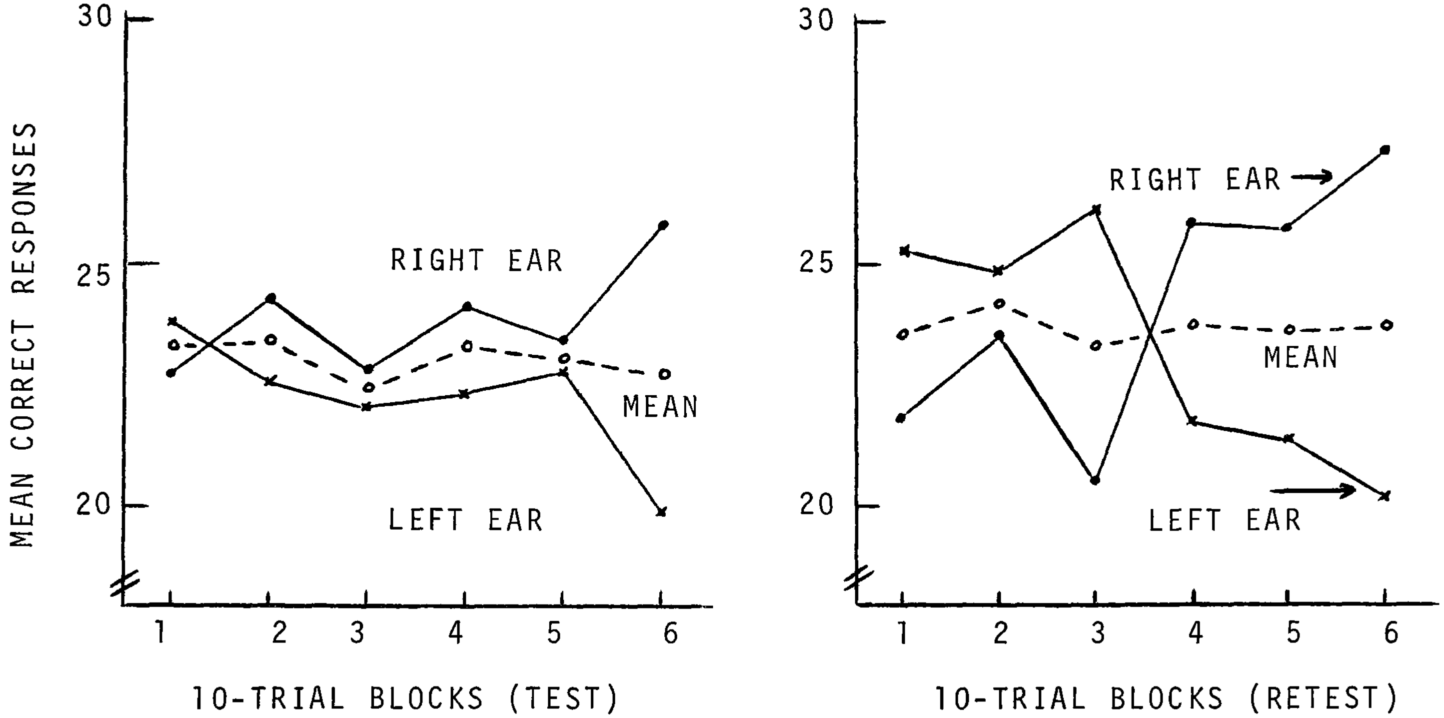

Fig. 5. Aurelle group mean correct responses on dichotic digits per trial block on test and retest.

however, after training, the total number of right-ear responses showed a clear increase.

The curves in Figure 4 show that increased responding on the right ear was matched by a concomitant decrease on the left ear. Vice versa, an increase in left-ear responses was associated with a decrease in right-ear responses. Thus, the curve for the mean score of both ears combined indicates that constancy in the total number of correct responses on dichotic digits was maintained across trial blocks.

Similarly, Figure 5 shows that, in the Aurelle group, the mean score on dichotic digits for both ears combined was consistent across trial blocks. Before training, in 10-trial Block 1, the two ears were nearly equivalent in responding; from Trial Block 2-6, the right ear showed superiority. On retest, after training, Figure 5 shows non-parallel curves, indicating an interaction in which the two ears responded differentially across trial blocks. In Trial Blocks 1-3, post-treatment, the Aurelle group's left-ear responding was superior and right-ear responses were concomitantly attenuated. In Trial Blocks 4-6, right-ear responses were superior and left-ear responding simultaneously dropped.

RESULTS AND DISCUSSION

The data tabulated in Appendix 13 and plotted in Figures 4 and 5 were submitted to an Fmax test. In this test, the observed value (Fmax = 3.37, k=4, df=10) did not exceed the critical value for a .05— level test, therefore the hypothesis of homogeneity of variance was retained. The data tabulated in Appendix 13 and plotted in Figures 4 and 5 were then submitted to analysis of variance (see Appendix 14, Table VI). The analysis indicated a significant main effect of test, i.e. pre-treatment test vs. post-treatment retest ($p < .04$). The mean correct score on test and retest is shown in Table X.

TABLE X

MEAN CORRECT SCORE ON DICHOTIC DIGITS IN SIX 10-TRIAL BLOCKS

Pre-Treatment TEST	Post-Treatment RETEST *
22.5	23.7

* $p < .04$

Note in Table X that the mean number of correct responses increased on retest. However, the main effect of trials was non-significant ($p=.23$). This confirms that average total responding was maintained consistently across trials. There was a highly reliable Trials X Ear interaction ($p < .0002$). This interaction is plotted in Figure 6. In

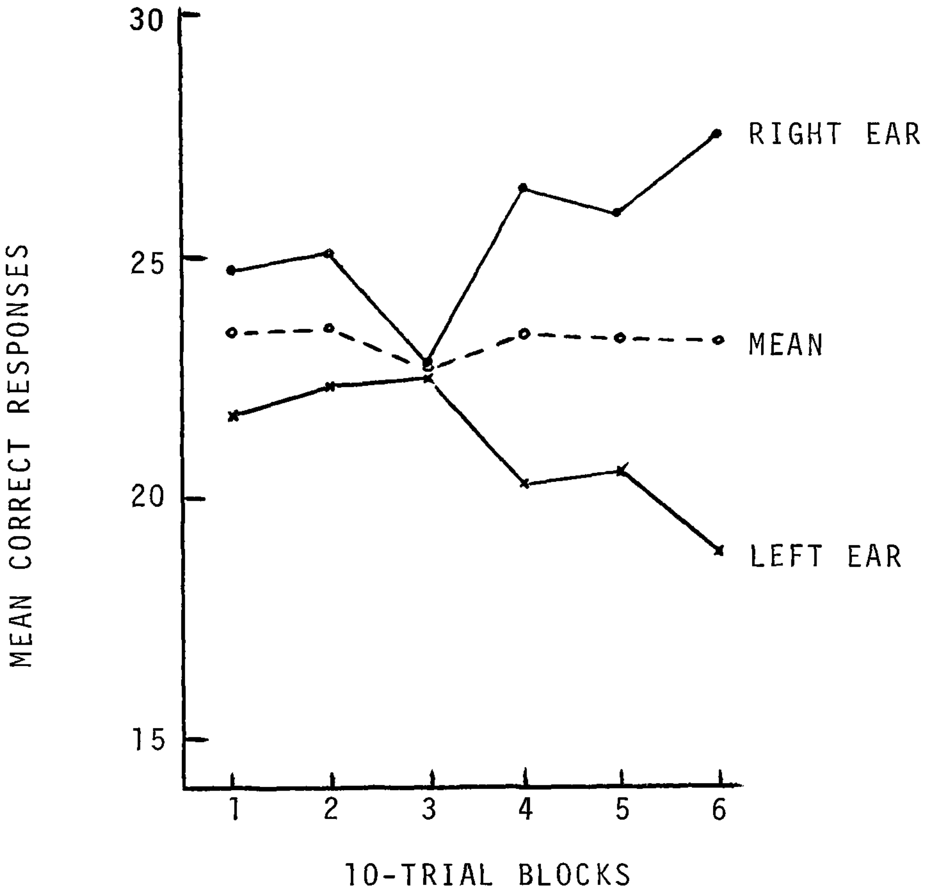

Fig. 6. Mean correct responses on dichotic digits per ear per trial block for both groups combined and mean of both ears combined.

Figure 6, the curve for the mean score of both ears combined indicates that the total number of correct responses was constant across trial blocks, illustrating the non-significant trials effect.

Referring to Figures 4, 5, and 6, it is evident that the Trials X Ear interaction is due to the post-treatment superiority of the Aurelle group in left-ear responding on the first 30 trials and, particularly, on 10-trial Block 3. On Trial Blocks 4-6, both the Aurelle and the Control group showed right-ear superiority. The Trials X Ear X Test interaction approached reliability ($p < .08$). This, too, reflects the Aurelle group left-ear responding, particularly on retest in Trial Block 3.

The Group X Ear X Test interaction was significant ($p < .04$). The data for this interaction are shown in Table XI.

TABLE XI

DICHOTIC DIGITS IN SIX TRIAL BLOCKS

MEAN CORRECT SCORE PER EAR PRE- AND POST-TREATMENT

GROUP	Pre-Treatment TEST		Post-Treatment RETEST *	
	Right	Left	Right	Left
AURELLE	23.8	22.2	24.1	23.2
CONTROL	25.7	17.8	28.8	18.6

* $p < .04$

Note in Table XI that all the means increased post-treatment; however, the smallest increase occurred in the Aurelle group right ear. The Control group increase in right-ear correct responses was ten times as great as in the Aurelle group. Paired comparison t-tests were applied to the means shown in Table XI. These tests indicated that the Control group increase in right-ear responding was highly significant (t=4.32, df=6, $p < .005$); however, the other mean increases did not reach significance.

Reviewing the results obtained on dichotic digits, it is clear, since there was no significant trials effect, that the overall number of correct responses was consistent across trials. The results suggest that subjects learn, or adopt a strategy, to listen to verbal material with the right ear. The Control group demonstrated this learning or strategy very early in the series of trials.

However, it appears that Aurelle treatment interfered with this learning or with application of this strategy. In addition, the increase which occurred on retest in mean correct responses per ear reached significance only for the Control group right ear. One must conclude, therefore, that the language-laboratory procedure administered to the Control group provided more right-ear practice with intelligible verbal material than the Aurelle procedure provided. Another hypothesis is that the Control group right-ear increase is an artifact, i.e. it would occur on retest without further practice. In the latter case, one would conclude that the Aurelle procedure suppressed the right ear on a verbal listening task. To test these hypotheses, it would be necessary to repeat this study, adding another Control group which would receive test and retest without any training during the intervening period. However, regardless of which hypothesis is correct, the results on this verbal listening task were contrary to what one would predict from Tomatis' theory and from the claims made for his therapy.

9) The pre-treatment sonograms were given a baseline rating of zero. Following treatment, the pre- and post-treatment sonograms were compared by Tomatis and he rated the post-treatment sonograms on a scale of zero to three, indicating the amount of change within a subject

following treatment. (See the data in Appendix 11, Sonogram Ratings by Alfred Tomatis).

The means and standard deviations of the sonogram ratings post-treatment for both groups are presented in Table XII.

TABLE XII

SONOGRAM RATINGS
DIFFERENCE PRE- AND POST-TREATMENT

GROUP		
AURELLE	$\bar{X}$	2.27
	SD	.964
CONTROL	$\bar{X}$	1.00
	SD	.927

A nonparametric test, the Mann-Whitney *U* test, was done on the sonogram ratings. This test yielded a difference in treatments significant at $p < .025$ (U=13.5, n_1=7, n_2=11).

