

OBJECTIVE AUDITORY TESTS ON NON-COOPERATIVE CHILDREN

A follow-up examination of 50 newborn infants and pre-school children with suspected hearing loss.

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For measuring the hearing of children less than 3 years old it is necessary to use objective methods. This is true also of older children who for some reason are unable to cooperate in play audiometry, say because of intelligence defect, immaturity or spasticity. In both kinds of subjects, I have performed two kinds of objective hearing tests.

(1) Threshold determination of the auropalpebral reflex (APR) consisting in the contraction of the orbicularis oculi muscle.

(2) Determination of the intensity of sounds required to waken the child who is in a certain depth of sleep. A specially designed tone audiometer was used for these tests.

These tests are conducted with the child lying on its side in a cot. In the first 20 subjects who had been selected as probably being normals, the APR was elicited at a threshold of 105—115 dB for all frequencies tested in the range 500—4000 cps. In some cases it was difficult to obtain the reflex.

(1) When the child was sleeping very deeply. It was then also impossible to awaken the child by tactile stimulus. In terms of anaesthesiology, the child would then be in the lower plane of the second stage of narcosis or the first plane of the third stage (Fig. 1).

(2) When the child was awake and agitated or preoccupied, as with screaming or some other display of discontent. In these cases the absence of response was probably due to reflex inhibition.

That it is possible to use these threshold determinations of APR as a test of the hearing level in the **newborn** is due to the similarity between APR and another acoustic reflex, the stapedius reflex: this latter function is familiar in both normals and persons with defective hearing. The APR reflex-threshold curve for **adults with normal hearing are very similar** (Figs. 2 and 3); also from the anatomic aspect the two reflexes have much in common. The afferent (acoustic nerve) and the efferent part (facial nerve) of the reflex arc are common to both but the centre of the stapedius reflex is situated in the pons and that of the APR in the reticular formation (Fig. 4).

The APR threshold curve for the children examined should indicate normal hearing. In the individual case, however, the fact that the APR has been elicited at a particular frequency with a tone of "normal" intensity cannot be taken as proof that the hearing for the frequency in question is normal. As

Signs of anaesthesia
(ad m T Gordh)

Intravenous anaesthesia						
	Stages	Lid-reflex	Skin-reflex	Respiration Diaphr. Int. cost.	Pupils	Approximate levels for abolition of reflexes.
I	Conscious Increasing drowsiness					
II	Nonconscious Eyeball movements Lidreflex retained					Lidreflex
III	1 Lidreflex abolished Skinreflex retained					Skinreflex
	2 Skinreflex abolished Respiratory depression sets in					Corneal reflex
	3 Shallow thoraco-abdominal respiration Contracted pupils					Glottic reflex Pup. light reflex
	4 Abdominal respiration Cyanosis Dilating pupils Insensitive to light					
IV	Respiratory paralysis Exitus					

Fig. 1.

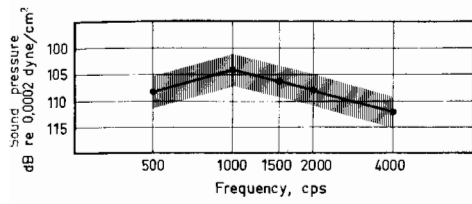


Fig. 2.

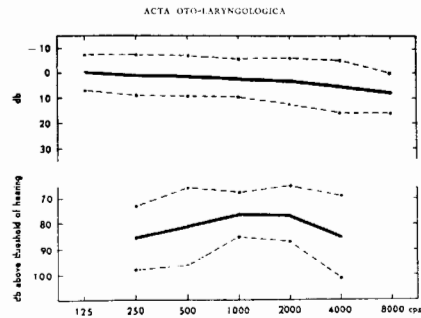


Fig. 3.

Fig. 2. Mean threshold curve for the auro-palpebral reflex of new-born infants.

Fig. 3. Thresholds of hearing and stapedius reflex, age groups 15-34 years.
(From O. Jepsen 1955).

