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Music Agnosias: Selective Impairments of Music Recognition After Brain Damage

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ABSTRACT

Neuropsychological findings suggest that music is a special faculty (e.g., with respect to language) by being carried out by dedicated processes that are subserved by distinct anatomical brain structures. In the present paper, we review the evidence provided by brain-damaged patients who suffer from music agnosia, a selective impairment in music recognition. Three cases of music agnosia (C.N., G.L., and I.R.) without concomitant disorders and previously described independently are compared, with respect to the specificity issue.

INTRODUCTION

Music is a universal auditory-vocal expression of human cognition. All cultures seem to have music, under different forms. Music is learned quite effortlessly in early childhood and plays a particular role in promoting social cohesion and interaction between people. The fact that these properties are shared, to some extent, with language (see Aiello, 1994; Sloboda, 1985) raises the question as to whether music and language are processed by the same neural structures in the brain. This is an old debate which is still ongoing. On one hand, music is regarded as the product of a general purpose cognitive architecture (e.g., Handel, 1989; Bregman, 1990) that is shared with language. Accordingly, music and language should be mostly processed by the same neural system. On the other hand, we argue, along with others (e.g., Fodor, 1983; Jackendoff, 1987; Peretz & Morais, 1989, 1993), that music may be subserved by a specialized cognitive architecture that is implemented in specific neural networks. This claim entails that music and language rely essentially on distinct neural systems.

SPECIFICITY FOR MUSIC

The concept of specificity simply states that the brain is structured in such a way that different cognitive functions, such as speech comprehension and visual object recognition, are carried out by different and dedicated processes that are, probably, subserved by different anatomical regions of the brain. The regular observation that brain injury can produce highly selective deficits, by being limited, for instance, to speech comprehension without concomitant disorders, support the idea that cognitive functions, or at least some of them, may be functionally and anatomically independent in the brain. In neuropsychological terms, specificity can generally be assimilated to selectivity (Shallice, 1981, 1988).

One powerful way to demonstrate specificity for a function is to obtain what neuropsychologists call a "double dissociation" (Shallice, 1988; Teuber, 1955). Suppose two tasks (T1 and T2), the one relying on function f(1), the other on function f(2). The finding of a brain-damaged patient whose performance is impaired only on T1 (simple dissociation) suggests that f(1) and f(2) are functionally independent. However, a simple dissociation does not necessarily imply functional independence, since T1 could be more difficult than T2 (Shallice, 1988). What is needed is a reverse dissociation, exhibited by a second patient who shows a selective deficit in T2. This pattern is referred to as double dissociation. All along the history of neuropsychology, numerous cases of double dissociation between music and language processing have been reported.

Gall (1825) was among the first to affirm the existence of a "musical organ" in the brain, that is, a specific region devoted to music processing that could be selectively spared or disrupted following brain damage. It is somewhat later, during the second half of the 19th century, that this hypothesis has been seriously considered. A few neurologists, shortly after the discovery by Broca (1861) of a centre responsible for the articulation of verbal language in the left frontal lobe, explored what happened to music as opposed to language in musicians who had undergone brain damage.

Bouillaud (1865, in Dorgueille, 1966) reported the case of a brain-damaged musician who could sing, compose, and write music, even though he was unable to speak, to write and to read language. Many similar cases of aphasia (with severe disorders of language production or comprehension following a brain damage) without amusia ("a generic term used to designate acquired disorders of music perception, performance, and reading or writing that are secondary to organic brain damage", Marin, 1982, p. 454) were reported subsequently (see Basso, 1993; Benton, 1977; Dorgueille, 1966; Marin, 1982; Samson & Zatorre, 1994, for reviews). For instance, Luria, Tvetskova and Futer (1965) described the case of a well-known Russian composer, Shebalin, who at the age of 57 had left-hemisphere strokes. A neuropsychological assessment six months after the last stroke revealed that Shebalin was still able to compose despite a severe disorder in spoken expression. One of Shebalin's last pieces for orchestra, the Fifth Symphony in C flat, was created during this period, and has been qualified by Shostakovich as "the creation of a great master" (Luria et al., 1965). Other similar cases have been reported later by Basso and Capitani (1985) and Signoret, Van Eeckhout, Poncet and Castaigne (1987).