The results obtained with the sonograms suggest that there are identifiable changes in phonation as a result of the Aurelle technique, and that these changes are detectable to Tomatis. A visual inspection of the sonograms indicates the presence of more high frequencies in the Aurelle group as compared to the Control group following treatment. This, indeed, is the Aurelle effect that Tomatis looks for on the sonograms[3]. (A spectrum analysis of the sonograms was not done by the investigator because the pre-treatment tape included ambient noise, especially from a noisy recorder, and these frequencies would have been analyzed along with the voice frequencies with no differentiation between the two.) One must recall the statement by Tomatis, namely: "In the progress of the therapy, the most remarkable signs will be reflected in the modification of the voice"[4]. Elsewhere, we are told that "the child speaks more loudly"[5]. In connection with these effects, one should recall, too, that the subject is instructed to speak loudly enough to light up the 'bascule' lamp, and the technician adjusts the apparatus so that a "certain intensity" (the level is not stated) is required to

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3 Statement made by Professor A.E. Sidlauskas during thesis committee meeting, March 1, 1973.

4 Alfred Tomatis, Dyslexia, Tr. Agatha Sidlauskas, Ottawa, University Press, 1969, p. 94.

5 A.E. Sidlauskas, "Tomatis Effect", New York, 1969, Mimeographed, p. 8.

illuminate the lamp[6]. Since the vocal mechanisms of frequency and intensity are so interrelated that it is virtually impossible to isolate one from the other[7], one wonders whether the "Tomatis effect" on phonation can be summed up in the phrase "the child speaks more loudly" and, consequently, produces more high frequencies.

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6 Alfred Tomatis, L'Oreille électronique, Ottawa, Centre d'Etude de l'Enfant, 1970, Mimeographed, p. 28-29.

7 H.J. Rubin, "Experimental Studies on Vocal Pitch and Intensity in Phonation", Laryngoscope, Vol. 73, 1963, p. 973-1015.

2. Individual Performance

As to miscellaneous observations, the experimenter observed during training that when the Aurelle group was started on the tape filtered at 3840 cps, during the verbal portion $\underline{S}_3$, $\underline{S}_5$, and $\underline{S}_6$ spoke very loudly; so they would not disturb other $\underline{S}_s$, the $\underline{E}$ asked them to lower their voices. When the entire sample returned for bone-conduction retests one month after the end of training, the parent of $\underline{S}_6$ complained to the $\underline{E}$ that the child "shouts all the time"; parents of $\underline{S}_2$ and $\underline{S}_7$ stated that their children had become verbally "demanding" and "talkative".

Another effect observed by the $\underline{E}$ was that, when the Aurelle group was started on the 3840 cps tape, several children sat up very straight and stiffly. This effect did not persist beyond the third session except intermittently. Remarks made by the parents during the course of training indicated that, for several hours after each session, $\underline{S}_3$ was "hyperactive", $\underline{S}_{10}$ was "excitable", and the parent of $\underline{S}_1$ said her child had become "active" whereas he was normally rather slow moving; the latter parent reported the same continuing effect one month after the end of treatment. None of the above-mentioned effects, nor any others, were observed in the Control subjects or reported by their parents.

Referring to Appendix 6, one notes that some subjects in both the Aurelle and Control groups decreased on retest in reading performance, others maintained their pre-treatment level, and some improved. It is impossible to say to what to attribute the improvements at that time. During the subsequent months and year, phone calls from teachers or parents regarding nine of the eleven Aurelle children indicated that all but one of the nine were again experiencing reading difficulties; the one who was reported to be doing well, $\underline{S}_6$, had been the youngest child in the sample (age 8^0 - 8^2) and, thus, had been at the early stages of learning to read.* No communications were ever received regarding $\underline{S}_{10}$ and $\underline{S}_{11}$. Of the Control group, no subsequent reports were received regarding $\underline{S}_5$ and $\underline{S}_6$ but the others were all reported to be having continuing reading problems.

Reviewing the group results and individual effects reported above, one must reiterate that the claims made for the Aurelle treatment by Tomatis, Le Gall, Beller and others are not supported by the results of this study. Improvement in listening with the right ear, which is the

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* Since this was written, the writer has received a letter reporting that $\underline{S}_6$ has been to the Royal Ottawa Hospital recently because of psychological and educational difficulties.

stated aim of the Aurelle training and the hypothesized basis for predicted concomitant changes in phonation, overall laterality, and reading achievement, did not occur. The Aurelle group showed only a slight, even negligible, increase on the right-ear verbal listening task. The significant change in listening occurred in the Control group. Further studies would be needed to determine whether right-ear performance on a verbal listening task improves on retest without treatment, is suppressed by the Aurelle treatment, or is enhanced by the Control procedure used in this study. Until such studies are done, it is appropriate to point out, regarding the possibility that Aurelle treatment may suppress verbal listening performance, that, if a sense organ is stimulated excessively, the sense organ undergoes a loss of sensitivity or becomes "fatigued"[8]. As a result of fatigue, auditory acuity and even the intelligibility of speech may diminish temporarily. Littler reviews the following studies on auditory fatigue, noting that, according to researchers, the slowness of recovery of auditory fatigue tends to indicate that the locus of fatigue is in the cochlea *i.e.* at the sensory-neural level.

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8 T.S. Littler, *The Physics of the Ear*, Oxford, Pergamon Press, 1965, p. 229-230.

Presenting a fatiguing tone of 800 cps and a sound pressure of 10 dynes per sq. cm. for 2 minutes, Von Békésy[9] demonstrated fatigue over the range 300-2000 cps. He found, too, that auditory fatigue distorts pitch: tones lower than the fatiguing tone were lowered in pitch (*i.e.* flattened) and those above it were raised in pitch (*i.e.* sharpened). Another series of studies, by Ewing and Littler[10], using tones of 256, 512, 1024, 2048, and 4096 cps, demonstrated fatigue beginning with intensities of 70 dB above the average threshold. These experimenters showed that fatigue was a function of frequency, intensity, and duration of the stimulus. They also showed that fatigue was greater for high than for low frequencies and extended to frequencies above that of the fatiguing tone. Most importantly, with regard to the Aurelle treatment, these authors noted that auditory fatigue may occur independently of any subjective experience. Auditory fatigue is not invariably accompanied by subjective phenomena of discomfort

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9 Georg Von Békésy, "Zur Theorie des Hörens" (1929), *Experiments in Hearing*, Tr. and Ed. E.G. Wever, New York, McGraw-Hill, 1960, p. 354-368.

10 A.W.G. Ewing and T.S. Littler, "Auditory Fatigue and Adaptation", *British Journal of Psychology*, Vol. 25, 1935, p. 284-307.

and/or pain. Hood[11] carried out investigations in the frequency range 250 to 8000 cps with fatiguing intensities varying from 50 to 110 dB above threshold and duration times from 1 second to 320 seconds. At intensities above 90 dB, he found that fatigue was severe and recovery time became progressively longer. He found that there was no critical duration of a fatiguing tone; instead, stimulus intensity was the vital factor. Since the critical intensity of 95 dB is so much below the threshold of pain (which, although varying with frequency, is, approximately, 130 dB above the audibility threshold), Hood notes that the pain threshold cannot be taken as a safe guide to the onset of severe pathological changes in the cochlea.

Studies by Davis[12] and his colleagues demonstrated that sufficiently high intensities and exposure times produced increased fatigue effects which could lead to permanent hearing damage. These experimenters exposed subjects' ears repeatedly, at intervals of several days, to pure tones of 500, 1000, 2000, and 4000 cps, and to a

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11 J.D. Hood, "Studies in Auditory Fatigue and Adaptation", Acta Oto-Laryngologica (London), Supplementum 92, 1950, 57p.

12 Hallowell Davis et al., "Temporary Deafness Following Exposure to Loud Tones and Noise", Acta Oto-Laryngologica (Stockholm), Supplementum 88, 1950, 56 p.

noise resembling airplane noise. Intensities were 110, 120, and 130 dB SPL, administered for periods of from 1 to 64 minutes' duration. Temporary impairment of hearing was produced regularly; a few hearing-losses, of more than 30 dB from the original threshold for the given subject, persisted a month and even a year after exposure. These investigators found that the greatest loss of sensitivity occurred regularly at a frequency range about half an octave above the fatiguing tone; often, the threshold was elevated throughout a range of one to two octaves above the exposure tone. These investigators cautioned that, although loud sounds in the middle and high frequencies are quite tolerable, they may cause severe hearing-loss, particularly when continued long. Thus, despite the criterion cited by Tomatis[13] and repeated by the technical officer of the Child Study Centre (see Appendix 15), namely, that the Aurelle apparatus should be operated at the intensity level which seems comfortable to the subject, it is apparent that the mechanism capable of producing awareness in the listener of affective changes as the result of intense sound is not an adequate form of protection

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13 Tomatis, L'Oreille électronique, p. 30.

against excessive and, possibly, harmful stimulation of the ears.*

With relation to the results in this study on the verbal listening task, it seems reasonable to conclude from the aforementioned experimental findings on auditory fatigue that the Aurelle technique and procedure of presenting high frequency and high intensity sound to the one (right) ear produce this very effect of auditory fatigue. Furthermore, considering the risk of displacement of pitch and permanent hearing damage, one wonders for what purpose someone trained in medicine and specializing in oto-rhinolaryngology would apply such experimental procedures to the normally-hearing individual and by what irony he calls the effect "the beautiful ear"[14].

Regarding the results in this study on phonation, Huizing[15] cites the phenomenon called the Lombard effect (discovered in 1911 by a French otologist). This cybernetic reflex occurs in a normally-hearing individual who at

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14 Tomatis, <u>On the Subject of Audiometrics</u>, p. 5.

15 H.C. Huizing, "The Significance of Cybernetic Phenomena in Audiology", <u>Progress in Biocybernetics</u>, Vol. 1, 1964, p. 56.

* Note that post-training audiometric tests, administered by standard methods, revealed no significant change in hearing thresholds in subjects employed in this study.

once raises his voice when the intensity of ambient noise reaches a level so high that self-control of speech threatens to be disturbed. Huizing[16] also notes that when a person tries out an apparatus (e.g., a hearing aid) which according to its amplifying property strongly emphasizes the higher frequencies, a considerable change occurs when the person begins to speak. His own voice may sound unnaturally and uncommonly sharp. Recalling that the sonograms of Aurelle subjects displayed an increase in high frequencies after treatment, it seems reasonable to suppose that a major component of the Aurelle apparatus and procedure was designed according to the above principles to elicit the phenomena described by Huizing. Tomatis has admitted to his interest in exploiting audio-phonatory feedback mechanisms. He expressed this as follows: "nous nous sommes longtemps attardés à l'exploitation des contre-réactions audio-phonatoires qui nous permettent de suivre, sans que le sujet en soit conscient, sa manière d'entendre"[17]. The latter quotation states (the translation is

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16 Huizing, Op. Cit., p. 61.

17 Alfred Tomatis, La Surdité, Paris, Centre du Langage, 1965, p. 16.

ours): we have tarried a long while in taking advantage of audio-phonatory counter-reactions which permit us to follow, without the subject being aware of it, his mode of hearing.

However, Shearer[18] notes that, in applying the cybernetic concept to voice therapy, care must be taken not to allow the patient to overexert the laryngeal muscles. By tightening and stretching the vocal muscles, increased tension may be applied to the vocal cords causing a higher vocal fluctuation. The therapist and patient should seek to determine and to modify the voice gradually in the direction of the optimal pitch level. Trying to extend the voice range upwards, beyond its natural limits, may put a great strain on the vocal cords and vocal organs, according to Brodnitz[19]. After a period of such hyperfunction, the muscles involved begin to weaken and hypofunction may set in.

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18 William M. Shearer, "Cybernetics in the Treatment of Voice Disorders", Journal of Speech and Hearing Disorders, Vol. 24, 1959, p. 280-282; William M. Shearer, Illustrated Speech Anatomy, 2d Ed., Springfield, Illinois, Charles C. Thomas, 1968, p. 45-46.

19 Friedrich S. Brodnitz, "Voice Problems of the Actor and Singer", Journal of Speech and Hearing Disorders, Vol. 19, 1954, p. 322-326.

As to laterality, Penfield and Roberts[20] found that, in more than seventy per cent of their patients, the left hemisphere subserved speech; in the rest, speech was mediated by the right hemisphere or bilaterally. Yet Tomatis insists (mistakenly calling it "the efferent cortex", "le cortex émetteur"[21]) that the left hemisphere must be the one specialized for speech.

