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**Jean-Martin Charcot's role in the nineteenth-century study
of "music aphasia"**

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Abstract

Jean-Martin Charcot (1825-1893) was a well-known French neurologist. Although he is widely recognized for his discovery of several neurological disorders and his research about aphasia, Charcot's ideas about how the brain processes music are less well known. Charcot discussed the music abilities of several patients in the context of his 'Friday Lessons' on aphasia, which took place at the Salpêtrière Hospital in Paris during 1883-1884. In his most comprehensive discussion about music, Charcot described a professional trombone player who developed difficulty copying music notation and playing his instrument, thereby identifying a new isolated syndrome of music agraphia without aphasia. Because the description of this case was published only in Italian by one of his students, Domenico Miliotti, there has been considerable confusion and under-acknowledgement of Charcot's ideas about music and the brain. In this paper, we describe Charcot's ideas about music and place them within the historical context of the growing interest in the neurological underpinnings of music abilities that took place in the 1880s.

Keywords: amusia; music agraphia; Charcot; aphasia; Miliotti

Introduction

Jean-Martin Charcot (1825-1893) is considered the founder of both French neurology and the Salpêtrière School of neurology (Goetz *et al.*, 1995; Broussolle *et al.*, 2012). He is widely celebrated for the discovery of a number of neurological disorders and remembered for his exceptional teaching skills. While Charcot's contribution to aphasia research is well documented (Brais, 1993; Bonduelle and Goetz, 1996; Tesak and Code, 2008), less well known are his ideas on how the brain processes music, which were informed by his clinical observations of music agraphia and motor amusia. Charcot discussed the music abilities of several patients in the context of his 'Friday Lessons' on aphasia, which took place at the Salpêtrière Hospital in Paris during 1883-1884. In his most comprehensive discussion about music, Charcot described a professional trombone player who developed difficulty copying music notation and playing his instrument, thereby identifying a new isolated syndrome of music agraphia without aphasia. Charcot's case history of the trombone player was only recorded in Italian by one of his students, Domenico Miliotti, in 1885 (Miliotti, 1885). The case of the trombonist was cited by other nineteenth-century neurologists in discussions of acquired music impairments; however, few details were typically provided, and its primary source was often missing. This contributed to confusion about the source of the case, and Charcot is rarely acknowledged for these discussions. Due to the rarity of music agraphia, the full details of Charcot's cases are provided here. His theoretical ideas about music processing are also placed within the historical context of the growing interest in the neurological underpinnings of music abilities that took place during the 1880s.

Jean-Martin Charcot was born in Paris in 1825. He worked and taught at the Salpêtrière Hospital in Paris for 33 years, starting as the *chief of service* in 1861 and becoming the Chair in Pathologic Anatomy in 1873 (Goetz *et al.*, 1995). His career was characterized by numerous distinctions and discoveries, and there are over a dozen medical eponyms attributed to him, the best known of which are

Charcot-Marie-Tooth disease and Charcot's disease, also called amyotrophic lateral sclerosis. During the 1860s and 1870s Charcot's clinical focus was primarily on diseases of the elderly, and his research focus was on the localization of motor function in the brain (e.g., Charcot, 1875; Charcot and Pitres, 1877).

In 1882, a new Clinical Chair for the Diseases of the Nervous System was created for Charcot at the Faculty of Paris. The following year he established a neurology clinic at the Salpêtrière. His inaugural series of lectures at the clinic in the summers of 1883 and 1884 was on the topic of aphasia and related disorders. It was in the context of these lectures about aphasia that Charcot also considered aspects of music and brain. While there has been a great deal written about Charcot's interests in art and literature (Goetz, 1991; Goetz *et al.*, 1995; Bogousslavsky, 2004), little is known about his ideas about music. Guillain (1959) states that while he did not have music training or play a musical instrument, he did attend both the Folies Bergères and the opera. He had a preference for eighteenth- and early nineteenth-century composers, such as Ludwig van Beethoven (1770-1827), Christoph Willibald von Gluck (1714-1787), Jean-Philippe Rameau (1683-1764), Wolfgang Amadeus Mozart (1756-1791), as well as Carl Maria von Weber (1786-1826). (Daudet, 1922; Guillain, 1959; Goetz *et al.*, 1995;). There is a great deal of information regarding the inclusion of painters, sculptors, architects, and writers in his social network (Goetz *et al.*, 1995), but there is little mention of any particular friendships with musicians. However, Charcot did appear to have set aside Thursday evenings for social activities and the appreciation of music, in particular (Daudet, 1915).

