

# TINNITUS AND AUDITORY IMAGERY

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## ABSTRACT

When a patient reports that he experiences voices, music, or other complex auditory perceptions in the absence of appropriate stimulation, the examiner suspects auditory hallucinations associated with psychosis or central nervous system (CNS) disorders. When the patient reports ringing or other such simple auditory perceptions, the examiner suspects tinnitus, symptomatic of otologic or neurologic dysfunction. However, a syndrome consisting of vivid auditory imagery recapitulating past experiences which is associated with hearing impairment rather than with psychosis has been defined and discussed in the literature. Only eleven case histories of this seemingly rare phenomenon have appeared in the English literature. Therefore, it was surprising to find six persons exhibiting this syndrome among a group of seventy-eight patients with tinnitus examined by otolaryngologists and referred to us for evaluation of tinnitus during the past eighteen months. This unusual occurrence suggests that this phenomenon may be more common than previously recognized and that there may be some relationship between tinnitus and this syndrome. Possible causes for the hearing impairment and tinnitus of these patients included noise exposure, acoustic trauma, ototoxicity, otosclerosis, and presbycusis. Speculation as to the mechanism underlying the tinnitus and the auditory imagery is tendered, and an appeal to otolaryngologists and audiologists to question their patients concerning this syndrome is made.

Ross, Jossman, Bell, Sabin, and Geschwind<sup>1</sup> defined a syndrome consisting of vivid recapitulation of musical perceptions associated with acquired peripheral hearing loss and no evidence of psychosis. The authors noted that only five substantiated cases had appeared in the English literature; therefore, they found it unusual that they had evaluated two such cases. They reported that a 75-year-old male who had experienced a progressive bilateral hearing loss and tinnitus during the previous 10 to 12 years presented with the complaint of a sudden onset of hearing music. This music consisted of familiar hymns and melodies produced by voices and instruments. The songs were continuous, as if played back through a tape recorder; however, he could change the tunes by singing or thinking about different songs, and he could mask the music by turning the radio. This patient had a severe sensorineural hearing loss in the right ear and no measurable hearing in the left ear. All other findings were normal and the medical history was unremarkable.

The second case was an 83-year-old female with a severe bilateral sensorineural hearing loss with a conductive component in the right ear. She

experienced a sudden onset of hearing music in the right ear which she initially believed to be produced by a radio. She sought neurologic and psychiatric treatment when she discovered that there was no radio producing the music. She described her music as a continuous medley of Christmas carols and Irish jigs. Over a period of two weeks, the music changed to a single tune which was repeated continuously. Later, this tune changed to a tinnitus that has since alternated with rock-and-roll music. The sounds occasionally shifted to the opposite ear. Exploratory tympanotomy revealed a normal middle ear and all other tests revealed no relevant abnormalities.

Ross et al.<sup>1</sup> reported information about a third case which they had not examined. An elderly woman who had experienced a progressive bilateral hearing loss and tinnitus for twenty years also experienced classical orchestral music during her last three to four years. She was considered to be free of psychiatric illness.

The five substantiated cases of this syndrome referenced by Ross et al.<sup>1</sup> are found in the articles by Rhein,<sup>2</sup> Colman,<sup>3</sup> and Rozanski and Rosen.<sup>4</sup>

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The nine cases in the non-English literature referenced by Ross et al.<sup>1</sup> are those reported by Hécaen and Ropert.<sup>5</sup>

Scott<sup>6</sup> replied to the article by Ross et al.,<sup>1</sup> stating that Fay and Scott<sup>7</sup> had reported on a similar case with musical imagery from meningioma. Ross<sup>8</sup> wrote a letter to the editor saying that since the publication of the article he had received twelve reports of this phenomenon from readers. He concluded that such cases might be more common than generally recognized.

Miller and Crosby<sup>9</sup> referred to the study of Ross et al.<sup>1</sup> and stated that perhaps as few as nine cases of the syndrome had been reported in the English literature. These authors presented one case of an elderly patient with a severe sensorineural hearing loss, auditory imagery of previously heard music and conversations, and no evidence of psychiatric illness or other neurologic deficit.