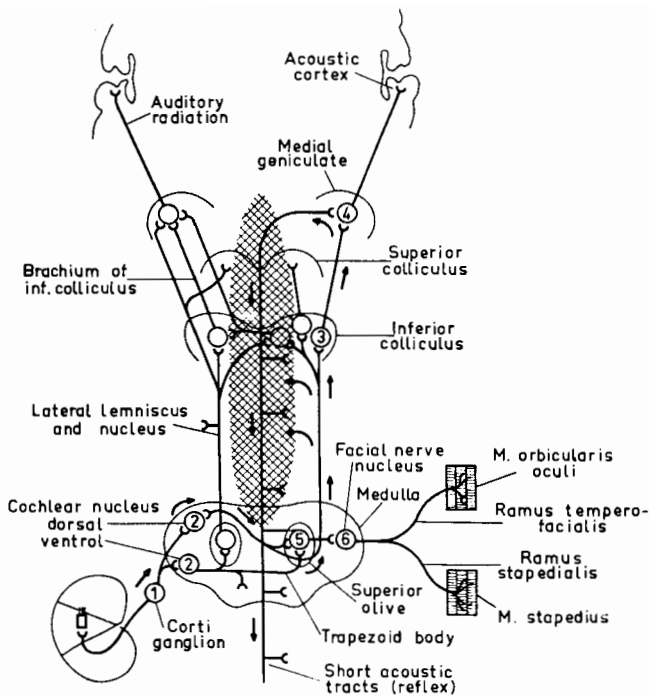


Fig. 4. The afferent acoustic pathways (based mainly on cat). The "order" of each neuron is indicated by a number. (From Hallowell Davis 1951.) In this figure are inscribed the supposed extent of the formatio reticularis (cross-hatched area), the reflex arcs of the stapedius and the auro-palpebral reflexes, ramus tempero-facialis and stapediais n. facialis, m. stapedius and m. orbicularis oculi. Superior olive is indicated with number 5, facial nerve nucleus with number 6. Arc for the stapedius reflex: 1-2-5-6-ramus stapediais. Arc for the auro-palpebral reflex:

$$1-2 < \begin{matrix} 3 \\ 4 \end{matrix} > 5-6\text{-ramus tempero-facialis.}$$

	Normal hearing	Cochlear hearing loss	Conductive hearing loss Retrocochlear hearing loss	Total deafness Severely hard of hearing
APR	+	+	—	—
Waking $\leq 70-75$ dB	+	—	—	—
Waking $> 70-75$ dB	+	+	+	—

Fig. 5. Prospective schedule of different kinds of hearing loss.

has been shown in the case of the stapedius reflex, there may be severe hearing loss with recruitment.

So as to distinguish between normal hearing and impaired hearing with recruitment, experiments were performed to find the intensity required to awaken a child in a depth of sleep such that the APR could be elicited by tactile stimulus. The audiometer was the same as that used in the APR tests. The frequencies were 500 and 3000 cps, and the tones were of 1—5 seconds duration, emitted irregularly for one minute. At an intensity of 70—75 dB, if not before, all the infants showed signs of waking, such as a change in the breathing rhythm or flickering of the eyelids.

As an aid in distinguishing between normal hearing and different types of hearing impairment a chart was compiled showing how a normal child and one with impaired hearing might be supposed to react to APR and awaking from sleep (Fig. 5).

When the first 20 newborn underwent these hearing tests in 1955 all reacted in the manner that was considered typical of a child with normal hearing. As a check, a follow-up play-audiometry test was performed on 10 of the children in 1961. They had all normal hearing.

The same hearing tests were also carried out on 30 children suspected of having impaired hearing. They ranged in age from 2 days to 4 yrs .5 mos. For none of these subjects could play audiograms be made at the first test owing to lack of cooperation — either because they were too young (25 were less than 2 years) or because they were of too low intelligence, immature or spastic (5 such children of more than 2 years).

More recently many control play-audiograms have been recorded for this series. Control audiograms have been made for 20 subjects and informal tests performed on 6. Four patients have died.

In all but 2 of the series the preliminary findings were verified by one of these two tests (Table 1).

In one of the exceptions the hearing was recorded as normal on the third day but an impairment was found at 2 yrs. 5 mos; it is highly probable that the preliminary result was correct, but that later on there was a severe impairment, probably of genetic origin, and similar to that associated with atrophy occurring in certain strains of rats, cats and mice with histologically normal cochlea at birth. All the relatives of this case were deaf.

In the second exceptional case there was so severe an intelligence defect that the control tests cannot be considered either to contradict or to confirm the preliminary findings.

Figs. 6—8. Audiograms of 3 subjects. Fig. 6 Normal hearing. Fig. 7 Cochlear impairment. Fig. 8. Retrocochlear impairment.

It is evident from the results that these objective hearing tests are extremely reliable. They enable one to determine with a high degree of certainty whether the hearing of a child, (newborn or older) is normal or defective, and in the latter case to establish the type and degree of impairment and even, in conductive and retrochlear hearing loss, to record an audiogram.