Studies of Music Agraphia before Charcot

Prior to Charcot's investigations in 1883-84, two case descriptions about an acquired difficulty writing music notation (music agraphia) had received attention. In 1867, a German medical student, Alexander Fischer, studied a 42-year old composer and music teacher as part of his thesis about aphasia

(Fischer, 1867). The composer had difficulty reading and writing music notation in addition to word blindness (alexia), aphasia, and verbal agraphia. In 1870, Karl Finkelnburg, a professor of Psychiatry from Bonn, Germany, described an amateur violinist with aphasia and verbal agraphia who also had difficulty reading and writing music notation although he could still play melodies by ear (Finkelnburg, 1870; Duffy and Liles, 1979). The patient died six months later, and the autopsy revealed lesions in the right hemisphere, including the anterior gyrus of the “central lobe” and corpus striatum. Finkelnburg used this case to argue that aphasia may extend beyond speech impairment to include deficits in comprehension, reading, writing, and use of non-verbal symbols, including music. While Fischer’s and Finkelnburg’s cases each had verbal agraphia and music agraphia, three other cases reported by Bouillaud, Trousseau, and Proust (Bouillaud, 1865; Trousseau, 1865; Proust, 1872) had both verbal aphasia and agraphia but a preserved ability to write music notation. All of these cases differ from Charcot’s trombone player, presented below, who had music agraphia but without aphasia.

The Friday Lessons on Aphasia (1883-1884)

Charcot’s dramatic teaching lectures attracted junior and senior clinicians from around the world. During the summers of 1883 and 1884, Charcot delivered a series of 14 lectures on aphasia at the Salpêtrière Hospital (Brais, 1993). Nine lectures were delivered during the summer of 1883 and five during the summer of 1884. Various parts of the lectures were transcribed and published by Charcot’s students and clinical associates (Goetz *et al.*, 1995). Charles Féré (1852-1907), an assistant physician and personal secretary to Charcot, published the first five lectures in 1883 (Féré, 1883*a, b, c, d, e*). Pierre Marie (1853-1940), a physician and head of Charcot’s clinic in 1883, also wrote a summary of the 1883 lessons in two publications (Marie, 1883, 1888). Two others carried out theses under Charcot’s supervision during this period, and each included discussions from the Friday Lessons: Désiré-Antoine-

François Bernard's (1853-1888) "*De l'aphasie et de ses diverses formes*" (Bernard, 1885) and Gilbert Ballet's (1853–1916) "*Le langage intérieur et les diverses formes de l'aphasie*" (Ballet, 1886). Gaetano Rummo (1853-1917), an Italian physician attending Charcot's clinic published in Italian what appears to be the only complete version of the 1883 lectures (Rummo, 1884). Domenico Miliotti (dates unknown), another Italian student-physician, attended the five lectures during the summer of 1884 and later published them in Italian: "*Lezioni cliniche dell'anno scolastico 1883-84 sulle malattie del sistema nervoso*" (Miliotti, 1885). (Figure 1) It was in the context of the Friday Lessons that Charcot discussed his ideas about music and brain.

This paper will present the details of Charcot's lectures that included discussion about music based on these second hand reports provided by his students and clinical associates. It must be noted that, in such instances, there is always the risk that the accounts of the lectures reflect the interpretations by the students rather than reproducing directly the ideas of their originator. For example, the veracity of transcriptions of Charcot's lectures on tics, published by another Italian student, Giulio Melotti, has been challenged (Kushner *et al* , 1999). However, Charcot wrote the preface for both the Miliotti and Rummo texts, thereby giving his approval of the translations, and Goetz and colleagues (1995) noted that Charcot's lectures were presented in a form that was nearly ready for publication. The goal of this paper is to provide one of the first comprehensive reviews of Charcot's ideas about music using available documents.