Clovis<sup>10</sup> reported a case of a man who had experienced tinnitus and his favorite songs in four-part harmony subsequent to a head injury. His favorites were Handel's *Messiah* and songs by Victor Herbert. If he heard music which he did not like he changed it by singing "Amen." Clovis reported that the man was not deaf nor was he psychotic.

In summary, there have been eleven detailed case reports of this syndrome presented in seven articles in the English literature to date, and twelve cases have been noted in a letter to the editor. Although the referenced authors have referred to this syndrome as an hallucination, this appellation does not seem appropriate because of the implication of psychosis. Therefore, auditory imagery is proposed.

Seventy-eight patients have received tinnitus evaluations at the Tinnitus Center at the University of Denver during the past eighteen months. Only patients who have been referred by otolaryngologists are accepted, to minimize the likelihood that a tinnitus patient may have a condition, serious or benign, which may be amenable to medical or surgical intervention. Of these seventy-eight tinnitus patients, six persons have presented with auditory perceptions and seemingly related tinnitus. All of these individuals perceived their sounds as internally generated and none had auditory hallucinations that were threatening, accusatory, or offensive. These persons appear to be normally functioning individuals who are free of psychosis. One patient has normal hearing and the other five have hearing losses resulting from noise exposure, otosclerosis, acoustic trauma, ototoxicity, and presbycusis. The occurrence of this complex auditory phenomenon in 8 percent of the tinnitus patients was quite unexpected and very surprising. The characteristics of these auditory imageries appear to differ from typical auditory hallucinations as reported in the literature; however, they are similar to the syndrome discussed above.

This phenomenon may be much more common than previously reported. The relationship between

tinnitus and complex auditory imagery may indicate that the mechanism causing tinnitus may be more complex in some cases than heretofore believed. Therefore, these cases are presented and discussed here to generate an awareness of this phenomenon, to encourage the elicitation of information about the existence of this syndrome in the case histories of patients, and to encourage the exchange of information concerning this seldom recognized phenomenon about which almost nothing is known.

## REPORT OF CASES

CASE 1. Mrs. G, an 81-year-old retired school teacher, was hospitalized for bacteremia and treated with neomycin, an antibiotic noted for ototoxicity, in August 1977. The patient reported that after a few days in the hospital she felt so much better than she sang along with the music which was piped into her room. The other patient in the semi-private room complimented her on her ability to remember so many old songs which she herself had long ago forgotten and which she had not heard in many years. Mrs. G. commented that she did not remember them, she was merely singing along with the songs being played on the Muzak. The roommate said that she did not hear any music. Mrs. G. asked her visitors if they heard any music, but none of them did. Mrs. G. continued to hear the songs familiar to her and heard by her many years before as if they were being played on Muzak or a tape recorder for about a week. She then reported a hearing loss, vertigo, and tinnitus.

Audiometric data had been recorded for Mrs. G. before and after the treatment with neomycin, as shown in Table 1. Mrs. G. had experienced a bilateral sensorineural hearing loss typical of presbycusis prior to the above treatment and she wore a hearing aid on her left ear to good advantage. Subsequent to the administration of neomycin, Mrs. G. experienced a dramatic drop in the pure-tone thresholds and in speech discrimination for the right ear. There was a lesser change noted in the left ear. The patient did not report the musical imageries to the attending physician for fear that he would think her crazy. Her music disappeared and was replaced with a mid-frequency tinnitus of a ringing-buzzing variety. She was fitted with a new ear level hearing aid on the left ear which provided some improvement in speech perception and masking of tinnitus.

The patient has subsequently experienced violent episodic vertigo which has resulted in a fractured pelvis and a fractured ulna. Cataracts have contributed to the vestibular disturbance. Mrs. G. has recovered from her fractures and she is very active, although she suffers occasional bouts of vertigo. Her medical history is otherwise unremarkable and she appears to be free of psychiatric and neurologic disorders.