The tests have proved of great value in hearing examinations on children where the play audiograms could not be made - those less than 3 years, and

Table 1. Group with suspected hearing impairment.

Case	Sex	General Diagnosis	Original Hearing Test			Follow-up Test		Comments	
			Age	Hearing Normal	Hearing Loss	Age	Confirmation by audiogram probable		
1 G.P.	F	Asphyxia neonatorum c. athletas pulm., immaturitas + cataract + vitium org. cord. cong. + haemorrhagia intracran + surditas?	< 1 month	+		4 y. 9 m.	+		
2 P.S.	M	Dysontogenesis auris sin. et mandibulae sin. + surditas?	"	right	left	4 y. 10 m.	+		
3 O.M.	F	Mikrocephalia + surditas?	"	+				Died at 7 months	
4 W.O.	M	Surditas hereditaria?	"		+	3 y.	+		
5 R.	F	" "	"	+		4 y.	+		
6 H.A.	F	" "	"	+		2 y. 5 m.	not verified		
7 L.	M	" "	"	+		3 y. 10 m.	+		
8 J.T.	M	Morbus haemolyticus neonatorum + icterus nucleosus + surditas?	"		+	3 y. 4 m.	+		
9 B.	F	Morbus haemolyticus neonatorum + surditas?	"	+		3 y. 5 m.	+		
10 J.A.	M	Surditas?	1-3 months	+		4 y. 5 m.	+		
11 O.	M	Morbus haemolyticus neonatorum (A-immunisation) + hydrocephalus incertae causae + surditas?	"	+		4 y. 9 m.	+		
12 E.	M	Immaturitas + encephalopatia + surditas?	"	+		4 y.	+		
13 P.A.	F	Status post morbus: haemolyticus neonatorum + icterus nucleosus + bronchopneumonia + surditas?	3-12 months		+			Died at 3 months	
14 S.	M	Encephalopatia + status post oscomyelit + amaurosis congenita bilat. + surditas?	"	+				Died at 2 years	
15 W.E.	F	Aplasia nuclei facialis → abduens → hypoglossus + agenesia dig II + V sin. et dig. II dx. + syndactylia dig. II-III dx. + bronchopneumonia + surditas?	"	+		3 y. 3 m.	+		
16 E.L.	M	Haemorrhagia subarachnoidalis + paresis nervi fac. dx + cystopyelit + rachitis + anaemia sec. + surditas?	"	+		4 y.	+		
17 W.E.	F	Paralysis cerebri + surditas?	1-2 years		+	6 y. 3 m.	+		
18 A.B.	F	Surditas?	"		+	4 y. 4 m.	+		
19 M.L.	F	Surditas hereditaria?	"		+	4 y. 1 m.	+		
20 J.E.	F	Oligophrenia + surditas?	"		+	5 y. 8 m.		uncertain	
21 R.E.	F	" "	"		+			Died at 2 1/2 y.	
22 S.A.	M	Encephalopatia progressiva + surditas?	"	+		5 y. 11 m.	+		
23 S.L.	F	Surditas?	"		+	3 y. 4 m.	+		
24 T.C.	M	Surditas?	"		+	2 y. 11 m.	+		
25 H.P.	M	Debilitas psychica + surditas?	"	+		4 y. 2 m.	+		
26 H.I.	M	Oligophrenia + amaurosis + surditas?	> 2 years	+		6 y.	+		
27 K.T.	M	Oligophrenia + surditas?	"	+		4 y.	+		
28 A.M.	M	Oligophrenia + epilepsia + surditas?	"		+	3 y. 7 m.	+		
29 S.R.	M	Surditas?	"		+	6 y. 11 m.	+		
30 J.K.	F	Debilitas psychica + surditas?	"		+	7 y.	+		
Total 30				17	14		19	5	4 died

older children who for one reason or another such as too low intelligence or spasticity, cannot cooperate in recording a play audiogram.

EPREUVES AUDITIVES OBJECTIVES EFFECTUÉES AVEC DES ENFANTS QUI NE COOPÈRENT PAS À L'EXPÉRIENCE

Examen suivi de 50 nouveau-nés et enfants à l'âge pré-scolaire chez lesquels on soupçonne une déficience de l'ouïe.

Lorsqu'il s'agit de mesurer la faculté auditive d'enfants qui n'ont pas atteint l'âge de 3 ans, il faut utiliser des méthodes de mesure objectives. Il en va de

même pour les enfants de plus de 3 ans qui, pour une raison ou pour une autre, ne peuvent pas coopérer aux épreuves d'audiométrie par le jeu (défiance de l'intelligence, manque de maturité, spasticité). Dans tous ces cas, l'auteur a procédé à deux espèces d'épreuves auditives.

