HISTORICAL

'All Out of Tune': Is it Curtains for the Tuning Fork?

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A Brief History of Tuning Fork Testing

What clinicians practice in both otolaryngology and neurology departments, the world often refer to as ''bedside hearing tests'', ''informal hearing tests'' or ''tuning fork tests'' are actually, as in the case of many other aspects of practical medicine, a culmination of centuries of pioneering and development... invention, discovery and perfecting... 'fine-tuning', one might say!

Of course, in reality, technological advances have slowly been replacing the once-invaluable role of the miniature pronged metal instrument. However, the use of tuning forks as a crude test to screen for hearing disorders has not yet perished entirely; not least among neurologists, nor has the colorfulness of its history.

In outlining the various developments that led to the widespread addition of tuning forks in clinical and bedside settings, the names that immediately come to mind are those credited with the commonly deployed tests—Heinrich Adolf Rinne and Ernst Heinrich Weber (and perhaps Albert Bing and Dagobert Schwabach). A closer look reveals that, just like investigations into the other senses, hearing tests followed a developmental course largely mirroring years of advancements in both examination techniques as well as in the field of neuroscience.

The interest in otology from a medical perspective can be traced back to Ancient Egyptian and Greek periods of history, where the Ebers Papyrus, a medieval scientific document, outlined war-inflicted wounds on the temporal bone and their consequences on hearing as well as on speech. Similarly, within Egyptian Pharmacopoeia stemming back as far as 1500 BC, one finds archaic outlines of treatment methodologies for the likes of tinnitus and dizziness, indicating early interest in both the cochlear and vestibular functions of the human ear. Also in the BC period, in ancient Greece, the physician Alcmaeon of Croton was regarded as the father of neuroanatomy, for his surmise that the mechanisms behind auditory perception involved air movements penetrating the ear to concuss and alter the position of the brain at specific responsible sites. The cochlea itself was first described by the Greek philosopher Empedocles, whose most renowned writings outlined the four basic elements. He termed the structure after a seashell of the same name in the Mediterranean regions. It should be noted, however, that his primary fascination at the time surrounded the anatomical structure and morphology of his newly described entity, rather than its functional role in auditory perception itself.[1]

It was the Padua physician, mathematician, and astrologer, Girolamo Cardano, who is credited for pioneering the juvenile steps toward modern-day informal tests in clinical practice. A well-decorated writer, his 1545 Latin publication coined ''Contradicentium medicorum'' outlined his theories of the human body and of both diagnostic and therapeutic principles, and he is considered the first to describe the manner by which sounds are perceived both through the bony skull as well as through the air.[2] Around the same time, Giovanni Filippo Ingrassia, Professor of Anatomy and Medicine at the University of Naples, was documenting through literature findings of dissection studies he was undertaking at the time, and in doing so, in 1546 earned the merit of being the first to describe the stapes bone.

It was not long after the works of Cardano that a fellow Padua physician, Hieronymus Capivacci recognized and built on the described phenomenon, suggesting its possible use as a diagnostic tool in differentiating between hearing disorders originating in the middle ear, and those originating in the acoustic nerve. By 1684, in Germany, physician Gunther Christoph Schelhammer had based his works around both Cardano and Capivacci, reporting results of multiple experiments he carried out using common cutlery forks! Research into ear disease however still proved to be very much in infancy in terms of its timeline, and with a lack of demand within practical otology at the time, there were no further developments for the next two centuries.[3,4]

The next major breakthrough was in 1711 when John Shore, a Sergeant trumpeter, and lutenist in London, was credited as the inventor of the tuning fork itself – an instrument which would go on to earn much success in Europe, although more so as a musical tool than a medical device (whereby the small steel instrument with a stem and two stout flat prongs could vibrate to produce a constant pitched musical note thus, serving as a standard for tuning instruments to a greater extent than acoustic investigations). Physicist Ernst Chladni in Wittenberg around 1800 then became the first to systematically investigate the mode of vibration of the recent tuning fork apparatus as well as its nodal points, and he became one of a number at the time to attempt to construct a complete musical instrument based on sets of tuning forks. However, his works would struggle to become