> Even in such cases where the right ear is not functioning, the individual can organize his posture and transpose the hearing inputs for analysis to the left hemisphere and, although without the right ear, be left-dominant hemispherically for language. There cannot be language in the right hemisphere.[22]

Kimura[23] has shown that, when speech is represented in the left hemisphere, the right ear is more efficient, and, in cases where speech is represented in the right hemisphere, the left ear is more efficient. Yet Tomatis[24] insists that

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20 Wilder Penfield and Lamar Roberts, Speech and Brain-Mechanisms, Princeton, University Press, 1959, 286 p.

21 Tomatis, Dyslexia, p. 63; Alfred Tomatis, La Dyslexie, Paris, Centre du Langage, 1967, p. 48.

22 Alfred Tomatis, "Body Image", Language, 1970, Mimeographed, p. 23.

23 Doreen Kimura, "Cerebral Dominance and the Perception of Verbal Stimuli", Canadian Journal of Psychology, Vol. 15, 1961, p. 166-171.

24 Tomatis, Dyslexia, p. 63; Tomatis, La Dyslexie, p. 48.

the right ear must be the dominant ear. In the same study, Kimura tried but could find no relation between handedness and the relative efficiency of the two ears. Milner[25], Kimura, Bryden, and others have shown that the two cerebral hemispheres are functionally specialized for different tasks. In the auditory modality, the left and right hemispheres in man usually subserve, respectively, verbal and non-verbal (e.g. musical) aspects of input. And Spellacy and Blumstein[26] have shown that subjects identifying vowels presented in a non-verbal context report better from the left ear than from the right ear; that is, when non-verbal properties (e.g. pitch) of verbal input are attended to, the input is mediated in the right hemisphere. Yet Tomatis[27] states that right-ear dominance is important not only for speech but also for music. And he declares that the

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25 Brenda Milner, "Laterality Effects in Audition", in Vernon B. Mountcastle, Ed., Interhemispheric Relations and Cerebral Dominance, Baltimore, Johns Hopkins Press, 1962, p. 177-195; Kimura, Op. Cit., p. 166-171; D. Kimura, "Left-Right Differences in the Perception of Melodies", Quarterly Journal of Experimental Psychology, Vol. 14, 1964, p. 355-358; M.P. Bryden, "Ear Preference in Auditory Perception", Journal of Experimental Psychology, Vol. 65, 1963, p. 103-105.

26 F. Spellacy and S. Blumstein, "The Influence of Language Set on Ear Preference in Phoneme Recognition", Cortex, Vol. 6, 1970, p. 430-439.

27 Tomatis, Dyslexia, p. 77; Tomatis, La Dyslexie, p. 59.

voice is more "sonorous" ("timbrée") when the right ear is dominant, whereas the dyslexic has a voice that is "dull" ("sourde", "terne") and without "affective tone" ("sans existence affective propre")[28]. In the light of the findings of Kimura, Bryden, Spellacy and Blumstein, and others, the Tomatis procedure of presenting music to the right ear for purposes of auditory lateralization seems eminently illogical.

As to the intensity levels used in the Aurelle technique, Tomatis[29] presents auditory stimulation at a base level of 60-80 dB and he admits to using 100 dB on stutterers; yet intense, prolonged aural stimulation can cause auditory fatigue, temporary threshold shift, and, eventually, permanent threshold shift (i.e. hearing loss)[30]. Tomatis asserts that "dyslexia is a deficiency in posture"; "[La dyslexie] est une mauvaise posture"[31]. Tomatis[32]

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28 Tomatis, Dyslexia, p. 71-72; Tomatis, La Dyslexie, p. 55.

29 Tomatis, L'Oreille électronique, p. 23; Tomatis, L'Oreille et le langage, p. 145.

30 T.S. Littler, The Physics of the Ear, Oxford, Pergamon Press, 1965, p. 229-235.

31 Tomatis, Dyslexia, p. 96; Tomatis, La Dyslexie, p. 72.

32 Tomatis, Dyslexia, p. 92-93; Tomatis, La Dyslexie, p. 69-70.

states that, especially at the beginning of Aurelle treatment, the child may show excessive aggressiveness and unusual outbursts; later, he says, the child becomes talkative. Le Gall[33] refers to the general excitation and tendency to be active which results from the Aurelle. We must point out that, in this study, the stiff upright posture noticed by the experimenter and the increased activity and excitation reported by some parents of children on Aurelle are probably aspects of temporary changes in the Autonomic Nervous System produced by noise greater than 75 dB[34]. Investigators have linked these nonaural, physiologic effects of intense sound to startle, fear, and particularly to stress. Moreover, Glorig[35] notes that the frequencies that are most hazardous to hearing are those above 300 to 400 Hz; Wilmot[36] reports the common finding that, in noise-

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33 André Le Gall, The Adjustment of Certain Psychological and Psycho-Pedagogical Deficiencies with the Tomatis Effect Apparatus, 1961, Mimeographed, p. 26, p. 29.

34 Aram Glorig, "Noise-Exposure - Facts and Myths", Transactions of the American Academy of Ophthalmology and Otolaryngology, Vol. 75, 1971, p. 1254-1262.

35 Glorig, ibid., p. 1259.

36 T.J. Wilmot, "The Meaning of Modern Audiological Tests in Relation to Noise-Induced Deafness: A Review", British Journal of Industrial Medicine, Vol. 29, 1972, p. 125-133.

induced deafness, the greatest loss is usually around 4 kHz although he reports some investigations which have found that 6 kHz is most sensitive to damage. But Wilmot[37] comments that hearing losses confined to 4 kHz or above have little effect upon the hearing of speech and that the important speech frequencies are 1k, 2k, and 3 kHz. He notes, furthermore, that speech audiometry uses an intensity of, approximately, 30 dB above the average audibility threshold. If his aim is to improve speech and the perception of speech sounds, as he claims, one wonders why Tomatis administers high-frequency sounds to the so-called dyslexic and imposes on the so-called dyslexic "auricular gymnastics"[38] at intensities which must be high enough to activate the stapedial muscle _i.e._, at a threshold of 65-90 dB SPL[39]. One should recall that Tomatis[40] has stated that the Aurelle plays on the stapedial muscle which, he says, not only regulates hearing but also the balance which mediates the individual's posture.

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37 Wilmot, _ibid_., p. 127, p. 131.

38 J.-E. Fournier, "A propos des théories du Docteur Tomatis", _Les Annales d'Oto-Laryngologie_, Vol. 79, 1962, p. 820.

39 Gordon Flottorp _et al_., "The Acoustic Stapedius Reflex in Relation to Critical Bandwidth", _Journal of the Acoustical Society of America_, Vol. 49, 1971, p. 457-461.

40 Tomatis, _L'Oreille électronique_, p. 39.

Tomatis[41] states that the two cerebral hemispheres are exactly symmetrical. Yet Geschwind and Levitsky[42] report that, even in stillborn neonates, there are anatomical differences in the auditory cortex of the two hemispheres. These researchers have found that the left hemisphere auditory cortex is much larger than the right hemisphere area in 65 per cent of adult brains and the same region on the right is larger in 11 per cent. In the left hemisphere, this region is part of Wernicke's area, of major importance for speech.

Tomatis states:

> The Vagus nerve is the nerve which penetrates all the vital organs, the digestive, the respiratory and the profound viscerality, and, relates all its messages to the cortex.[43]
>
> It is the neuronal information ascending from the viscera via interoceptors that is asymmetrical and leaves the imprint of this asymmetry in the cortex.[44]

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41 Tomatis, L'Oreille et le langage, p. 153; Tomatis, "Body Image", Language, p. 20.

42 Norman Geschwind and Walter Levitsky, "Human Brain: Left-Right Asymmetries in Temporal Speech Region", Science, Vol. 161, 1968, p. 186-187; Norman Geschwind, "The Organization of Language and the Brain", Science, Vol. 170, 1970, p. 940-944.

43 Tomatis, "The Human Being", Language, p. 25.

44 Tomatis, "Body Image", Language, p. 20.

The vagus is "the guardian of whatever penetrates the ear" since it innervates both the tympanum and the stapes. If incoming sound recalls undesirable memories, neither the tympanum nor the stapes will obey the input[45]. Yet Leichnetz[46], having implanted electrodes on the vagus nerve, on eight cortical and subcortical sites, and having attached an electromyograph (EMG) lead to the neck in five cats, observed in these unanesthetized and unrestrained animals that in nearly every case the cortical and subcortical EEG activity preceded the vagus in alterations of activity associated with various stages of waking and sleeping. Furthermore, the alterations in tonic vagal activity often resembled muscle activity recorded on the EMG but the two activities were independent: for example, the EMG increased abruptly in amplitude and frequency with body movement while the reappearance of tonic vagal activity was delayed until 10-12 seconds later in the record.

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45 Tomatis, "Neurology", Language, p. 13; Tomatis, "Cybernetics", Language, p. 31.

46 George R. Leichnetz, "Relationship of Spontaneous Vagal Activity to Wakefulness and Sleep in the Cat", Experimental Neurology, Vol. 35, 1972, p. 194-210.

Finally, one could say that the many theories of Tomatis have a kind of pre-scientific, cosmogonic logic. Furthermore, the role assigned to the vagus nerve gives prime importance to a circuit that, in fact, must be slow and inefficient. And what an odd neglect of the acoustic nerve, the primary sensory nerve for hearing and equilibrium.

Fournier, a French specialist in audiology and phonology whose work is internationally respected, reviewed some of the so-called experiments reported by Tomatis plus a number of his diverse theories and claims for the capacities of the Aurelle. Fournier began his review with the words (the translation is ours):-

> The interest shown for several years by the press in the theories of Doctor Tomatis seems to have acutely surprised the majority of French specialists of audiology and phonology. Since many among them seem not to have been able to study those theories with the care they would have liked for want of easy access to the sources, we thought they might be interested in the succinct exposé which follows and in the critique of the diverse postulates of that author in the light of known facts and of some controlled experiments which we have been led to undertake.[47]

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47 Fournier, Op. Cit., p. 801.

At the end of the article, after summarizing ten conclusions, Fournier finished with the words (the translation is ours):

> Among the postulates of Doctor Tomatis which we have reviewed, there are some which do not take account of the actual state of our knowledge in the field of the psycho-physiology of hearing, others which are disproved by experiment, and still others which spring from evident methodological errors; not one seems able to stand up to examination.[48]

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48 Fournier, Op. Cit., p. 820.

SUMMARY AND CONCLUSIONS

In a comparison of the Aurelle therapy with a language laboratory treatment of children with reading difficulties, no significant difference was found in right-side preference (*i.e.* laterality) and in reading achievement between the two groups.

A significantly greater increment occurred in right-ear verbal listening in the language laboratory group as compared to the Aurelle group. This was contrary to the experimental hypothesis which was based on Tomatis' theory. It was suggested that this increase was a function either of language laboratory enhancement or Aurelle treatment suppression of performance on this task.

The null hypothesis of no significant difference between the two methods in their effects on phonation was rejected. The Aurelle group produced more high frequencies in the vocal output as compared to the language laboratory group. It was suggested that this change was due to a feedback mechanism in response to the high intensity and high frequency auditory stimulation which characterizes the Aurelle treatment.

The problems that emerge from this study are, firstly, whether the Aurelle method is valid, *i.e.*, does it do what it is supposed to do. Listening, laterality, and reading performance were not significantly, much less permanently, improved by the Aurelle therapy. And one must question the need for, and the possible benefit of, a change in the speech spectrum in relation to reading attainment.

Secondly, the effects of high frequency/high intensity sounds, in both this study and in reports by Tomatis and his colleagues, were considered in relation to studies which document somatic and auditory impairment.

Thirdly, serious inexcusable scientific errors in the theories outlined of Alfred Tomatis were discussed.

The writer suggests that, prior to further clinical use, the exact specifications of the Aurelle apparatus regarding intensity and frequency levels should be strictly ascertained. In addition, a careful experimentally-controlled research program should be undertaken into the effects of the Aurelle.

The present study could be replicated with the following modifications:-

1) A more comprehensive reading test could be included in the test battery along with the WRAT.