The opposite pattern — amusia without aphasia — is less common. However, early cases have been described. For example, Quensel and Pfeiffer (1922, reported in Dorgueille, 1966) described an interesting case of a brain-damaged amateur musician who did not have any aphasic problem, he could understand, speak and write normally. Nonetheless, he was not able to recognize any melody at all, whether sung, whistled or played on an instrument. Another case was reported more recently by McFarland and Fortin (1982). The patient was an amateur organist who, following a right cerebral infarct, displayed mainly an instrumental expressive amusia (he was no longer able to play the organ) without any aphasic symptom.

Taken together, these findings suggest some specificity for music. However, most of these case reports are anecdotal. Moreover, all patients were musicians. Since there is increasing evidence that musicians represent a special category of people whose cognitive architecture and brain organization may differ from that of the majority of listeners who are nonmusicians (e.g., Bever & Chiarello, 1974; Elbert, Pantev, Wienbruch, Rockstroh, & Taub, 1995; Schlaug, Jäncke, Huang, & Steinmetz, 1995), the double dissociation observed between music and language may not apply to the general population.

More recently, however, nonmusicians' auditory deficits have been studied in more controlled conditions. These analyses have largely confirmed the earlier suggestion of a double dissociation between language and music. Nonmusicians have been found to exhibit quantified deficits in language but not music (Godefroy et al., 1995). Conversely, nonmusicians have been found to exhibit deficits in music but not language under similar testing conditions (Griffith et al., 1997; Peretz, 1996; Peretz, Belleville & Fontaine, 1997; Peretz et al., 1994).

AUDITORY AGNOSIA

So far we have considered specificity as applying to whole faculties, without discriminating between perception and performance. In this section, we will focus our attention to recognition abilities and evaluate to what extent these abilities are domain-specific.

In general, any impairment in the recognition of auditory events (such as speech, music and environmental sounds) following brain damage is referred to as "auditory agnosia" (Lichtheim, 1885; see Peretz 1993 for a review). This disorder is limited to the auditory modality (recognition is possible by sight or touch) and cannot be explained by deafness.

Most often, auditory agnosia is a global syndrome, by affecting the recognition of all categories of sounds. In some cases, however, the auditory deficit can be quite selective. A well-established line of division concerns verbal agnosia and non-verbal agnosia. The first refers to a selective loss of recognition abilities for speech sounds and the latter to a selective loss of recognition for nonverbal sounds, involving both music and other familiar environmental sounds (such as animal cries, traffic noises, etc.). This distinction is supported by a double dissociation, as illustrated in Table 1.

The verbal/non-verbal distinction does not exhaust all possibilities. Music recognition abilities appear dissociable as well. Cases of selective sparing and of selective losses have been documented (see Table 1). The evidence is less clear for the category of environmental sounds. Although there are cases of selective sparing (Eustache, Lechevalier, Viader, & Lambert, 1990; Tanaka, Yamadori, & Mori, 1987; Mendez & Geehan, 1988, during recovery), selective losses have never been observed at onset but only during recovery (Motomura, Yamadori, Mori, & Tamaru, 1986).

To sum up, recognition processes for auditory events are not subserved by a common and unique system but instead rely on multiple mechanisms that are domain specific. Multiple dissociations lead to the conclusion that at least two separable systems of auditory recognition exist, one for speech and one for music. Recognition of other

Table 1. Case reports of selective impairment in the recognition of speech sounds, music and environmental sounds.