Discussion of Music during the Friday Lessons

During the Friday Lessons, Charcot discussed music abilities of several patients as illustrations of organization of the language faculty. These lectures appear to be a unique instance in which Charcot

considered aspects of music abilities and impairments; no mention of this topic appears in his own publications. However, the writings of Féré, Ballet, Bernard, and Miliotti document four cases that Charcot discussed with regard to his ideas about music in the 1883-84 lectures. The following sections detail these cases, which are also summarized in Table 1.

The Aphasic who could Sing “La Marseillaise”. Féré (1883d) recorded the case of patient “H” who could correctly sing the melody of the French national anthem “*La Marseillaise*” but only while using a “guttural sound.” Féré commented that the preserved ability to produce the melody without the song text exemplified the fractionization of music abilities. He stated:

If time permitted, it would be the case for you to notice that the musical faculty may be, too, as the language faculty, split, somehow, by the disease, in a number of compartments. I could indeed give you several examples where it is musicians who have retained the ability to recognize the song to play the piano, however, had become unable to decipher written music. (Féré, 1883d, p. 522.) (original text in Appendix)

This dissociation between the melody and song text was the most common report of music in earlier neurology literature (Johnson *et al.*, 2010). Féré also referred to other cases (without citations) in which musicians with brain damage were able to recognize a familiar melody but not read music notation, possibly referring to the those by Finkelnburg (1870) and Fischer (1867) discussed above. Bernard (1885) also mentioned patient “H” but provided no additional details.

The Piano Teacher with “Music Blindness”. Bernard (1885) reported Charcot’s case of a 45-year old piano teacher (a woman also called “H”) who had a non-fluent aphasia and complete music blindness (*cécité musicale complète*) due to epilepsy. She suffered aphasia several years earlier, but recovered somewhat before she entered the Salpêtrière on December 12, 1881. Charcot discussed her on Friday, June 1, 1883, making it likely that this case was discussed as a part of that Friday Lesson. Patient H was also known as “*la Dame blanche*”, as she often sang an aria from the comic opera of this

name by Boïeldieu. (It is important to note that “*la Dame blanche*” was not Blanche Wittmann the famous patient depicted on the *Lecon à la Salpêtrière* painting by Brouillet.) Bernard noted that although her speech was impaired, she was able to accurately sing both the melody and text of this song and a few others, but she refused to sing other less familiar songs. Bernard (1885) wrote:

The lyrics are distinct, the melody exactly repeated. When she sings H... uses her left hand, her fingers beat time on the bed cover. The condition of the patient does not allow us to try placing her in front of a piano, to see how these movements were related. She regularly sings a rude song. It was impossible to get her to sing other familiar melodies. But she hums dance tunes when asked, rhythmically waving her fingers of her left hand. Impossible also to talk with her about famous opera, music of masters (teachers). "I forgot all that, I do not know". (p. 120) (original text in Appendix)

Bernard (1885) also noted that she was unable to read music notation:

The score itself, the musical notation is completely indecipherable for her. Often the experiment was done. No sign on (musical) stave could not be recognized or called by her. She read the header of a piece, line by line, by following it with the finger. On staves, her finger stopped or went astray. In vain we pressed, we varied the questions: "What have you under your eyes? Where such a key? where such a note? ... The uncertain eyes, she answered steadily: "I do not know, I do not know"... The words and figures arranged between staves, the text of songs and signs showing the movement were read as well as printed words posted. (p. 122) (original text in Appendix)

Patient H, died of pneumonia on May 11, 1884, and an autopsy revealed a large “yellow plaque” on the surface of the left frontal and parietal lobes that extended to several subcortical structures. Bernard provided a schematic of the lesion (Figure 2). Such pathological evidence was viewed as key by Charcot and his disciples for theorizing about the localization of brain functions. (However, see Bastian, 1898 for an alternative interpretation of the case based on the autopsy findings.)