2) Voices should be recorded in a soundproof room using instructions on tape. The latter could include phrases to be repeated by the subject and recorded; the voice of the subject should also be recorded reading a short passage.

3) Hearing should be tested both by standard and by Tomatis' methods.

4) Material presented during training sessions should be changed weekly to maintain interest. In the writer's opinion, filtering levels should be considerably below the maximum used in this study.

5) To isolate relevant factors, one group could be administered only music, another words, and a third both music and words. Separate groups should be trained on left-ear input and right-ear input. A control group, administered tests and retests after the established interval but no intervening training, should be included in the study.

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APPENDIX 1

CRANIAL NERVES

Nerves	Components	Function	Central Connection	Cell Bodies	Peripheral Distribution
I. Olfactory	Afferent Special visceral	Smell	Olfactory bulb and tract	Olfactory epithelial cells	Olfactory nerves
II Optic	Afferent Special somatic	Vision	Optic nerve and tract	Ganglion cells of retina	Rods and cones of retina
III Oculomotor	Efferent Somatic	Ocular movement	Nucleus III	Nucleus III	Branches to Levator palpebrae, Rectus superior, medius, inferior, Obliquus inferior
	Efferent General visceral	Contraction of pupil and accommodation	Nucleus of Edinger-Westphal	Nucleus of Edinger-Westphal	Ciliary ganglion, Ciliaris and Sphincter pupillæ
	Afferent Proprioceptive	Muscular sensibility	Nucleus mesencephalicus V	Nucleus mesencephalicus V	Sensory endings in ocular muscles
IV Trochlear	Efferent Somatic	Ocular movement	Nucleus IV	Nucleus IV	Branches to Obliquus superior
	Afferent Proprioceptive	Muscular sensibility	Nucleus mesencephalicus V	Nucleus mesencephalicus V	Sensory endings in Obliquus superior
V Trigeminal	Afferent General somatic	General sensibility	Trigeminal sensory nucleus	Trigeminal ganglion (Gasserian)	Sensory branches of ophthalmic maxillary and mandibular nerves to skin and mucous membranes of face and head
	Efferent Special visceral	Mastication	Motor V nucleus	Motor V nucleus	Branches to Temporalis, Masseter, Pterygoidei, Mylohyoideus, Digastricus, Tensores tympani and palatini
	Afferent Proprioceptive	Muscular sensibility	Nucleus mesencephalicus V	Nucleus mesencephalicus V	Sensory endings in muscles of mastication
VI. Abducent	Efferent Somatic	Ocular movement	Nucleus VI	Nucleus VI	Branches to Rectus lateralis
	Afferent Proprioceptive	Muscular sensibility	Nucleus mesencephalicus V	Nucleus mesencephalicus V	Sensory endings in Rectus lateralis
VII. Facial	Efferent Special visceral	Facial expression	Motor VII nucleus	Motor VII nucleus	Branches to facial muscles, Stapedius, Stylohyoideus, Digastricus
	Efferent General visceral	Glandular secretion	Nucleus salivatorius	Nucleus salivatorius	Greater superficial petrosal nerve, sphenopalatine ganglion, with branches of maxillary V to glands of nasal mucosa Chorda tympani, lingual nerve, submaxillary ganglion, submaxillary and sublingual glands
	Afferent Special visceral	Taste	Nucleus tractus solitarius	Geniculate ganglion	Chorda tympani, lingual nerve, taste buds, anterior tongue

(Continued on Next Page)

CRANIAL NERVES (cont'd)

	Afferent General visceral	Visceral sensibility	Nucleus tractus solitarius	Geniculate ganglion	[illegible]
	Afferent General somatic	Cutaneous sensibility	Nucleus spinal tract of V	Geniculate ganglion	With auricular branch of vagus to external ear and mastoid region
VIII Acoustic	Afferent Special somatic	Hearing	Cochlear nuclei	Spiral ganglion	Organ of Corti in cochlea
	Afferent Proprioceptive	Sense of equilibrium	Vestibular nuclei	Vestibular ganglion	Semicircular canals saccule, and utricle
IX Glossopharyngeal	Afferent Special visceral	Taste	Nucleus tractus solitarius	Inferior ganglion IX	Lingual branches, taste buds, posterior tongue
	Afferent General visceral	Visceral sensibility	Nucleus tractus solitarius	Inferior ganglion IX	Tympanic nerve to middle ear, branches to pharynx and tongue, carotid sinus nerve
	Efferent General visceral	Glandular secretion	Nucleus salivatorius	Nucleus salivatorius	Tympanic, lesser superficial petrosal nerves otic ganglion with auriculo-temporal V to parotid gland
	Efferent Special visceral	Swallowing	Nucleus ambiguus	Nucleus ambiguus	Branch to Stylopharyngeus
X Vagus	Efferent General visceral	Involuntary muscle and gland control	Dorsal motor nucleus X	Dorsal motor nucleus X	Cardiac nerves and plexus ganglia on heart Pulmonary plexus, ganglia respiratory tract Esophageal, gastric celiac plexuses myenteric and sub-mucous plexuses muscle and glands of digestive tract down to transverse colon
	Efferent Special visceral	Swallowing and phonation	Nucleus ambiguus	Nucleus ambiguus	Pharyngeal branches superior and inferior laryngeal nerves
	Afferent General visceral	Visceral sensibility	Nucleus tractus solitarius	Ganglion nodosum	Fibers in all cervical, thoracic, and ab-dominal branches carotid and aortic bodies
	Afferent Special visceral	Taste	Nucleus tractus solitarius	Ganglion nodosum	Branches to region of epiglottis and taste buds
	Afferent General somatic	Cutaneous sensibility	Nucleus spinal tract V	Jugular ganglion	Auricular branch to external ear and meatus
XI Accessory	Efferent Special visceral	Swallowing and phonation	Nucleus ambiguus	Nucleus ambiguus	Bulbar portion communication with vagus, in vagus branches to muscles of pharynx and larynx
	Efferent Special somatic	Movements of shoulder and head	Lateral column of upper cervical spinal cord	Lateral column of upper cervical spinal cord	Spinal portion branches to Sterno cleidomastoideus and Trapezius
XII Hypoglossal	Efferent General somatic	Movements of tongue	Nucleus XII	Nucleus XII	Branches to extrinsic and intr[illegible] muscles of tongue

From Sebastian Peter Grossman, A Textbook of Physiological Psychology, New York, Wiley, 1967, p. 152-153.

APPENDIX 2

SUMMER CLINIC FOR POOR READERS

REQUIRED:

- 40 children
- Age 8 or 9
- Average or above-average intelligence, but lagging behind their school-mates in reading and spelling.
- No obvious sensory or brain damage; not hyperactive; corrective glasses acceptable.

PROGRAM:

- Candidates must be available for 2 or 3 screening sessions (e.g., hearing test) to be held in May and June.
- Those chosen will receive training with the "Electronic Ear". Participants must be available during July and August, for ½ hour sessions, 5 days weekly, for 8 weeks.
- Absences due to illness or vacation will have to be made up.

COST:

- None

PLACE:

- University of Ottawa
  Child Study Centre
  265 Nicholas Street
  Tel: 231-2361

(Mrs.) Leah Schnitzer, M.A.

(April 15, 1971)

APPENDIX 3

WORD LIST

hello
so
no

bat
sat

chat
that

fin
sin
skin
thin
spin

bee
fee
three

coy
joy
toy
annoy

bed
fed
shed
sled

band
hand
sand
stand

dig
jig
pig

chill
Jill
till

cook
shook
took

bake
cake
take

dim
rim
slim
trim

bay
day

may
ray

cow
now
chow
sow

hut
jut
rut

five
live
jive
dive

den
Ken
pen
when

hook
look
nook
took
shook

meat
seat
cheat
treat

right
sight
tight

better
wetter
setter

just
dust
rust
crust
trust

car
tar
scar
star

dope
hope
slope

less
mess

chess
tress

jeep
sheep
sleep
peep
steep

lord
ford

afford
border
storm

evil
event
evening

fetch
catch
scratch

itch
witch
twitch

swan
swatch

bell
tell
shell
well

beach
teach

bent
lent
rent
tent

cake
sake
take

mock
sock
clock
flock

sip
tip
zip

grip
ship
skip
trip

talk
walk
chalk

king
ring
sing

linger
singer

crop
chop
stop

head
bread
spread

feather
leather

heavy
steady

after
catcher

shorter
tighter
teacher
teacup

could
would

clay
play
stay
away
stray

belt
melt
shelter

stiff
jiffy
different

game
tame
shame

duck
puck
tuck
truck

near
appear

appetite
kite

hot
tot
jot
blot
spot
slot

cage
stage

deluge
human

keen
queen
queer
cheer
steer

squad
squall

quantity
ability

tiny
only

hour
flour
flounder
astound

cry
dry
spy
try

apply
terrify
horrify

silk
hulk
sulk
bulge

shown
blown

exhibit
exhibition

exclaim
expand
expire
extra

prize
realize

hedge
ledge

fudge
budgie

charm
alarm
harm

spun
stun
thunder

out
about
spout
trout
shout
ouch

came
name

nation
station
motion
potion

posture
gesture
feature
creature

insult
consult

zap
chap
clap
trap
relapse

repeat
retake
recess
retell
reteach

chief
thief

purge
surge
splurge

chick
sick
trick

sample
trample
example

cool
pool
school
stool

chew
stew

button
mutton

use
fuse

jump
hump
stump

zoo
moo
too

crash
flash
trash
thrash
smash
splash

chain
again
strain
sprain

away
today
someday

tomorrow
borrow

blow
crow
grow
show
snow

bridge
fidget
midget

pep
step

core
more
store

back
lack
sack
tack

cracker
tracker

josh
slosh

hunt
punt
runt
stunt

cone
bone

zone
stone

dish
fish

cinder
circle
circus

ice
icicle

nice
slice
spice
twice

corn
horn
torn
thorn

jest
best
rest
chest

pencil
stencil

fence
pence

silence
existence
confidence

soak
croak
toad

chirp
squirm
third

whistle
thistle

cuff
stuff
bluff

ink
wink
blink
think

tinkle
sprinkle
wrinkle

jingle
jangle
dangle

care
mare
scare
stare
flare

pocket
rocket
socket

picket
ticket
cricket
thicket

tape
scrape

season
spring
summer

autumn
winter

aeroplane
insane
Jane
lane

poke
broke
choke
smoke

carnival
cannibal

cube
tube

date
late
rate
skate

loft
croft
soft

self
shelf

sister
mister

skeleton
Halloween
spooky

attic
magic

cupcake
snowflake

butterfly
scarecrow
careful
pocket book

scissors
science

beside
inside
outside

pile
tile

crocodile

jail
pail
tail
snail

number
one
once
two
twice
three
thrice
four
fourth
five
fifth
six
sixth
seven
seventh
eight
eighth
nine
ninth
ten
tenth
eleven

eleventh
twelve
twelfth

thirteen
fourteen
fifteen
sixteen
seventeen
eighteen
nineteen
twenty

plenty

thirty
dirty

forty
fifty

nifty

sixty
seventy
eighty

weighty
ninety
hundred

month
year

January
February
March
April
May
June
July
August
September
October
November
December

remember

Christmas
holiday
feast
Easter

showers
flowers

lily
peony
tulip
cowslip

garden
harden

wall
tall
small

grass
class

chance
dance

chimney
donkey
monkey

honey
money

WORD LIST

Sunday
Monday
Tuesday
Wednesday
Thursday
Friday
Saturday

change
strange

kettle
settle

old
cold
scold

bush
push

cushion

moon
spoon

wave
shave

riddle
fiddle

seeds
weeds

house
mouse

floor
door

calf
half

dog
frog

lizard
wizard

shore
more

five minutes

five minutes more

please

let me stay

five minutes more

can't I just

stay five minutes?

well, can't I stay

just four?

three minutes?

two minutes?

can't I stay

<u>one</u> minute more?

good-bye

APPENDIX 4

AUDIOMETRIC TESTS

a) Air Conduction Test, Standard Method of Administration

This is a test of the audibility threshold for the external ear canal, middle ear, and inner ear[1]. Although the terms 'audibility threshold' and 'absolute threshold' are used interchangeably, this test is not a measure of the absolute sensory capacity of the auditory channel[2]. It is administered in order to determine the S's ability to perceive weak sounds at different frequencies under specified test conditions in a given test session[3]. Within the context of a specific experiment or a given test session, the audibility threshold is generally given an

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1 Price, "Pure-Tone Audiometry", in Rose, Ed., Audiological Assessment, p. 167-205.