1. Détermination des seuils du réflexe auro-palpébral (APR) qui se produit par contraction de la m. orbicularis oculi.

2. Détermination de l'intensité requise pour éveiller l'enfant plongé à un certain niveau de sommeil. Un audiomètre à ton pur de construction spéciale a été employé pour ces épreuves.

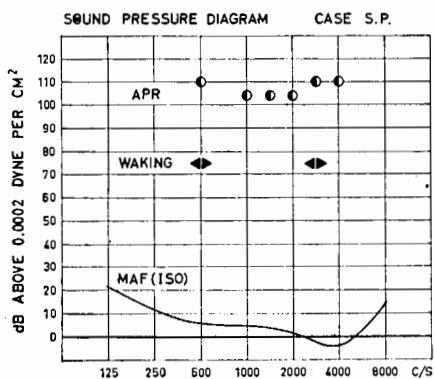


Fig. 6 A. Auditory tests in a normal hearing child with APR and Waking Thresholds recorded in dB above 0.0002 dynes per sq cm.

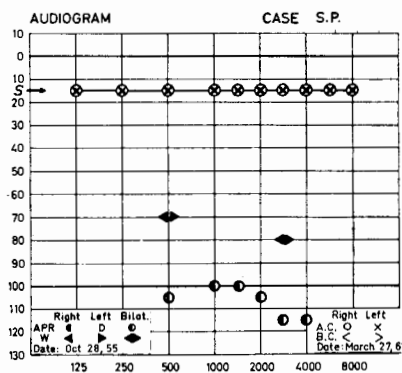


Fig. 6 B. Same values as in fig. 6 A in audiometric representation, i.e., with reference to normal threshold of hearing. Subject's air conduction from threshold follow-up examination added. For details, see text.

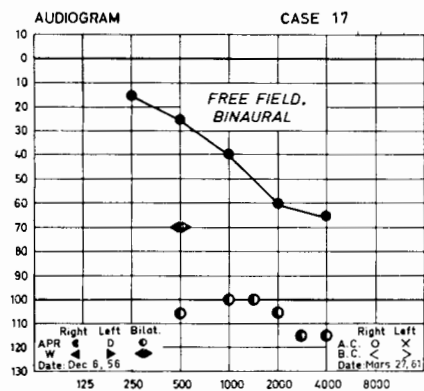


Fig. 7.

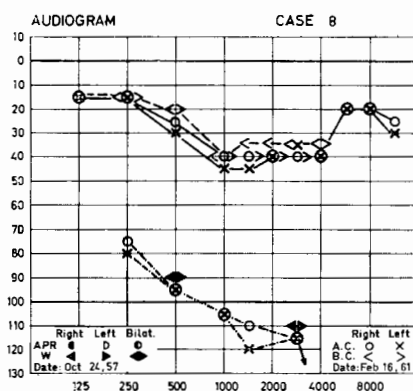


Fig. 8.

Fig. 8. Objective auditory tests on non-cooperative children. Dash-dotted curve: Stapedius reflex bilat. Feb. 16, 61.

Le faculté auditive des 20 premiers «cas normaux» a été étudiée de cette façon en 1955. En contrôlant ces cas par des épreuves d'audiométrie par le jeu en 1961, on a constaté, cette fois encore, une faculté auditive normale. On a procédé aux mêmes épreuves auditives avec 30 enfants dont on soupçonnait qu'ils souffraient d'une déficience de l'ouïe, l'âge des sujets variant de 2 jours à 4 ans et 5 mois. On a établi ultérieurement, dans une large mesure, des audiogrammes de contrôle pour ces sujets.

Les résultats obtenus montrent que ces épreuves auditives objectives donnent, à un très haut degré, des indications valables. Il est possible de déterminer avec une grande exactitude si l'ouïe d'un enfant (nouveau-né ou plus âgé) est normale ou défectueuse, de déterminer dans ce dernier cas la nature et le degré du défaut auditif et de réaliser, même en cas de défaut conductif ou de défaut rétrocochléaire, un audiogramme.

Ces épreuves prennent toute leur valeur dans l'examen de l'ouïe d'enfants pour lesquels un audiogramme par le jeu s'avère impossible à effectuer: enfants n'ayant pas encore atteint l'âge de 3 ans et sujets plus âgés qui, pour une raison ou pour une autre, ne peuvent pas coopérer à l'établissement d'un audiogramme par le jeu.

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