The Medical Professor and Musician with “Music Blindness”. Both Bernard (1885) and Ballet (1886) referred to another of Charcot’s aphasic patients with music blindness (*cécité musicale*) discussed in the 1883 lectures. Bernard (1885) discussed Charcot’s report of this case:

Charcot reported in one of his lectures in 1883 that in one of his colleagues at the Faculty of Medicine, who died aphasic and hemiplegic on the right, the first symptom of his brain damage was a music blindness. One day he sits at the piano, opens a partition and can not

decipher a single note, while he moves his fingers on the keyboard with ease and accuracy. Finkelnburg's patient, struck with the same blindness, could play from memory and play melodies he heard sung or perform. Bouillaud's patient cited above presented verbal and music blindness. (p. 118-119). (original text in Appendix)

Ballet (1886) also made a brief reference to this case:

M. Charcot told us that one of his colleagues, an eminent Faculty of Paris professor and distinguished musician, was unpleasantly surprised when he was at the piano one day and was not able to play as usual. He saw the notes, but did not understand them any more. Musical blindness was, in this particular case, the forerunner of a hemiplegia to which the patient succumbed. (p. 110) (original text in Appendix)

Both Ballet and Bernard discussed this case in context of comprehension of symbols, such as numbers and mathematical equations. Because he was interested in documenting isolated deficits and dissociations, Charcot used this case to point out that music alexia could be initially present as an isolated syndrome, with aphasia and hemiplegia evolving later. As noted by Ballet (1886), Charcot was also aware of cases by Finkelnburg (1870) and Bouillaud (1865) who had both music alexia and verbal alexia.

The Trombonist with “Music Agraphia” and “Music Aphasia”. The final case relating to music abilities is the most detailed and significant of the four cases presented by Charcot during his 1883-84 Friday Lessons. It includes a description of what Charcot called “music aphasia” and “music agraphia”. During the May 16, 1884 lesson at the Salpêtrière hospital, Charcot discussed a professional trombone player who had difficulty playing his instrument and copying music. These music deficits contrasted with his preserved verbal language skills. Charcot further discussed this case during the June 13, June 20, and June 27 lessons of the same year as documented by Miliotti (1885) in Italian. This report by Miliotti has been translated into English for the first time by Monica Pianezzi and is summarized below.

In the preamble to the lecture demonstration, Charcot discussed aphasia as an impairment of concept expression in speech and writing. He extended this by analogy to other faculties and means of expression, such as numbers and gestures, and questioned whether music was a similar ability. Prior to his illness, the trombonist played for several years in the well-known “Republican Guard” military band, which traveled throughout the world. The trombonist is identified as Dherbecourt (last name) by Gasser (Gasser, 1995), and Comettant (1894) lists Dherbecourt as one of the saxhorn players in the Republican Guard military band that visited Boston, Massachusetts for the Peace Jubilee in 1872. (Figure 3). After a few years in the military band, the trombonist played in orchestras and theaters in Paris and was a professional copyist employed by some of the “greatest music teachers in Paris”, such as Jules Massenet (1842-1912), to produce performance copies of musical scores. Charcot noted that copying music at this level demanded a good knowledge of music, the ability to read music notation quickly and write clearly, as well as to correct mistakes.

The trombone player’s past medical history included an unconfirmed report of syphilis as a child. His father was an alcoholic and had a hand tremor; and while the trombonist also had a hand tremor, he did not drink alcohol. Charcot, therefore, deduced that the tremor was a benign familial tremor. Importantly, the tremor did not interfere with the trombonist’s ability to copy music or play his instrument prior to his present illness.

At age 45, the trombonist was described as having “sudden dazes” and dizziness that caused him to vomit and fall (without loss of consciousness). Charcot noted some similarities to Ménière’s disease (only recently defined by the French physician Prosper Ménière in 1861), but ruled out this diagnosis as several of the auditory symptoms were absent in the trombonist.

In September 1883 after leaving Trouville where he had been working long hours playing in an orchestra, the trombonist returned to his work as a music copyist; however, he found that although he

could “sing the music in his mind”, he could not write it. There was no change in his hand movements or written language. Charcot compared the inability to copy music notation, or music agraphia, to verbal agraphia. He also suggested that the dissociation of writing music notation and writing verbal language supported the theory of cerebral localization but required confirmation by autopsy.

Charcot then went on to demonstrate a second impairment, namely a difficulty playing his instrument. The patient was unable to move the trombone slide or produce a meaningful sound (using his lips and tongue to make an embouchure). The interpretation provided for this was as follows:

As the musical phrase sounded in his brain, awakened by the reading of written music, he should have been able to translate it in sounds through his instrument; but instead he has lost the memory of those movements of lips, tongue, and hand which allowed him to do that. (Miliotti, 1885, p. 141) (original text in Appendix)

Charcot also acknowledged the need to imagine the melody and then translate this imagined melody into specific motor movements required for playing an instrument, such as the trombone, which has no keys.