2 James P. Egan and Frank R. Clarke, "Psychophysics and Signal Detection", Chapter 5 in Sidowski, Ed., Experimental Methods and Instrumentation in Psychology, p. 211-246; Harold W. Hake and Albert S. Rodwan, "Perception and Recognition", Chapter 8 in Sidowski, Ed., ibid., p. 331-381; J.A. Swets, "Is There a Sensory Threshold?", Science, Vol. 134, 1961, p. 168-177.

3 Ira J. Hirsh, "Audition", Chapter 6 in Sidowski, Ed., Op. Cit., p. 247-271.

operational definition, namely, the intensity of the stimulus to which the S responds with "Yes, I detect it" on 50 per cent of the stimulus presentations.

The audiometer generates eight or more fixed frequencies, i.e., tones. The intensity of a tone is measured in decibels (dB) relative to audiometer zero, as established either by the American Standards Association (A.S.A.) 1951 or the International Organization for Standardization (I.S.O.) 1964 standards, the zero point being the average threshold of hearing of the normal young adult ear. The intensity in decibels that the energy at a given frequency must be increased above zero is stated as the hearing level or the hearing loss for that frequency.

To avoid a sound field and minimize the influence of the acoustic environment, pure tones are produced through earphones which fit snugly over the ears. The tone pulses set up pressure changes in the air of the external ear canal by electronically producing a vibration of the diaphragm of the earphone. The S is instructed to make a response, usually by pushing a button, whenever he hears a tone. To make sure the S understands what he is to do, the S is asked to repeat the instructions. The E, after placing the earphones over the S's ears (being careful to place the right phone over the right ear and vice versa), demonstrates the kinds of sound that will be used.

Instructions Used In This Study

"You'll be hearing some sounds now. Every time you hear a sound, I want you to press the button. Sometimes the sound will be soft or little. Even if you think you hear the sounds, I want you to press the button".

Procedure Used In This Study

The procedure used was the method of limits. It consists in the presentation of a tone at a particular frequency and at a moderate intensity level which should, normally, be clearly audible. If the S responds, the level is decreased in steps until the tone no longer elicits a response. At this point, the intensity variation changes direction: the E increases the intensity level of the tone until the listener again responds. The former point is the descending threshold, while the latter is called the ascending threshold. In both the ascending and descending method of limits, the process is repeated several times. The E records the level of the tone at which these response changes occur. A series of threshold crossings, involving 2 or 3 descents and ascents, are sufficient to define a threshold. The entire set of measurements for a single frequency is completed before a new frequency is used. In this study, the frequency presentation was

$$1\ k \longrightarrow 8\ k$$
$$1\ k \longrightarrow 125\ cps$$

Intensity was begun at 30 dB → 15 dB → 0 → -5. If the S missed one, the E increased the intensity by 5 dB, increased another 5 dB if the latter was missed, and then decreased again in 15 dB steps.

b) Bone Conduction Test, Standard Method of Administration

This is a test of the audibility threshold for the cochlea, in the inner ear[4]. The threshold is defined as the intensity of the stimulus to which the S responds with "Yes, I detect it", on 50 per cent of the stimulus presentations. If the bone-conduction threshold is lower (better) than the air-conduction threshold, the audiologist knows that the hearing dysfunction probably occurs elsewhere than in the cochlea, either in the external or middle ear.

A bone-conduction receiver is placed either on the forehead or, as in this study, on the mastoid process of the temporal bone. The receiver can be vibrated electronically and, in turn, vibrates the skull. Earphones are used in bone-conduction testing only in order to deliver a masking

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4 Price, Op. Cit., p. 176-178, p. 188, p. 202-204.

noise to the untested ear: masking is critical in order to test each ear without the participation of the other ear. Only then can the audiologist say anything about the hearing of each ear individually, and, with some certainty, that, when results are recorded from a particular ear, he has actually tested that ear.

Instructions Used In This Study

"You'll be hearing some sounds now. Every time you hear a sound, I want you to press the button. Sometimes the sound will be soft or little. Even if you _think_ you hear the sounds, I want you to press the button. There will be some noise in the other ear or in the ear not under test. (Point to the ear referred to). Don't listen to the noise. Press the button every time you hear a sound in _this_ ear". (Point to the ear under test).

The procedure thereafter is the same as for air conduction.

c) Selectivity Test (Tomatis' Test)

Instructions Used In This Study

"You're going to hear two beeps or sounds. One will be higher or squeakier than the other. I want you to tell me which it is". An example is given. Then the tone pairs are presented. The Ss — only two in this study, one girl in the Aurelle group and one girl in the Control group and both only in the pre-training test — who do not understand "higher" or "squeakier" are told to "sing what you hear".*

Procedure Used In This Study

Nine pairs of tones were presented, in descending frequencies, i.e., 8k - 6k, 6-4, 4-3, 3-2, 2-1.5, 1.5-1k, 1k-500 cps, 500-250, 250-125 cps. This is the invariable order of presentation, the higher frequency always being presented first. All tones are presented at 40 dB relative to audiometric zero. The second stimulus in the pair is presented immediately after the first, i.e., beep beep; the S responds, then the next pair of tones is presented. The interpair interval is brief, just long enough for a response.

Comment on the Selectivity Test

1) As a rule the psychophysicist does not feel obliged to undertake the rank ordering of stimuli that have convenient physical dimensions when one of these dimensions is clearly a monotonic function of the

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* This is a modification introduced by P. Kramer.

> attribute under investigation. He skips the issue because the rank order is obvious [...] He does not bother to rank-order a series [... where] the order is readily apparent.[5]

2) Persons with normal hearing have much finer acuity than this test suggests. For example[6], at sensation levels above 30 dB and at frequencies below 1k, a change of about 3 cps can be detected and, at high frequencies, the differential frequency threshold increases so that, at 8k, a change of about 20 cps can be detected. The comparisons in this test are very extreme. If a child responds incorrectly, this may indicate a problem of labeling, of naming, i.e., the error may be due to confusion or lack of comprehension of the concept "higher" or "squeakier", especially since the "lower" becomes the "higher" in the next pair.

3) Frequency comparisons are usually given against a standard frequency (the method of constant stimulus differences)[7]. The variable frequencies are scheduled according to a random series, not in descending order; usually the

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5 S.S. Stevens, in S.S. Stevens, Ed., Handbook of Experimental Psychology, p. 38.

6 Licklider, in S.S. Stevens, Ed., Op. Cit., p. 1000.

7 Hirsh, Op. Cit., p. 261-263; Price, Op. Cit., p. 196-199. Note that, with regard to the perception of speech and the psychological dimension of pitch, Hirsh suggests using complex tones instead of pure tones to measure the frequency difference limen.

first or second sound is "higher", according to a random schedule.

4) In this test, the S may adopt a response bias that has no relation to auditory perception. The S may adopt a positional set, a pattern of response (especially after two or three pairs), a strategy for solving the task. The S may expect alternation and, thus, make an error when two frequencies are more alike than other pairs[8].

5) All frequencies are presented at 40 dB re audiometric zero, regardless of the S's audibility thresholds.* Since intensity interacts with frequency to influence perceived pitch[9], it would be more accurate to present each frequency at 40 dB SL (sensation level), i.e., at 40 dB above the given S's audibility threshold for each frequency.

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8 Hake and Rodwan, Op. Cit., p. 331-347.

9 Peter B. Denes and Elliot N. Pinson, The Speech Chain, The Physics and Biology of Spoken Language, New York, Bell Telephone Laboratories, 1963, p. 84.

* Tomatis, La Surdité, p. 14, states that the auditory selectivity test is given at "a threshold" of 30 to 40 dB. This is an imprecise, meaningless statement.

d) Air and Bone Conduction Tests, Tomatis' Method

To begin with, it should be noted that in the method of limits it is usual to find that a S can follow a descending tone to a point well below the first level to which he will respond again on an ascending series[10]. That is, an ascending series gives a higher (worse) threshold.

Air Conduction Test

In Tomatis' method, this test consists in presenting a continuous tone which starts at the inaudible level and follows an ascending order, increasing the dB level, e.g., -5dB → 0 → +5. The test for each tone ends the first time the S responds to indicate "Yes, I detect it". There is no check, no repeat presentation, no series of threshold crossings.

Comment on Tomatis' Air Conduction Test

Though audiologists agree that the threshold may be established by using only the ascending order, all seem to insist that more than one presentation is necessary[11].

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10 Hirsh, Op. Cit., p. 260.

11 Eldon L. Eagles et al., Hearing Sensitivity and Related Factors in Children, Pittsburgh, University of Pittsburgh, 1963, xv-220 p.; Price, Op. Cit., p. 173.

Bone Conduction Test

In Tomatis' method, this test is administered without masking noise to the other ear (the ear not under test) and, therefore, the S can hear the tone in the untested ear as well as in the ear under test. This is a critical error[12]. Again, as in his Air Conduction method, the tone presented is continuous, the order is from the inaudible level gradually increasing in intensity, and there is only one presentation for each frequency.

Comment on Tomatis' Bone Conduction Test

Fournier[13], in discussing the bone-conduction curves obtained by Tomatis, concluded that Tomatis must be using a faulty audiometer because such curves are not obtained customarily!

General Comments on Tomatis' Tests

Although Tomatis' methods of administering pure-tone hearing tests were not used in this study, (largely because his methods were demonstrated to the testers at

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12 Price, Op. Cit., p. 178; Wilmot, Op. Cit., p. 125, p. 127.

13 Fournier, Op. Cit., p. 810.

the Child Study Centre only at the end of August, 1971, and until then one assumed that his audiometric tests were standard, appropriate tests of hearing sensitivity), it is important to note that many modified psychophysical methods, developed with the aim of more truly measuring "perception", have proven to be a methodological trap[14]. They measure other variables, e.g., motivation, attitudes, values, patterning tendencies, etc.*

Moreover, it must be mentioned that the hearing curves Tomatis obtains may be, in part, an example of a transfer-of-training and, in part, an artifact of his test method. One would predict that, prior to Aurelle training, Tomatis' audiometry would result in elevated (worse) thresholds as compared to standard audiometry. However, having been trained over many sessions with high frequency sound, the Aurelle trainee as opposed to the 'naive' S may be able more easily to detect high frequency tones if these are presented by an ascending, continuous method; this would produce the lower threshold which Tomatis favors for high frequencies. Vice versa, since the Aurelle training

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14 Hake and Rodwan, Op. Cit., p. 333.

* Indeed, Tomatis has stated that his aim is to measure "attitude". See below.

excludes the lower frequencies, this lack of training would make it more difficult for the Aurelle trainee to detect low frequencies when tested from the inaudible level; this would produce, on Tomatis' audiometry, the desired elevated threshold for low frequencies. This may explain why Tomatis' ratings of the audiograms in this study were statistically non-significant: by beginning with a descent from the clearly audible level and by presenting more than one trial, our method did not give the Aurelle-trained Ss the advantage of familiarity provided by Tomatis' audiometric method. This hypothesis is in accord with the finding of Davis[15] and his colleagues who reported that it is possible to have, with increasing frequency, an increasing sensitivity to faint tones but a decreasing sensitivity to loud tones.

One should recall that Tomatis states that he gives "a thorough examination of audition", ("examen très approfondi de l'audition"[16]). Indeed, Tomatis administers pure tones in his tests; and these stimuli, generally, are used in tests to indicate normal hearing ability or loss of

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15 Davis *et al.*, "Temporary Deafness", *Op. Cit.*, p. 41.