CASE 2. Dr. G. is a 51-year-old corporation president and the son of Mrs. G. He has a history of noise exposure in military service during the years 1942-1946. He has a bilateral sensorineural hearing loss typical of a noise-induced hearing loss as shown in Table 1. He has experienced an intermittent tinnitus which sounds like a telephone ring or a door bell for about thirty years. After learning how to read music as a young boy, Dr. G. discovered that he did not need to read music in order to play an instrument. He merely asked his music teacher to play the piece for him and he could then replicate it exact-

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TABLE 1. AIR AND BONE CONDUCTION PURE-TONE THRESHOLDS

Case	Date	Age	Hz:	Right Ear					Left Ear						
				250	500	1000	2000	4000	8000	250	500	1000	2000	4000	8000
1	7-9-75	78		50	40	55	65	70	90	50	50	60	65	75	NR
	12-1-75	79		40	45	55	75	75	NR	50	55	65	65	75	NR
	7-2-76	79		40	40	60	70	65	NR	40	50	60	65	75	NR
	8-31-77	81		45	45	90	100	100	NR	45	55	70	60	95	NR
2	11-30-75	51		0	0	30	70	105	NR	0	0	5	55	95	75
3	9-1-77	47		15	15	15	10	45	60	15	10	10	10	60	65
4	3-28-79	53		5	0	0	0	0	0	10	5	5	0	20	5
5	10-31-78	48	AC:	30	40	55	60	70		40	40	25	40	55	
	10-31-78	48	BC:	10	25	25	40	55		0	5	5	20	55	
	5-21-79	48	AC:	10	10	20	40	60		15	15	15	15	50	
6	9-18-79	45	AC:	20	20	15	25	40	85	20	25	30	40	55	90
	9-18-79	45	BC:	15	15	10	20	35		20	15	15	25	45	

ly as she had played it. He also discovered that he could play any instrument after he found what manipulation of it resulted in which notes produced by it. He found that he had perfect pitch. Dr. G. also learned to practice the piano for his mother's benefit while he read a book hidden in the piano music. Dr. G. reports an internal production of musci which is a continuous sequence of popular songs, jazz, rag, and dixieland similar to what he used to play in bands. Occasionally he hears the classical music which he also played professionally. He says that this continuous personal concert is always there, although he does not necessarily pay attention to it. It does not interfere with speech perception nor with playing music. It does not start and stop with his shifts in attention but acts as if it is being continuously produced by a tape recorder. He had been very disturbed by the tinnitus; however, he now finds that he can control it by refusing to listen to it. Dr. G. also reports that he now hears music one step too sharp. In order to play with someone he must transpose the piece one step down, for example, if he wants to play what sounds like the key of F he must play in the key of E flat. Upward displacement of pitch as a result of exposure to loud tones and noise was reported and discussed by Davis, Morgan, Hawkins, Galambos, and Smith.<sup>11</sup> Presumably, this is the same phenomenon. Dr. G.'s medical history is otherwise unremarkable.

CASE 3. Mr. G. is a university administrator, a musician, and the 47-year-old brother of Dr. G. and the son of Mrs. G. Mr. G. has a bilateral sensorineural sloping hearing loss and a history of noise exposure in military service. Mr. G. also experiences intermittent tinnitus and an internal concert somewhat similar to that of Dr. G. Mr. G. sings professionally and his internal music usually involves repetitions of the songs which he is presently practicing. He may experience all of the pieces to be performed by all of the members of the concert group or production or he may hear only his own pieces. The music is not disturbing nor does it interfere with his activities, although he finds the tinnitus annoying. Mr. G.'s medical history is otherwise unremarkable.

The third sibling in this family, a 50-year-old female, has a bilateral sensorineural sloping hearing loss similar to that of Mr. G., and tinnitus; however, she has no experience of internal music and she is not a musician.

CASE 4. Mr. P. is a 53-year-old geologist who has hearing sensitivity within normal limits bilaterally with a slight dip at 4 kHz for the left ear which was suggestive of some damage from the noise exposure he received in military service. Mr. P. reports no difficulty hearing. He experienced a sudden onset of visual and auditory hallucina-

tions two years before coming to the Tinnitus Center. The visual hallucinations consisted of spots in the total visual field and the auditory hallucinations were the voices he had heard via earphones during the war. The spots disappeared but the voices continued. Mr. P. went to a psychiatrist who examined him and recommended a complete neurologic work-up. He was examined locally and at Harvard University. No condition that could be treated medically or surgically was identified as the cause of his symptoms. The most effective means for eliminating the voices was found to be use of the antipsychotic drug, thiothixene (Navane). When Mr. P. takes this drug the voices disappear and are replaced with a very high frequency tinnitus. When he discontinues the drug, the tinnitus disappears and the voices return.