He attributed the inability to play the imagined melody to a deficit in the memory for movements:

When he tries to play his instrument, which does not have existing notes like a piano, he needs to evoke in his spirit the tonal image, the note, actually a hallucination of the note; he needs to use his interior hearing; and when the note plays in his ear through this hallucination, he needs to express it, to externalize it through his instrument using his tongue and lips to articulate the note (this is what the patient says) and then his hand too, to extend or contract the instrument following the intonation’s need. (Miliotti, 1885, p. 140) (original text in Appendix)

It is not clear if this account is from Charcot, or the patient himself, or how much of Miliotti’s own thinking also shaped this interpretation of the trombone player’s difficulties in the complex series of steps from an imagined melody to producing a musical tone.

Discrepancies were also described between the sounds made by the trombone and the musical qualities of the imagined sounds:

The sound that came out of his trombone did not represent the musical thought he had seen written; it was a weird sound which did not have musical qualities. With everything he says, and you can hear him now repeating the statement that he intended to replay

perfectly the notes in his brain, he had an interior hearing, he created a concept of the melody he saw in writing, but he could not play it. (Miliotti, 1885, p. 140) (original text in Appendix)

Thus, Charcot pointed out that the trombonist was able to imagine the melody but was unable to produce sounds that matched the imagined melody. Such discussion of the mental representation of music was relatively new in the field of neurology.

In contrast to his difficulty with music production, the trombonist was able to speak, write, and understand verbal language without difficulty. Importantly, there was no change in his tremor or ability to write verbal language. Charcot discussed the trombone player's ability to move his lips and tongue, blow, whistle, suck, grimace, and concluded that he did not have oral apraxia. Charcot also utilized the findings from a comprehensive examination to detect any limb apraxia, noting that the trombonist could make the movements required to play the trombone in the absence of the instrument. This ability to make learned movements was at odds with his difficulty in making similar movements when actually playing his musical instrument.

It is not clear from the case description whether or not Charcot asked the trombone player to attempt to write music notation or perform during the lecture. (There is, however, mention of the trombonist playing an aria from the Faust opera after treatment with potassium iodide.) The testing of different types of music writing, such as copying music notation from a written source, writing musical notes after hearing them played, or spontaneously writing music without a written or aural source for the notes (music composition), were not documented. These tasks would later be added to the examination of music writing in patients (e.g., Knoblauch, 1888).

In the more general neurological examination, the patient's pupils were slow to react to light, but otherwise normal. The patient's evolution of symptoms was also discussed. While his difficulties with playing the trombone showed some gradual improvement, he had begun to show a mild decline in

memory and word finding, and his gait showed slight hesitation. He was in a “sort of intellectual slumber” (Miliotti, 1885, p. 141). Charcot argued that these slight difficulties were independent of his difficulties with music. Charcot thought this reflected “chronic diffuse peri-encephalopathy” (*periencefalite diffusa cronica*) (without delirium) of the “congestive and motor” form (*forma congestiva e motoria*), which was shown to affect primarily the frontal lobes by his colleague Jules Falret (Falret, 1853).

Charcot diagnosed the trombone player with music aphasia (*afasia musicale* in Italian and *aphasie musicale* in French) and music agraphia (*agrafia musical* in Italian and *agraphie musicale* in French). Thus, Charcot attached the label “music aphasia” to the inability to perform the correct motor movements needed to produce music on a musical instrument, and “music agraphia” to the inability to copy music. He concluded that this was the first example of a case of music aphasia and music agraphia *without verbal aphasia*. Charcot pointed out the dissociation between writing music notation and writing language saying,

He only suffers from what we call music agraphia, as he is not agraphic with ordinary writing. (Miliotti, 1884, p. 139)

Thus, Charcot made three important observations regarding the trombonist. First, he identified the possibility that the inability to copy music could exist without verbal aphasia or agraphia. Second, he identified an inability to play a musical instrument without oral or limb apraxia. Charcot attributed this to a defect in the “memory” for the movements needed to play the musical instrument. And third, Charcot also considered the dissociation between creating and imagining a melody (musical thought) and recognizing the musical qualities of a melody.