16 Tomatis, *Dyslexia*, p. 77; *La Dyslexie*, p. 58.

hearing, and to suggest the site of the lesion[17]. However, as already described, the Tomatis audiometry is unorthodox in procedure; and, despite the assertion that he gives a thorough hearing test, Tomatis states elsewhere:

> Rather than use audiometrics as an expression of acoustic phenomena, we should use it as an expression of the individual's attitude towards a stimulus of an undetermined sound quality. We should search for the indices of behavior of the individual rather than for a physical measure. An individual who refuses to pay attention to the sound stimulus of minimal intensity, obviously will have the same behavior, only magnified, towards stimuli of a complex nature, such as language.* Seen in these terms, the audiogram is one of the criteria which indicates how this particular individual behaves in his universe of sounds.
>
> We should not really do what most examiners do in audiometrics, that is, seek to obtain the "real" curve. They recurr [sic] to all sorts of gimmicks, such as masking, to obtain the desired response. This is actually of little interest to us. What we are really interested in is the real behavior of the subject [...] we are not interested in acoustics as such, but in the human behavior related to sound.[18] **

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17 Price, Op. Cit., p. 167-205.

18 Tomatis, On the Subject of Audiometrics, p. 1-2.

* Hirsh, Op. Cit., p. 263, states that "frequencies to be discriminated in speech are rarely if ever those of pure tones and are mostly not those of continuous tones."

** This quotation refers to another aspect of Tomatis' theory and procedures which is not directly pertinent to this thesis, namely, the use of audiograms for personality assessment.

APPENDIX 5

DICHOTIC DIGITS, LISTENING TEST

The dichotic listening test consisted of digits from 1 to 9 spoken in English. The digit stimuli were constructed so that the S heard one series of 4 numbers at the right ear, and at the same time, a second series of 4 different numbers at the left ear. Thus, a number arrived at one ear simultaneously with a different number arriving at the other ear. The numbers were presented at the rate of two per second, and there was an interval of about 20 seconds between each trial on the tape to allow the Ss to report the material.[1]

Procedure

Each S heard 60 four-pair trials.* The S was instructed to recall as many of the numbers as he could remember, in any order. Subjects responded aloud. Presentation was at 40 dB re audiometer zero (I.S.O. 1964 standards).

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1 D.E. Broadbent, "Successive Responses to Simultaneous Stimuli", Quarterly Journal of Experimental Psychology, Vol. 8, 1956, p. 145-162.

* The voice on tape was that of P. Kramer.

The following scoring procedure was used. The numbers reported were scored correct if they corresponded to those presented, with no correction factor applied for guessing. The maximum score for each ear was 240.

APPENDIX 6

SOME CHARACTERISTICS OF THE TREATMENT GROUPS

Group Aurelle	Age	Sex	WISC IQ	WRAT READING PRETEST (SS)	WRAT READING RETEST (SS)	WISC IQ - WRAT READING PRETEST (SS)
S_1	10^8-10^{11}	M	99	73	75	26 points
S_2	8^6-8^9	M	120	87	94	33
S_3	9^0-9^2	M	103	90	109	13
S_4	8^8-8^{11}	M	112	91	89	21
S_5	8^{10}-9^1	M	93 (1970: IQ 117)	85	84	8
S_6	8^0-8^2	M	105	81	86	24
S_7	8^7-8^{10}	M	100	88	88	12
S_8	9^1-9^5	F	93	83	83	10
S_9	9^7-9^{11}	F	112	84	84	28
S_{10}	9^9-10^0	F	107	100	109	7
S_{11}	9^{11}-10^2	F	107	93	88	14
			(IQ Range) (93-120)			

(Table Continued on Next Page)

SOME CHARACTERISTICS OF THE TREATMENT GROUPS (Cont'd)

Group Control	Age	Sex	WISC IQ	WRAT READING PRETEST (SS)	WRAT READING RETEST (SS)	WISC IQ - WRAT READING PRETEST (SS)
S_1	8^1-8^4	M	105	91	91	14 points
S_2	8^7-8^{10}	M	103	92	93	11
S_3	9^0-9^2	M	88	93	96	(Higher IQ; culture gap)
S_4	8^9-9^0	M	101	86	83	15
S_5	8^{11}-9^2	M	112	88	90	24
S_6	8^2-8^5	M	107	87	87	20
S_7	9^5-	M	105	93	--	12 (Dropped out)
S_8	9^{11}-	F	99	80	--	19 (Dropped Out)
S_9	9^1-9^4	F	91	83	83	8
			(IQ Range) (88-112)			

Ages: 8^0-10^{11}

Grades: 2 - 6

Schools: 10 Ss from non-Catholic, 8 Ss from Separate schools

Residence: 4 inner-city children (2 Aurelle, 2 Control)

14 children from suburban areas (Ottawa South, Ottawa West, Nepean, and Hull)

APPENDIX 7

LATERALITY TEST(T) AND RETEST(R)

+ = RIGHT - = LEFT 0 = MIXED

Aurelle	HAND (4)		EYE (3)		FOOT (2)		EAR (1)		TOTAL (10 TASKS)	
	T	R	T	R	T	R	T	R	TEST	RETEST
S1	+4	+4	+3	+3	+2	+2	+1	+1	+10	+10
S2	+4	+4	-3	-2+1	+2	+2	-1	-1	(-4) +6	(-3) +7
S3	-2+2	-2+2	+3	+3	0+1	0+1	+1	+1	(0-2) +7	(0-2) +7
S4	+4	+4	+3	+3	+2	+2	+1	+1	+10	+10
S5	+4	+4	+3	+3	+2	+2	+1	+1	+10	+10
S6	+4	+4	+3	+3	-1+1	-1+1	-1	+1	(-2) +8	(-1) +9
S7	+4	+4	0+2	-3	+2	+2	-1	-1	(0-1) +8	(-4) +6
S8	+4	+4	-2+1	-2+1	+2	+2	+1	+1	(-2) +8	(-2) +8
S9	-1+3	+4	-3	-3	0+1	+2	+1	+1	(0-4) +5	(-3) +7
S10	+4	+4	+3	+3	-1+1	0+1	-1	-1	(-2) +8	(0-1) +8
S11	+4	+4	-3	-2+1	0+1	0+1	-1	-1	(0-4) +5	(0-3) +6

(Table Continued on Next Page)

LATERALITY TEST(T) AND RETEST(R) (Cont'd)

+ = RIGHT — - = LEFT — 0 = MIXED

Control	HAND (4)		EYE (3)		FOOT (2)		EAR (1)		TOTAL (10 TASKS)	
	T	R	T	R	T	R	T	R	TEST	RETEST
$\underline{S}_1$	+4	+4	-1+2	+3	-1+1	0+1	+1	+1	(-2) +8	(0) +9
$\underline{S}_2$	00+2	+4	+3	+3	00	0+1	+1	+1	(0000) +6	(0) +9
$\underline{S}_3$	-1+3	0+3	+3	+3	00	-2	+1	+1	(00-1) +7	(0-2) +7
$\underline{S}_4$	+4	+4	-3	-3	-1+1	00	+1	+1	(-4) +6	(00-3) +5
$\underline{S}_5$	+4	+4	+3	+3	0+1	-1+1	-1	-1	(0-1) +8	(-2) +8
$\underline{S}_6$	+4	+4	-3	-3	+2	+2	+1	+1	(-3) +7	(-3) +7
$\underline{S}_7$	+4	--	-1+2	--	0+1	--	+1	--	(0-1) +8	----
$\underline{S}_8$	+4	--	+3	--	+2	--	+1	--	+10	----
$\underline{S}_9$	0+3	00+2	+3	+3	0+1	+2	0	+1	(000) +7	(00) +8

APPENDIX 8

HEARING THRESHOLDS ON TEST (T) AND RETEST (R)

The numbers (scores) represent intensity in decibels (dB) re audiometer zero, I.S.O. 1964 standards. The scores range from a minimum intensity of -5 dB to a maximum of +35 dB in five-decibel steps as follows:-

dB : -5 0 +5 10 15 20 25 30 35 n(no response)

Group	125 cps								250 cps							
	RIGHT				LEFT				RIGHT				LEFT			
	BONE		AIR		BONE		AIR		BONE		AIR		BONE		AIR	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
<u>Aurelle</u>																
$\underline{S}_1$	-	-	n	10	-	-	n	5	0	5	0	10	5	5	5	5
$\underline{S}_2$	-	-	5	n	-	-	0	n	0	5	5	10	5	5	5	5
$\underline{S}_3$	-	-	n	n	-	-	n	n	0	0	5	-5	0	-5	0	0
$\underline{S}_4$	-	-	20	n	-	-	10	n	0	0	5	5	15	5	10	5
$\underline{S}_5$	-	-	5	n	-	-	0	n	0	5	0	0	0	0	0	0
$\underline{S}_6$	-	-	n	n	-	-	n	n	5	5	5	5	0	0	5	0
$\underline{S}_7$	-	-	25	n	-	-	10	n	5	0	10	5	5	0	10	0
$\underline{S}_8$	-	-	10	n	-	-	5	n	5	0	5	0	5	0	5	0
$\underline{S}_9$	-	-	15	n	-	-	10	n	0	-5	5	5	0	5	0	5
$\underline{S}_{10}$	-	-	n	5	-	-	n	5	5	5	5	0	-5	0	0	5
$\underline{S}_{11}$	-	-	n	n	-	-	n	n	10	10	5	10	10	5	5	10
<u>Control</u>																
$\underline{S}_1$	-	-	n	n	-	-	n	n	10	5	10	15	0	0	10	10
$\underline{S}_2$	-	-	35	n	-	-	5	n	-5	-5	10	10	-5	-5	5	0
$\underline{S}_3$	-	-	n	10	-	-	n	10	10	-5	5	5	0	5	5	5
$\underline{S}_4$	-	-	15	n	-	-	5	n	0	0	0	0	0	5	-5	0
$\underline{S}_5$	-	-	15	n	-	-	10	n	5	0	15	5	5	0	5	0
$\underline{S}_6$	-	-	15	n	-	-	20	n	5	-5	5	0	10	0	20	15
$\underline{S}_9$	-	-	15	n	-	-	15	n	-	0	5	5	-	0	5	0

(Table Continued on Next Page)

HEARING THRESHOLDS ON TEST (T) AND RETEST (R) (Cont'd)

Group	500 cps								1 k							
	RIGHT				LEFT				RIGHT				LEFT			
	BONE		AIR		BONE		AIR		BONE		AIR		BONE		AIR	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Aurelle																
$\underline{S}_1$	5	0	5	15	10	0	10	0	0	0	0	15	10	0	10	0
$\underline{S}_2$	5	5	0	5	10	0	5	0	5	-5	0	0	5	0	5	0
$\underline{S}_3$	5	0	0	-5	5	0	0	0	-5	0	0	-5	0	0	0	-5
$\underline{S}_4$	-5	-5	10	0	10	-5	10	0	-5	0	0	-5	0	0	0	-5
$\underline{S}_5$	5	0	5	0	10	5	10	5	5	5	0	0	5	10	5	5
$\underline{S}_6$	-5	-5	5	0	-5	0	5	-5	5	0	5	0	5	0	15	0
$\underline{S}_7$	10	-5	10	5	0	0	10	5	10	0	5	0	10	0	5	0
$\underline{S}_8$	10	5	5	0	5	5	5	5	5	-5	5	-5	5	0	0	-5
$\underline{S}_9$	0	0	5	5	10	0	5	5	5	-5	-5	0	0	-5	-5	5
$\underline{S}_{10}$	0	5	0	0	-5	0	0	5	5	5	0	0	5	0	5	0
$\underline{S}_{11}$	10	-5	5	5	5	0	5	10	5	5	0	0	0	5	-5	5
Control																
$\underline{S}_1$	5	0	15	20	0	0	15	20	0	5	5	15	0	-5	10	10
$\underline{S}_2$	-5	-5	15	10	-5	-5	5	0	0	-5	20	10	5	-5	5	-5
$\underline{S}_3$	10	0	5	5	0	10	10	10	0	-5	0	0	0	-5	0	0
$\underline{S}_4$	0	-5	5	-5	5	0	5	0	5	5	0	0	0	5	0	-5
$\underline{S}_5$	0	-5	15	10	0	0	10	0	10	0	20	5	5	5	0	-5
$\underline{S}_6$	5	-5	5	5	10	-5	10	20	-5	-5	-5	-5	5	0	5	15
$\underline{S}_9$	-	-5	5	5	-	0	5	0	-	0	0	0	-	5	0	0