Reports	Domain		
	Speech	Music	Environmental sounds
Metz-Lutz and Dahl (1984)	–	+	+
Yaqub et al. (1988)	–	+	+
Takahashi et al. (1992)	–	+	+
Spreen et al. (1965)	+	–	–
Habib et al. (1995)	+	–	–
Laignel-Lavastine and Alajouanine (1921)	–	+	–
Godefroy et al. (1995)[a]	–	+	–
Peretz et al. (1994), C.N. and G.L.	+	–	+
Peretz et al. (1997), I.R.	+	–	+
Griffith et al. (1997)	+	–	+
Tanaka et al. (1987)	–	–	+
Eustache et al. (1990), case I	–	–	+
Mendez and Geehan (1988)[a], case II	–	–	+
Motomura et al. (1986)[a]	+	+	–

+ = normal recognition; – = impaired recognition
[a]during recovery

environmental sounds my be subserved by a specialized system as well. However, this latter category is ill-defined and requires further neuropsychological scrutiny. For the time being, the taxonomy of auditory agnosias involves verbal agnosia (or verbal deafness) and music agnosia. We will see below that phonagnosia, corresponding to loss of recognition abilities for human voices, and aprosodia, corresponding to an impairment in recognizing the tone of voice, may constitute distinct abilities. However, these latter categories are rarely assessed in patients suffering from some form of auditory agnosia.

MUSIC AGNOSIA

As mentioned above, we have been able to study three cases of music agnosia in some detail (C.N., G.L., and I.R). Since these cases have been published independently (in Peretz et al., 1994, Peretz, 1996, and Peretz et al., 1997), we take this opportunity to integrate their results related to the domain specificity issue in the present section.

Case history

All three cases had an identical neurological history. All three suffer from bilateral damage to the auditory cortex as a consequence of successive brain surgeries for the clipping of mirror aneurysms located on each middle cerebral artery. As a consequence and at least 6 years post-surgeries, all three patients complained about persisting musical difficulties while their understanding of speech was fully functional. We have been able to study one of the cases — C.N. — early after her brain surgeries and to follow her up for 5 years. We will consider here only C.N.'s results 6 years post-onset so as to allow more direct comparison with the other two cases — G.L. and I.R. — who were studied 9 to 10 years post-onset.

All three patients are right-handed and are musically inclined, although none of them received formal musical education. Both C.N. and I.R. were tested in their early forties and G.L. was in his early sixties. I.R. was the least educated patient, with 10 years of education. C.N. and G.L. had about 15 years of education.

Neuropsychological evaluation

All three patients have a normal intelligence and memory functioning, as assessed by the Wechsler intelligence and memory scales. None of them display signs of language disorders as assessed by standard aphasic examination tests. It is noteworthy that they normally recognize from memory the lyrics taken from familiar songs. A summary of the major outcome is provided in Table 2.

Their common and remarkable symptom is that all three patients are severely impaired in the recognition of melodies that were once highly familiar to them. They cannot name a single tune; they fail to reach normal performance when having to decide whether a melody is familiar or unfamiliar (familiarity decision task) and they fail to recognize them in a memory recognition task. In contrast, all three can easily recognize familiar environmental sounds (including animal cries, traffic noises, household noises, etc.) and recognize these among distractors in a memory recognition task. The patients perform as well when instead of melodies, they are presented with familiar lyrics, in a familiarity decision task and in a memory recognition task. Hence, C.N., G.L., and I.R. represent three clear-cut cases of music agnosia, as depicted in Table 1.

However, explorations of less traditional areas of auditory events reveal that the auditory losses go beyond music. All three patients encounter difficulties in recognizing musical instruments and human voices. Although the severity of these deficits is not as striking as the ones observed for musical patterns, their presence suggest that the auditory agnosia exhibited by our three music agnosic patients is not purely musical.

Another important but neglected area of comparison concerns speech prosody. Analogies between prosody and music are compelling. Indeed, I.R. was found to have similar difficulties when dealing with prosodic and music-like patterns (Patel, Peretz, Tramo, & Labreque, 1998). This deficit was only apparent when the task involved short-term memory. None of the patients exhibit deficiencies in interpreting intonation patterns in on-line tasks. Thus, it is as yet unclear whether common cortical mechanisms are mediating the processing of some aspects of prosody and music.

Table 2. Summary of the results obtained by C.N. (6 years post-onset), G.L., and I.R.