Ballet (1886) added further discussion of the trombone player:

...I point out a curious case reported by Mr. Charcot in his Lessons, [in which he writes about] observations of a trombone player who lost the memory of the hand and mouth movements necessary to play the instrument. All the others driving memories were intact

except this one. The musician had forgotten the handling of the trombone, as others forgot that of the pen. (p. 134) (original text in Appendix)

Ballet further developed the idea of auditory images, including images of musical sounds (*les images de sons musicaux*) which were analogous to images of words.

Charcot's ideas about brain and music

In his presentation of the trombone player, Charcot speculated about underlying brain mechanisms for music abilities. He proposed four centers for music that were different and independent from the language centers. The centers included those for music auditory images, music visual images, music articulation images, and music writing images. It is not clear whether or not Charcot proposed a fifth center, an independent idea center for music, or if music and language processing is shared by a single center for ideas. Miliotti (1885) wrote, "Needless to say that, even in these cases, the center of ideas is isolated and independent." (p. 180). Charcot, however, acknowledged the existence of musical thought. Miliotti (1885) referenced the music centers in his discussion about the trombone player:

In the specific case of the patient I presented, as the tonal (hearing) image of the notes exist, because when he reads music, he hears the tones in his ear (interior musical word) and can recognize music played by others; as there is the visual image because he reads music; but is unable to play (articulate notes with his instrument) and copy music... (p. 180) (original text in Appendix)

Thus, it was possible for the trombone player to read and comprehend music because the centers for these functions remained intact, while the centers for "articulating notes" (playing the trombone) and copying music were damaged. These centers for music processing are analogous to those in Charcot's model of language discussed using the "Bell diagram": two sensory centers for listening and reading, two motor centers for speaking and writing, and a fifth center for ideas. (Figure 4).

Charcot developed the Bell diagram as a teaching aid to help explain four types of aphasia. Similar to other contemporary diagram-makers (e.g., Wernicke, Kussmaul), he proposed specialized

cortical centers (represented as circles) and connections between the various centers and their input / output modalities (i.e., ear, eyes, hands, lips) (Miliotti, 1885; Gelfand, 1999). The centers were thought to contain brain cells that store memories, a concept that was based on Théodule Ribot (1839-1916). Music functions were not included in any known versions of his Bell diagram, and Charcot did not publish a diagram specifically for music. Although no such music diagram is known to exist, Charcot did describe music centers and connections between centers in a similar fashion to his model and other contemporaries' models of language function (Lecours, 1993). Charcot's discussion about centers for music also preceded August Knoblauch's (1863-1919) publication of a diagrammatic model of music (Knoblauch, 1888).

Charcot's interpretation of clinical impairments, such as aphasia, as partial memory disorders is formulated in terms of Ribot's model (Lorch, 2009; Brais, 1993; Ribot, 1881). Ribot, a French psychologist, and Charcot were close colleagues. Charcot attributed the trombonist's inability to play to a memory deficit for movements; the patient could imagine the melody but could not "remember" the movements of the tongue, lips and hands required to produce the imagined melody.

In the context of developing ideas about localization of function, one concern for Charcot was the need to demonstrate the neuropathological dissociation of particular behavioural abilities to determine the composition of the faculties. The one significant focus for this debate was the dissociation of spoken and written language deficits. Initially clinicians asserted that in aphasia both spoken and written language would be equally affected; however cases began to be observed in which these two modes of expression were differentially or selectively impaired (Lorch and Barriere, 2004). A strong argument for the idea that written language was a separate faculty was presented in an 1884 paper by Albert Pitres, another of Charcot's many students. In his paper describing pure agraphia, Pitres presents a case of Charcot's as the starting point (Barrière and Lorch, 2003). In the discussion of the trombone

player's difficulty with writing music notation, Charcot draws a direct analogy to verbal agraphia. With his description of the disassociation between preserved language function and impaired music abilities, Charcot extended the discussion to include written music and "spoken" or played music as additional modes of expression that could be selectively impaired. Through his clinical testing, he demonstrated the dissociation between the impaired memory of limb movements involved with playing an instrument and the absence of apraxia in the trombone player's case.