(Table Continued on Next Page)

HEARING THRESHOLDS ON TEST (T) AND RETEST (R) (Cont'd)

Group	1.5 k								2 k							
	RIGHT				LEFT				RIGHT				LEFT			
	BONE		AIR		BONE		AIR		BONE		AIR		BONE		AIR	
Aurelle	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
S_1	-5	5	-5	0	0	0	0	-5	0	0	0	0	-5	-5	-5	-5
S_2	5	5	5	5	0	-5	-5	-5	0	5	0	5	0	-5	0	-5
S_3	0	-5	-5	-5	5	-5	-5	-5	-5	-5	0	-5	-5	0	-5	-5
S_4	-5	-5	0	0	0	-5	0	-5	-5	-5	5	0	5	0	5	0
S_5	5	10	5	5	0	5	5	5	0	5	0	0	5	0	-5	-5
S_6	5	-5	5	-5	-5	-5	0	-5	-5	-5	0	-5	-5	-5	0	-5
S_7	5	0	0	0	0	-5	0	0	0	0	0	0	5	5	5	5
S_8	10	0	10	0	5	0	5	0	-5	-5	0	-5	5	0	5	0
S_9	0	0	0	0	0	5	0	5	5	5	5	0	10	0	10	5
S_{10}	5	0	5	0	0	0	5	5	5	0	5	0	0	5	5	5
S_{11}	10	0	5	0	5	5	-5	-5	-5	5	5	0	5	5	5	0
Control																
S_1	5	0	0	5	5	5	5	0	0	0	0	5	5	0	5	0
S_2	-5	-5	10	0	-5	-5	-5	-5	-5	-5	0	-5	-5	-5	-5	-5
S_3	0	0	0	0	0	0	0	5	0	5	0	0	5	-5	0	-5
S_4	0	0	0	0	0	-5	-5	-5	5	-5	5	5	-5	-5	10	-5
S_5	10	5	15	10	0	-5	0	-5	5	0	15	10	-5	0	-5	-5
S_6	0	-5	-5	5	0	0	5	10	0	0	0	0	0	10	5	20
S_9	-	0	0	0	-	-5	5	5	-	-5	5	5	-	0	5	5

(Table Continued on Next Page)

HEARING THRESHOLDS ON TEST (T) AND RETEST (R) (Cont'd)

Group	3 k								4 k							
	RIGHT				LEFT				RIGHT				LEFT			
	BONE		AIR		BONE		AIR		BONE		AIR		BONE		AIR	
Aurelle	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
$\underline{S}_1$	0	0	-5	0	5	-5	5	-5	-5	5	-5	0	10	0	10	-5
$\underline{S}_2$	10	5	5	10	5	0	0	-5	10	5	5	5	10	-5	5	5
$\underline{S}_3$	0	0	0	0	5	0	-5	-5	10	0	5	5	10	0	5	0
$\underline{S}_4$	5	0	5	0	5	0	5	5	5	0	0	0	0	0	-5	0
$\underline{S}_5$	0	0	0	0	5	0	-5	-5	5	0	0	0	10	0	5	-5
$\underline{S}_6$	0	0	0	-5	0	0	-5	-5	10	0	10	0	5	0	5	5
$\underline{S}_7$	5	0	5	0	10	5	10	5	10	0	10	0	5	5	5	5
$\underline{S}_8$	10	0	5	5	5	5	5	5	5	-5	10	5	0	0	10	5
$\underline{S}_9$	5	0	10	5	10	5	5	0	0	5	5	0	0	-5	-5	-5
$\underline{S}_{10}$	0	-5	0	5	5	10	10	5	0	0	0	0	10	5	10	10
$\underline{S}_{11}$	5	0	0	5	0	0	-5	5	10	-5	5	5	0	-5	-5	-5
Control																
$\underline{S}_1$	5	10	0	10	0	0	0	0	5	15	5	25	5	10	5	10
$\underline{S}_2$	0	-5	5	-5	0	-5	-5	-5	-5	-5	10	0	-5	-5	-5	-5
$\underline{S}_3$	5	5	5	5	10	-5	0	-5	5	0	0	0	5	5	10	5
$\underline{S}_4$	5	5	10	15	0	0	10	5	10	0	5	0	5	5	5	0
$\underline{S}_5$	5	10	10	10	0	-5	-5	-5	10	0	5	5	5	-5	0	-5
$\underline{S}_6$	0	0	-5	-5	0	-5	5	5	5	-5	0	0	-5	-5	-5	-5
$\underline{S}_9$	-	0	5	0	-	0	5	0	-	-5	5	5	-	-5	10	5

(Table Continued on Next Page)

HEARING THRESHOLDS ON TEST (T) AND RETEST (R) (Cont'd)

Group	6 k								8 k							
	RIGHT				LEFT				RIGHT				LEFT			
	BONE		AIR		BONE		AIR		BONE		AIR		BONE		AIR	
Aurelle	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
$\underline{S}_1$	-	-	n	n	-	-	n	n	-	-	5	-5	-	-	0	-5
$\underline{S}_2$	-	-	10	n	-	-	5	n	-	-	5	0	-	-	20	10
$\underline{S}_3$	-	-	n	n	-	-	n	n	-	-	10	10	-	-	20	0
$\underline{S}_4$	-	-	15	n	-	-	10	n	-	-	10	5	-	-	5	5
$\underline{S}_5$	-	-	10	n	-	-	10	n	-	-	-5	-5	-	-	-5	5
$\underline{S}_6$	-	-	n	n	-	-	n	n	-	-	15	5	-	-	20	0
$\underline{S}_7$	-	-	20	n	-	-	20	n	-	-	20	5	-	-	25	20
$\underline{S}_8$	-	-	5	n	-	-	10	n	-	-	5	0	-	-	5	5
$\underline{S}_9$	-	-	0	n	-	-	-5	n	-	-	0	0	-	-	0	5
$\underline{S}_{10}$	-	-	n	n	-	-	n	n	-	-	0	0	-	-	20	5
$\underline{S}_{11}$	-	-	n	n	-	-	n	n	-	-	5	5	-	-	0	0
Control																
$\underline{S}_1$	-	-	n	n	-	-	n	n	-	-	0	20	-	-	0	15
$\underline{S}_2$	-	-	20	n	-	-	15	n	-	-	10	5	-	-	5	5
$\underline{S}_3$	-	-	n	n	-	-	n	n	-	-	5	0	-	-	0	0
$\underline{S}_4$	-	-	5	n	-	-	20	n	-	-	10	0	-	-	15	15
$\underline{S}_5$	-	-	10	n	-	-	-5	n	-	-	15	20	-	-	10	5
$\underline{S}_6$	-	-	0	n	-	-	15	n	-	-	5	5	-	-	20	10
$\underline{S}_9$	-	-	10	n	-	-	15	n	-	-	15	5	-	-	20	10

APPENDIX 9

AUDITORY SELECTIVITY ON TEST (T) AND RETEST (R)

Score of 1 = incorrect; 2 = correct response.

Group	8-6 k				6-4 k				4-3 k				3-2 k				2-1.5 k			
	RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Aurelle																				
$\underline{S}_1$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_2$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1
$\underline{S}_3$	2	1	2	1	2	2	2	2	2	1	2	1	2	2	2	1	2	2	1	2
$\underline{S}_4$	2	1	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	1	2
$\underline{S}_5$	1	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	2	2	1	2
$\underline{S}_6$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_7$	2	2	2	1	2	1	2	1	2	1	2	2	2	1	2	1	1	2	2	2
$\underline{S}_8$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_9$	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	2	2	1	2
$\underline{S}_{10}$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_{11}$	2	2	2	2	2	2	2	2	2	1	2	1	2	2	2	2	2	2	2	2
Control																				
$\underline{S}_1$	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2	2	1	2	1
$\underline{S}_2$	2	1	2	1	2	2	2	2	2	2	2	1	1	2	2	2	2	2	2	2
$\underline{S}_3$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_4$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_5$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_6$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2
$\underline{S}_9$	2	1	2	1	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2

(Table Continued on Next Page)

AUDITORY SELECTIVITY ON TEST (T) AND RETEST (R) (Cont'd)

Score of 1 = incorrect; 2 = correct response

Group	1.5-1 k				1-500 cps				500-250				250-125 cps			
	RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT		RIGHT		LEFT	
	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R
Aurelle																
$\underline{S}_1$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_2$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_3$	2	2	2	1	2	2	2	1	2	2	1	2	1	2	2	2
$\underline{S}_4$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_5$	2	2	1	1	2	2	2	2	2	2	2	2	2	1	2	2
$\underline{S}_6$	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2	2
$\underline{S}_7$	2	1	1	2	2	2	2	1	2	2	2	2	2	1	2	2
$\underline{S}_8$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_9$	2	2	2	2	2	2	2	2	2	2	2	2	1	2	2	2
$\underline{S}_{10}$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_{11}$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Control																
$\underline{S}_1$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_2$	2	2	2	2	2	2	2	2	1	2	1	2	1	2	1	2
$\underline{S}_3$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_4$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_5$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_6$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
$\underline{S}_9$	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2

APPENDIX 10

AUDIOGRAM RATINGS BY ALFRED TOMATIS

Amount of Difference Pre- and Post-Treatment

Group	RATING			
Aurelle	0	1	2	3
$\underline{S}_1$		1		
$\underline{S}_2$		1		
$\underline{S}_3$			2	
$\underline{S}_4$		1		
$\underline{S}_5$		1		
$\underline{S}_6$				3
$\underline{S}_7$	0			
$\underline{S}_8$		1		
$\underline{S}_9$			2	
$\underline{S}_{10}$		1		
$\underline{S}_{11}$		1		
Control				
$\underline{S}_1$	0			
$\underline{S}_2$			2	
$\underline{S}_3$			2	
$\underline{S}_4$	0			
$\underline{S}_5$			2	
$\underline{S}_6$	0			
$\underline{S}_9$		1		

APPENDIX 11

SONOGRAM RATINGS BY ALFRED TOMATIS

Amount of Difference Pre- and Post-Treatment

Group	RATING			
Aurelle	0	1	2	3
S_1				3
S_2				3
S_3			2	
S_4			2	
S_5				3
S_6			2	
S_7		1		
S_8				3
S_9	0			
S_{10}				3
S_{11}				3
Control				
S_1		1		
S_2			2	
S_3			2	
S_4	0			
S_5			2	
S_6	0			
S_9	0			

APPENDIX 12

DICHOTIC DIGITS, TOTAL CORRECT (MAXIMUM PER EAR = 240)

Sixty Trials, Four Pairs of Digits Per Trial

Group Aurelle	RIGHT EAR		LEFT EAR	
	TEST	RETEST	TEST	RETEST
$\underline{S}_1$	171	184	101	130
$\underline{S}_2$	106	105	137	155
$\underline{S}_3$	155	132	117	124
$\underline{S}_4$	150	152	130	137
$\underline{S}_5$	184	173	116	118
$\underline{S}_6$	144	163	145	142
$\underline{S}_7$	107	98	136	141
$\underline{S}_8$	155	159	106	83
$\underline{S}_9$	166	171	126	136
$\underline{S}_{10}$	105	98	209	207
$\underline{S}_{11}$	123	150	132	159
Control				
$\underline{S}_1$	170	191	63	46
$\underline{S}_2$	183	210	65	99
$\underline{S}_3$	173	213	74	107
$\underline{S}_4$	164	171	105	123
$\underline{S}_5$	71	84	172	167
$\underline{S}_6$	173	187	112	101
$\underline{S}_7$	177	---	105	---
$\underline{S}_8$	122	---	116	---
$\underline{S}_9$	146	152	146	135

APPENDIX 13

DICHOTIC DIGITS IN SIX TRIAL BLOCKS

TEN TRIALS PER BLOCK, FOUR PAIRS OF DIGITS PER TRIAL

NUMBER CORRECT PER EAR ON TEST (T) AND RETEST (R)
(MAXIMUM PER BLOCK = 40)