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widely accepted at the time. Another German, industrialist Johann Scheibler, who held a deep fascination in both science and music, in the 1830s intriguingly determined the pitch of average Viennese concert pianos as well as developed considerably more accurate methods to tune them, before his own invention of a tuning fork tonometer, comprising over 50 precision-engineered tuning forks ranging from 220–440 Hz at intervals of 4 Hz to spark a 19th century race internationally towards a scientific standardization of tuning forks. In France, and under government commission, Jules Lissajous and colleagues attempted a standard fork and accompanying resonance box based on Scheibler's work, as well as presenting his own method of calibration, termed *''Lissajous figures''*, and although his works failed to avoid controversy in their intended field of use, they would go on to form a basis in many other fields including calibration of later television transmission in the 20th century.[2,3,5]

As technological advancements and developments continued, with an ever-increasing demand for tuning forks, it was Rudolph Koening, a Paris-based German physicist, who continued the trends with a novel clockwork mechanism to create a tuning fork that could be kept in continuous vibration thus, generating continuous sound while Herman von Helmholtz in Heidelberg in 1863 used similar principles with sets of electromagnetically powered tuning forks for his experiments on sensations of tone. Until the future invention of an electronic valve, tuning forks had established their status as indispensable instruments for producing defined sinusoidal vibrations.

With tuning forks being in existence and in development for well over a century in the field of music, it would be a wait until the 19th century when they finally began to see an increasing role in practical medicine, attributed significantly to Heinrich Adolf Rinne who in 1855 began describing methods by which air and bone conduction can be compared in the ears through the use of a tuning fork, with a purpose of diagnosing and differentiating between types of deafness. Interestingly enough, however, the very same test method had been described in detail 13 years prior in 1842 by Viennese doctor Franciscus Polansky, and later by Dresden otologist Eduard Schmalz in 1849, and indeed like Polanky's and Schmalz's reports, Rinne's work was also forgotten until its value was confirmed retrospectively in three reports published in the 1880s, the last being by Schwabach in 1885 who described his own test method based on Rinne's work. After that, it would be only Rinne who would be credited for the modern-day tuning fork test.[2,6]

Years ago, in 1802 physicist Giovanni Battista Venturi in Modena had demonstrated that perception of sound direction is determined by sound hitting the closer ear more intensely, while in 1827 German physician Caspar Theobald Tourtual also showed the phenomenon to occur for sound conduction via skull bones using a watch, showing that occluding both ear canals increases sensation in both ears equally while occluding one side would increase sensation only on that side. London physicist Sir Charles Wheatstone in London drew the same conclusion that year, as well as investigating the mode of vibration of the tympanic membrane using a tuning fork, and in 1891 Albert Bing proposed the very same occlusion effect as the now-named Bing clinical test, although the very same method had been described prior by Rinne in 1885. In 1834, anatomist and physiologist Ernst Heinrich Weber in Leipzig confirmed the very same phenomena yet again and set about attempting to prove that airborne sound is perceived by the vestibulum and semi-circular canals while the bone-conducted sound is perceived by the cochlea, however, neither he nor Tourtual and Wheatstone had suggested any clinical use of their findings, instead the suggestion made by Schmalz in 1845, and the tuning fork test was introduced and explained diagnostically for clinical practice, named after Weber, which while being unnoticed in his time, continues in practice today.[6,7]

It was in 1889 that Heinrich Rumpf, a Professor at the University of Marburg, became the first to apply the tuning fork also for vibration sense, which initiated a separate but simultaneous vast research into proprioceptive function and the organs involved in such. Rumpf's findings would remain controversial, however, and it wasn't until more than a decade later, in 1903, that vibration sense was accepted as a valid clinical test, and Adam Rydel and Friedrich Wilhelm Seiffer found vibratory and proprioceptive senses to be closely related, carried through the posterior column of the spinal cord.[2,8]

Thus, we see that today's tuning fork tests are based on a rich tapestry of scientific endeavor... however, is it now time to put them back into their case and relegate them to the past?

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