Charcot's clinical observations of selective impairments in both music and language domains, however, were used to develop the broader support for his anatomo-clinical approach and ideas about cortical localization. Charcot published his initial ideas about cortical localization in 1875 - 1876 (Charcot, 1875; Charcot, 1876) and also participated in a seminal debate with Charles-Edouard Brown-Séquard (1817-1894) justifying his anatomo-clinical approach at the Société de Biologie in Paris in 1875 (Gasser, 1995). Charcot argued that the selective breakdown of language or other higher cortical functions, like music, after brain damage suggested the existence of multiple, relatively independent and specialized brain centers (Bonduelle and Goetz, 1996). With the trombone player, Charcot was able to identify a new isolated clinical syndrome (i.e., music agraphia without aphasia) that provided additional evidence for this approach. Thus, as proposed by Bonduelle and Goetz (1996), his interest in aphasia and its various forms was primarily used to justify his overall anatomo-clinical approach rather than a specific focus on aphasia.

The propagation and impact of Charcot's 1883-84 amusia cases

Charcot's interest in the organization of music abilities in the brain was a novel clinical focus in 1883-84. This legacy is apparent in the next generation in the work of Paul Oscar Blocq (1860 – 1896), Georges Marinesco (1864-1938), and Achille Souques (1860-1944), . Blocq, who was an intern with

Charcot from 1887-1892, published five articles about amusia between 1892 and 1895 (Blocq, 1893a, Blocq, 1893b, Blocq, 1894, Blocq, 1895, Blocq and Onanoff, 1892). By the time Blocq published his first manuscript about music and aphasia, Knoblauch had produced a diagrammatic model of music processing and coined the term “amusia” to refer to an impairment in music abilities after brain damage (Knoblauch, 1888). Blocq used Knoblauch’s “amusia” rather than Charcot’s term “music aphasia”. Blocq & Onanoff’s (1892) chapter about language includes amusia in the classification of language disorders. They identify five types of amusia, including *amusie sensorielle vraie*, *alexie musicale*, *amusie motrice vraie*, *amimie musicale*, and *agraphie musicale*. In Blocq’s reviews about amusia, he often referred to Charcot’s trombone player. Marinesco was a Romanian physician who studied with Charcot and also interacted with Pierre Marie (Broussolle *et al* , 2012). In 1905, Marinesco published a review of amusia (Marinesco, 1905). Souques was another of Charcot’s students who published about music and aphasia. Souques and Baruk (1930) presented a case of amusia with autopsy and mentioned Charcot’s trombone case (Souques and Baruk, 1930).

Charcot’s work was also discussed by others who were not students or directly related to the Salpêtrière. For example, Joseph Jules Dejerine (1849-1917), who studied under Charcot’s rival, Alfred Vulpian (1826-1887) before succeeding his chair at the Salpêtrière in 1911, also considered music in his studies. However, Dejerine generally focused on music reading and singing, not the wider aspects of music processing (e.g., Dejerine, 1892). Brazier (1892) wrote a comprehensive review about amusia in which he discussed Charcot’s ideas about auditory images in the context of the trombone player and the pianist with music alexia. It has been difficult to establish the identity of Brazier, but he may have been Edmond Brazier who wrote a thesis about the esophagus in Paris in 1879. Edmond Brazier’s name appears on the roster of the Rosenwald directory of physicians (*L’annuaire des Médecins*) from 1880-1896 (personal communication, O. Walusinski, December 15, 2011.) The German physician Alfred Kast

(1856-1903) also adapted Charcot's proposal that "memory for musical ideas" were localized in specific brain areas (Kast, 1885) but did not mention Charcot.

In the first extensive review of amusia in 1895, Johan Gustaf Edgren (1849-1929) (Edgren, 1895) referred to Charcot via Oppenheim (1888); however, Oppenheim did not provide a citation for Charcot's case. In another comprehensive review by Solomon Henschen (1847-1930) two decades later (Henschen, 1920), several of Charcot's amusia cases were listed: the medical professor with music alexia and patient "H" who could sing with a guttural sound (Henschen cases 113 and 114). Henschen (1920) also attributed to Charcot a case of a 50-year old man with alexia and agraphia without amusia (Henschen case 113a), but no citation is provided; this case remains unidentified. Henschen omitted Charcot's female piano teacher with alexia, documented by Bernard (1885) and discussed above. Most notably, Charcot's trombonist (Henschen case 112) was referenced via Ingegneros (Ingegneros, 1906). In contrast, Edgren (1895) and Wallaschek (Wallaschek, 1891, Wallaschek, 1894) cited Charcot's trombonist but only with respect to his motor symptoms rather than his music agraphia. Others mentioned the trombone player but did not link the case to Charcot or provide a citation (e.g., (Oppenheim, 1888, Ireland, 1894). Thus, details about Charcot's cases are often limited or incorrectly referenced, which likely contributed to the under-acknowledgement of Charcot's ideas about music and aphasia.