Mr. P. read about the tinnitus masking devices in a popular publication and asked an otologist to refer him to the Tinnitus Center. His tinnitus (10,991 Hz at 1 dB SL) was easily masked with a narrow band noise at the tinnitus frequency. An Audiotone T-510 tinnitus masker which produces a band of noise from 2 kHz to 18 kHz was fitted to his left ear with a free field ear mold. Mr. P. reports that this device completely masks the tinnitus and that it does not interfere with speech perception. Mr. P. is working and functioning normally and appears to be free of psychosis.

CASE 5. Mr. K. is a 48-year-old male who was twenty-five feet from the center of the explosion of a gasoline refinery in October 1978. He was knocked unconscious by the concussion. When he became conscious he noticed that he could not hear and that he had a noise in his ears. It was reported that he was hemorrhaging from all cranial orifices. He was hospitalized and treated for fractures of the right temporal bone and vertebrae. Both tympanic membranes were perforated and one of the crura of the stapes of the right ear had been fractured. Audiometric testing revealed a mixed hearing loss, which has improved as shown in Table 1. He experienced episodic vertigo which gradually diminished over six months. Mr. K. initially experienced a perception of concert music with many violins which disturbed him, as he did not like concert music. After about a month, the concert music gradually diminished and was replaced with tinnitus.

Eight months after the accident only the tinnitus remained as a disturbing symptom. This tinnitus was identified as a very narrow band of frequencies within  $\pm 2$  percent of 5 kHz at 2 dB SL. However, masking could be achieved only with a very intense narrow band noise. Therefore, none of the available tinnitus maskers

provided relief. It has been hypothesized that tinnitus resulting from one sudden acoustic trauma is very resistant to masking. This tinnitus could easily be the result of several factors; such an accident as Mr. K.'s could produce a lesion almost anywhere in the auditory system. Mr. K.'s medical history was otherwise unremarkable.

CASE 6. Mr. W. is a 45-year-old musician who has had bilateral stapedectomies for otosclerosis. Audiometric evaluation revealed borderline normal hearing in the right ear for low and middle frequencies, sloping to a severe sensorineural hearing loss at the high frequencies; and a mild to moderate mixed loss for the left ear in the low and middle frequencies, sloping to a severe loss at the high frequencies. The stapedectomy on the right ear was performed in 1967 and the stapedectomy on the left ear was performed in March 1979. Mr. W. suffered from an overdose of aspirin in 1967 which resulted in a temporary loss of hearing, tinnitus, and vertigo. Mr. W. experimented with psychoactive drugs such as LSD, PCP, marijuana, and hashish in 1972. In 1974, he experienced a sudden onset of voices which he initially thought were externally produced, and he was very frightened. He soon realized that they were internalized and that they were constant repetitions of innocuous phrases. For example, during one period he heard the phrase, "Praise the Lord," repeated continuously. He found this experience irritating but he did not notice that it interfered with his activities. The voices gradually faded and were replaced with a ringing tinnitus which has increased in loudness over the past five years. The tinnitus was measured as a 9552 Hz pure tone at 6 dB SL. Complete masking of tinnitus could be obtained only with a very intense high frequency narrow band noise. The Audiotone T-570 tinnitus masker provided some relief and is presently being evaluated by the patient.

Upon questioning, Mr. W. revealed that he also hears music similar to that heard by Mr. G. in case 3. He stated that the two phenomena were not similar, as the music was pleasant and unobtrusive and the voices and tinnitus were irritating. Mr. W.'s medical history was otherwise unremarkable.

## DISCUSSION

The article by Ross et al.<sup>1</sup> noted that the patients exhibiting this syndrome fit into a stereotypical pattern. They had a progressive hearing loss and tinnitus with an onset of hearing music concurrent with further loss of hearing and an experience of the phenomenon in the more impaired ear. The music consisted of a voice or instrument or some combination of these which typically reflected past experience or memory. Some were continually changing and others were constantly repetitive. The authors argued that these imageries resulted from the pathologic factors in the peripheral mechanism. This was compared with the illusion of the phantom limb and with the visual hallucinations in ocular disorders of neural and non-neural, structural origin. Sensory deprivation was also noted. The authors concluded that a variety of sensory mechanisms may be operating in the production of these imageries and that they may be similar to those involved in normal sensory perception.