Tests	C.N.	G.L.	I.R.
Intellectual abilities (WAIS)	n	n	n
Memory (Wechsler)	n	n	n
Language			
Token test	n	n	n
Boston Diagnostic Aphasia Examination	n	n	n
Familiar/unfamiliar spoken lyrics	n	n	n
Lyrics recall	n–		n–
Memory recognition for familiar lyrics	n		n
Familiar music			
Naming	–	–	–
Familiarity decision	–	n–	n–
Memory recognition	–		–
Environmental sounds			
Naming	n	n	n
Memory recognition	n		n
Musical instruments			
Naming		n–	n–
Human voices			
Naming	n–	n–	n–
Prosody			
Intonation	n	n	n

n = normal; n– = below normal but above chance; – = chance

The present results should be viewed more as incentives for carrying out systematic investigations than as definitive support for an alternative taxonomy of cortical auditory disorders. Still, the data in hand argue that 1) nonverbal auditory agnosia is not a homogeneous syndrome; and 2) the observed functional associations may emerge as the result of damage to specialized neural subsystems that lie in anatomical proximity within the superior temporal region.

Heterogeneity

It must be emphasized that music agnosia is a syndrome, or a generic term, in the sense that the failure to recognize music can arise from the disruption of different mechanisms. For example, both C.N. (at an early stage of recovery) and G.L. suffered from difficulties to deal with pitch variations and not temporal variations, which were spared. As we have later shown in normal subjects (Hebert & Peretz, 1997), consideration of pitch variations is crucial for melody recognition. Hence, disruption to this single pathway can compromise music recognition by itself. Another source for music recognition failures may lie at the level of the memory stored representations that can be selectively degraded by the lesions. For example, C.N. after recovering most, if not all, her perceptual abilities was still found to exhibit recognition failures for music in a variety of tasks (Peretz, 1996). Conversely, I.R. may still possess most of these stored representations but access to these are compromised by severe perceptual and expressive disorders (i.e., I.R. cannot sing a single pitch).

Neural correlates

Auditory agnosias, affecting either all kinds or only a subset of sounds, are usually associated with bilateral damage to the superior temporal regions (see Peretz, 1994, for a review, but see Griffith et al., 1997, for the observation of music agnosia after unilateral lesion to the right hemisphere). Other scenarios are possible, depending on the mechanisms responsible for the observed agnosia. With respect to music agnosia, it is conceivable that a unilateral lesion on either side be responsible for the disorder. In effect, unilateral brain damage on either side can impair music perceptual mechanisms. With respect to pitch sequential variations, a right-sided lesion will disturb the extraction of the melodic contour (i.e., the succession of pitch directions) whereas both a right-sided and a left-sided lesion can impair computation of pitch interval structure (Liégeois-Chauvel, Peretz, Babaï, Laguitton, & Chauvel, 1998; Peretz, 1990; but see Zatorre, 1985, 1994, for an overall right-hemisphere predominance). Moreover, temporal structure may recruit more of the left-hemisphere structures. Similarly, memory representations of music may be stored in the left-hemisphere (Platel et al., 1997).

At this stage, a grid is necessary for fractionating the music recognition system in order for its relevant components to be identified and, hence, their neural substrates circumscribed (see Peretz, 1993, for just such a proposal).

CONCLUSIONS

We have shown how informative the detailed study of neurological disorders of high level audition can be. This is already well-established in other domains, such as in visual agnosia (e.g., Farah, 1990). Curiously, very few scientists have worked on auditory agnosia, and hence numerous questions remain unanswered. With respect to the musical domain with which the present issue is concerned, we would like to add that there is ample room for future investigations. Musical disorders are not rare, since accidental vascular lesions often invade the sylvian territory where the major areas devoted to music lie. Moreover, multiple processing components, such as those involved in temporal processing, remain underinvestigated. Similarly, recognition activities are not the sole, nor even the major, reason why we listen to music. These other aspects of music functioning deserve more empirical attention as well. For example, we recently explored music processing via emotional judgements and found new exciting dissociations that suggest the existence of multiple and separable modules for music appreciation (Peretz & Gagnon, in press; Peretz, Gagnon, & Bouchard, 1998). In sum, even if the study of brain-damaged patients has already a long tradition, there is still plenty room for innovative and exciting discoveries.

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