Although studies about amusia increased in number throughout the end of the nineteenth century to present times, reports about music agraphia without aphasia remain rare. Music reading and writing are not typically examined as this requires musical expertise, so cases may go undetected. Following Charcot's discussion of the trombonist, only three other cases of music agraphia without aphasia have been documented. In 1892, Dejerine reported a 68-year old singer for who developed alexia (for both music and language) and agraphia (for both music and language) over three years (Dejerine, 1892).

Similarly, Dorgueille described a case with both music agraphia and music alexia without aphasia (case 12) (Dorgeuille, 1966). Most recently, Midorikawa & Kawamura (2000) described a piano teacher with damage to the left upper parietal lobule following surgery to remove a tumor (Midorikawa and Kawamura, 2000). She had both music and verbal agraphia but not aphasia or alexia. The authors examined the ability to write music using single notes, music symbols, and both familiar and unfamiliar melodies. Although she was able to write single notes and symbols to dictation, she had difficulty writing the melodies, making mostly rhythmic errors. In contrast, she was able to copy eight measures of music, even though she took a long time to complete the task. This case differs from Charcot's trombone player, in that the piano teacher was able to copy music. It is not known if Charcot's trombonist could write music notation to dictation, as Miliotti only describes a difficulty with copying music.

Discussion

Although he is not commonly linked to nineteenth-century studies of music in aphasia, Charcot discussed music abilities in four cases in his Friday Lessons at the Salpêtrière during the summers of 1883 and 1884 and documented the first case of music agraphia without verbal aphasia. During these lectures Charcot provided early discussion of "music aphasia" and ideas about localization of music in the brain. Charcot provided some of the earliest thinking about how the brain processes music prior to the work by Knoblauch (1888), who coined the term "amusia" and who developed the first diagrammatic model of music (Knoblauch, 1888). Charcot used the term "music aphasia" to refer to difficulty with making the motor movements involved in playing the trombone, and "music agraphia" to refer to difficulty with copying music notation. However, after Knoblauch (1888) coined the term "amusia", the term "music aphasia" did not appear in subsequent literature. Knoblauch's diagrammatic

model explained several clinical syndromes that could exist, including motor amusia and music agraphia. Although Charcot did not publish a diagrammatic model for music, he did publish the “Bell diagram” to conceptualize language processes and deficits, and he speculated about parallel music processes and deficits. Prior to 1883, work about music in patients with neurological disorders focused primarily on the preserved ability to sing in the context of severe aphasia (Johnson et al., 2010). Charcot departed from this theme in his discussion of the trombonist and focused on motor deficits of playing the trombone and the inability to write music notation. However, Charcot’s name is rarely linked to the topic of amusia. One reason is that his original ideas were only published by his student in Italian and not included in Charcot’s “*Œuvre*”. In addition, music agraphia is a rare condition. Given Charcot’s relatively early contributions to the study of amusia, he deserves an important place in the history of music and brain.

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Figure Captions

Figure 1. Reproduction of the book cover of Miliotti (1885).

Figure 2. Sketch of location of brain damage after autopsy of Bernard's (1885) case with "music blindness" discussed by Charcot during the Friday Lessons.

Figure 3. Photograph of the Republican Guard military band taken during a trip to Boston, Massachusetts in 1872. The photo likely includes Dherbecourt; however, we were unable to locate a list of persons in this photo. The original photo is part of the archive of la Garde Républicaine de Paris and is reproduced with permission from la Garde Républicaine.

Figure 4. Charcot's Bell diagram depicting the centers for auditory memory for words (CAM), visual memory for words (CVM), articulated language (CPM), written language (CVC), and the center for ideas (IC). (reproduced from Miliotti, 1885, p. 153)