Miller and Crosby<sup>9</sup> also noted that case

histories of persons exhibiting this syndrome included a progressive hearing loss of long duration, either conductive or sensorineural, which preceded a sudden onset of vivid auditory imageries reflecting past experience. They found that these perceptions were disturbing not in content but in their monotony and persistence. The authors noted that hearing loss rather than cerebrovascular disease appeared to be the common element. They speculated that this phenomenon is related to sensory deprivation, since it is similar to that experienced by the rare persons with slowly progressive blindness.

Rozanski and Rosen<sup>4</sup> stated that although it had been assumed that hallucinations could arise only from activity in the cerebrum, it had been shown that irritation in the peripheral ocular mechanism alone could induce such perceptions. They concluded that their patient's auditory imageries arose from an irritation of the peripheral auditory system because of the otosclerotic process there. They hypothesized that it may not be possible to distinguish between sensory centers and pathways in the designation of a locus of the production of imageries, since they are all a part of the whole system.

The six cases presented in this paper provide a wide variety of characteristics and possible etiologic factors. Only one of the six has a hearing loss that could be considered substantial enough to result in sensory deprivation. Even in this case, auditory imageries disappeared when the hearing impairment worsened. Peripheral pathologic factors could exist in all of the cases; however, it would be difficult to advance this argument for Mr. P., in case 4, who had normal hearing.

Penfield and Jasper<sup>12</sup> report the occurrence of voices and music and tinnitus resulting from electrical stimulation of certain areas of the temporal cortex. These perceptions are strikingly similar to those reported for the syndrome under discussion. It is as if a tape recording from some prior experience of the patient has been played back through his auditory system. A compelling argument can be made that these perceptions occur as a result of some unknown stimulation of the cortex or some lack of stimulation of the auditory cortex resulting in disinhibition, or some compensatory activity of the auditory system.

There is an extraordinary phenomenon of the visual system known as eidetic imagery which is characterized by vivid and detailed photographic images of complex visual stimuli. This unusual phenomenon has been demonstrated to be a real visual perception with a locus in the visual system rather than a memory of a visual stimulus as reported by Haber.<sup>13</sup> This author found that about 5 percent of the more than 500 children he screened in elementary schools reported visual images that lasted from a half-minute to more than thirty minutes. It has been hypothesized that artists may exhibit this eidetic imagery. It may be that such a vivid auditory imagery exists for some individuals



also. It could be hypothesized that those musicians exhibiting total recall of thousands of musical pieces, such as Dr. G., case 2, may be experiencing this phenomenon. It may be a latent phenomenon which only appears when the auditory system is disturbed as in case 1. It may exist in varying degrees, as in case 3 vs. case 2.

The origin of tinnitus has been theorized by Stevens and Davis<sup>14</sup> to be the result of the hyperirritability of the hair cells or the nerve cells connected to them. Kiang, Moxon, and Levine<sup>15</sup> stated that although it had been assumed that tinnitus associated with sensorineural hearing loss resulted from increased activity because of hyperirritability, they found a decrease of activity. The authors concluded that it may be the absence of activity or the pattern of the distribution of activity which results in tinnitus. Shea and Harell<sup>16</sup> argued that the administration of local anesthetics reduced or eliminated tinnitus by blocking the hyperactivity of the auditory reflex arc in the central nervous system. Masking of tinnitus with sound may be efficacious because it blurs the sharp gradients between the patterns of activity and absence of activity. It may also have an inhibitory effect in the auditory cortex. It would be interesting to see what effect masking by sound and the administration of local anesthetics would have on auditory hallucinations associated with psychosis.

The preceding discussion raises more questions than it answers. However, there is much to be learned by seeking the answers to these questions so that the complexities of the auditory perceptual system can be better understood and so that those suffering from dysfunction in this system can be helped. Therefore, a plea is made to clinicians to query their patients concerning this unusual

phenomenon, since the common element appears to be peripheral otologic pathologic factors.

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## DATA BANK

The percutaneous nerve excitability test, to evaluate facial paralysis, was first introduced by Duchene in 1872 and popularized in the United States by the introduction of the Hilger stimulator in 1964. (Mark May, *Facial Nerve Surgery*, by U. Fisch.)