Group	BLOCK(1)				BLOCK(2)				BLOCK(3)			
	Rt. Ear		Left Ear		Right		Left		Right		Left	
Aurelle	T	R	T	R	T	R	T	R	T	R	T	R
$\underline{S}_1$	26	31	25	23	34	33	22	25	27	26	16	25
$\underline{S}_2$	10	14	32	28	24	19	16	26	21	14	21	29
$\underline{S}_3$	26	21	18	21	22	13	13	26	18	18	21	29
$\underline{S}_4$	26	26	22	23	26	25	23	24	19	20	29	25
$\underline{S}_5$	28	28	17	21	32	30	15	19	28	24	22	26
$\underline{S}_6$	29	23	25	28	19	28	32	27	24	24	22	25
$\underline{S}_7$	16	07	26	31	19	22	25	21	19	16	21	22
$\underline{S}_8$	24	26	16	11	23	23	24	14	21	25	18	20
$\underline{S}_9$	26	28	22	25	27	27	23	25	31	26	20	21
$\underline{S}_{10}$	17	15	36	35	20	16	33	36	20	12	34	36
$\underline{S}_{11}$	22	22	23	32	20	23	22	31	22	20	18	29
Control												
$\underline{S}_1$	28	25	12	16	25	32	15	06	27	31	13	07
$\underline{S}_2$	33	35	12	15	29	32	13	17	25	29	17	22
$\underline{S}_3$	24	38	21	15	29	36	14	17	25	35	10	19
$\underline{S}_4$	32	27	17	19	31	30	17	19	26	27	18	17
$\underline{S}_5$	17	23	26	21	13	14	29	32	08	09	30	31
$\underline{S}_6$	28	33	15	14	30	31	22	18	27	26	24	26
$\underline{S}_9$	27	27	23	23	20	24	29	25	21	22	23	24

(Table Continued on Next Page)

DICHOTIC DIGITS IN SIX TRIAL BLOCKS (Cont'd)

TEN TRIALS PER BLOCK, FOUR PAIRS OF DIGITS PER TRIAL

NUMBER CORRECT PER EAR ON TEST (T) AND RETEST (R)
(MAXIMUM PER BLOCK = 40)

	BLOCK (4)				BLOCK(5)				BLOCK(6)			
Group	Rt.	Ear	Left	Ear	Right		Left		Right		Left	
Aurelle	T	R	T	R	T	R	T	R	T	R	T	R
S_1	24	30	17	19	26	32	14	22	34	32	06	16
S_2	14	19	26	27	15	15	25	28	22	25	18	17
S_3	29	28	23	14	30	25	22	19	30	28	20	15
S_4	26	25	22	22	25	29	24	24	28	27	19	19
S_5	33	31	20	20	29	26	28	16	35	34	15	17
S_6	21	28	29	20	26	31	21	21	27	31	16	19
S_7	20	17	20	23	18	20	19	22	16	16	25	24
S_8	28	32	16	17	28	22	16	07	31	31	15	14
S_9	32	30	16	24	29	37	18	19	21	25	28	23
S_{10}	14	14	36	35	15	18	36	33	20	24	34	32
S_{11}	24	31	20	18	15	28	27	24	19	26	22	25
Control												
S_1	27	34	06	08	28	39	10	02	35	31	07	09
S_2	36	37	07	13	30	37	09	19	31	39	07	13
S_3	26	36	14	16	34	32	12	22	35	36	03	19
S_4	24	34	19	18	24	28	23	22	26	25	21	27
S_5	11	14	29	28	12	15	27	25	10	11	31	30
S_6	30	32	18	18	26	31	18	15	31	35	15	10
S_9	27	26	25	24	27	28	22	19	23	24	24	20

APPENDIX 14

TABLE I

Analysis of Variance of the Laterality Scores (Maximum = 10) as a Function of Group and Trials

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	2.858	2.858	0.715
S/G (Subjects within Groups)	16	63.948	3.997	
Within subjects				
Trials (B) (Test, Retest)	1	1.361	1.361	2.189
BA	1	0.191	0.191	0.307
BX S/G	16	9.948	0.622	

TABLE II

Analysis of Variance of the WRAT Reading Scores (Standard Scores) as a Function of Group and Trials

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	1.524	1.524	0.015
S/G	16	1590.948	99.434	
Within subjects				
Trials (B) (Test, Retest)	1	38.028	38.028	2.608
BA	1	15.161	15.161	1.040
BX S/G	16	233.312	14.582	

TABLE III

Analysis of Variance of the Number of Correct Responses on Auditory Selectivity as a Function of Group, Frequencies, Ear and Trials

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	0.234	0.234	0.630
S/G	16	5.933	0.371	
Within subjects				
Frequencies (B) (9 pairs)	8	1.083	0.135	2.195*
BA	8	0.352	4.397	0.713
BX S/G	128	7.898	6.171	
Ear (C) (Right vs. Left)	1	9.877	9.877	2.932
CA	1	2.894	2.894	0.859
CX S/G	16	0.539	3.369	
Trials (D) (Test, Retest)	1	0.395	0.395	2.244
DA	1	97.002	97.002	0.055
DX S/G	16	2.817	0.176	
BC	8	0.540	6.752	1.391
BCA	8	0.579	7.237	1.491
BC X S/G	128	6.214	4.855	
BD	8	1.077	0.135	1.461
BDA	8	0.908	0.113	1.232
BD X S/G	128	11.793	9.213	
CD	1	61.728	61.728	0.191
CDA	1	3.207	3.207	0.992
CD X S/G	16	0.517	3.233	
BCD	8	0.410	5.131	0.840
BCDA	8	0.214	2.670	0.437
BCD X S/G	128	7.820	6.110	

* $p < .03$

TABLE IV

Analysis of Variance of the Intensity (dB) Difference Scores on Air Conduction Hearing Thresholds As a Function of Group, Frequency, and Ear.

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	3.385	3.385	0.559
S/G	16	96.851	6.053	
Within subjects				
Frequency (B) (8 Levels)	7	6.764	0.966	0.844
BA	7	5.681	0.812	0.708
BX S/G	112	128.305	1.146	
Ear (C) (Right vs. Left)	1	1.681	1.681	0.577
CA	1	45.094	45.094	0.002
CX S/G	16	46.565	2.910	
BC	7	1.431	0.204	0.242
BCA	7	1.755	0.251	0.297
BC X S/G	112	94.565	0.844	

TABLE V

Analysis of Variance of the Intensity (dB) Scores on Bone Conduction Hearing Thresholds As a Function of Group, Frequency, Ear, and Trials

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	6.107	6.107	1.552
S/G	15	59.019	3.935	
Within subjects				
Frequency (B) (7 Levels)	6	14.807	2.468	2.655**
BA	6	0.903	0.151	0.162
BX S/G	90	83.647	0.929	
Ear (C) (Right vs. Left)	1	1.891	1.891	0.019
CA	1	2.054	2.054	2.059
CX S/G	15	14.963	0.998	
Trials (D) (Test, Retest)	1	34.960	34.960	46.042***
DA	1	0.115	0.115	0.151
DX S/G	15	11.390	0.759	
BC	6	4.202	0.700	1.263
BCA	6	5.097	0.850	1.532
BC X S/G	90	49.916	0.555	
BD	6	7.731	1.289	2.209*
BDA	6	2.550	0.425	0.729
BD X S/G	90	52.504	0.583	
CD	1	21.008	21.008	0.002
CDA	1	0.986	0.986	1.002
CD X S/G	15	14.762	0.984	
BCD	6	1.395	0.232	0.507
BCDA	6	4.821	0.804	1.752
BCD X S/G	90	41.284	0.459	

* $p < .05$
** $p < .02$
*** $p < .00001$

N.B. This test is not reliable due to re-calibration of the audiometer prior to retest. See text.

TABLE VI

Analysis of Variance of the Number of Correct Responses on Dichotic Digits as a Function of Group, Trial Block, Ear, and Test

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	40.592	40.592	0.477
S/G	16	1362.371	85.148	
Within subjects				
Trial Block (B) (6)	5	43.796	8.759	1.397
BA	5	2.058	0.412	0.066
BX S/G	80	501.479	6.268	
Ear (C) (Right vs. Left)	1	1976.333	1976.333	3.053
CA	1	1571.456	1571.456	2.427
CX S/G	16	10359.211	647.451	
Test (D) (Before, After)	1	151.704	151.704	5.236*
DA	1	41.717	41.717	1.440
DX S/G	16	463.579	28.974	
BC	5	767.222	153.444	5.603**
BCA	5	158.021	31.604	1.154
BC X S/G	80	2190.757	27.384	
BD	5	9.019	1.804	0.345
BDA	5	8.723	1.745	0.334
BD X S/G	80	418.259	5.228	
CD	1	6.259	6.259	0.533
CDA	1	60.447	60.447	5.146*
CD X S/G	16	187.960	11.747	
BCD	5	146.519	29.304	2.085
BCDA	5	92.638	18.528	1.319
BCD X S/G	80	1124.176	14.052	

* $p < .04$
** $p < .0002$

TABLE VII

Analysis of Variance as a Function of Group of Tomatis' Sonogram Ratings, With Ratings of Zero to Three As the Amount of Change Post-Treatment Relative to the Pre-Treatment Baseline of Zero

Source	df	SS	MS	F
Between subjects				
Group (A) (Aurelle vs. Control)	1	6.929	6.929	6.851*
S/G	16	16.182	1.011	

* $p < .02$

APPENDIX 15

UNIVERSITÉ D'OTTAWA
Centre d'étude de l'enfant

UNIVERSITY OF OTTAWA
Child Study Centre

265 RUE NICHOLAS ST.
OTTAWA 2 CANADA
K1N 6N5

April 11, 1972

To all personnel concerned with the Electronic ear:

Recently the organization of American audiometrists warned that serious damage to the ear could occur when using headphones for music listening. I decided to test the electronic ear with a constant input driving the VU meter to its white-red border line. The interesting results obtained follow:

volume control setting	SPL (dB) at headphones
2	85
3	100
4	105
5	110
8	125

I am herewith repeating operating instructions for the electronic ear. Arrange the microphone and recorder levels to read on the VU meter the border line between red and white. After this is done adjust the headphone volume control "puissance" to a comfortable level. Do not set puissance above "3" unless you were unable to obtain the desirable VU meter reading. Check at the headphones for level, it must be comfortable.

Note that the results tabulated above were obtained under ideal laboratory conditions and that in reality it is doubtful that they are truly representative.

M. Maples T.O.

APPENDIX 16

ABSTRACT OF

Listening, Phonation, Laterality, and Reading Effects of the Aurelle Therapy of Alfred Tomatis on Children with Reading Difficulties[1]

Eighteen children with reading difficulties were trained using either the Aurelle apparatus and technique of Alfred Tomatis or a language laboratory procedure. For thirty sessions of 45 minutes a day, recorded music and words were presented via earphones to subjects in separate cubicles. From the twentieth session on, subjects read as well as heard and repeated the words. Children undergoing the Aurelle procedure received 100% input to the right ear and, decreasing within five sessions from 70% to 50% to 30%, from the seventh session onward they received 10% input to the left ear; in addition, for the first nine sessions input was filtered to include only frequencies above 960 cps, then above 1920 cps for the next five sessions, and above 3840 cps for the last sixteen sessions. Children in the language laboratory

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1 Leah Schnitzer, doctoral thesis presented to the Faculty of Psychology of the University of Ottawa, Ottawa, Ontario, September 1974, xii-180 p.

procedure were administered the same music and words for the same duration; however, the material was not filtered and was presented 100% to both ears.

Language laboratory subjects performed significantly better than Aurelle subjects on right-ear verbal listening. This was contrary to the hypothesized result. Aurelle subjects showed a significant increase over other subjects in vocal high frequencies. No significant differences occurred in hearing, laterality, or reading achievement. Somatic and auditory disadvantages of the monaural high frequency, high intensity Aurelle technique were discussed. Errors in terminology, methodology, fact, and theory evident in the work of Alfred Tomatis were pointed out. Suggestions were made for future research.