

What Makes Music, Music? A Look At Congenital Amusia Expression In Tonal Language Speakers

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Author Bio

Jocelyn Wang is currently a senior studying at Ridley College High School in Canada who has been curious about the intersection of neuroscience and musicianship for as long as she can remember. How do musicians hone their craft? Why is music so inexplicably tied to emotion? And what makes music, music? These are the types of questions she hopes to answer in the future.

Abstract

Research advancements in recent decades have given rise to the notion that there exist specialized brain structures to facilitate music perception independently of other mental processes. The study of pitch-related congenital amusia, a disorder wherein an individual has a reduced ability to perceive and distinguish pitch, has allowed significant contribution to the development of this music-specific brain model. This paper aimed to find how, if at all, congenital amusia expression is affected by the speaking of a tonal language – a language that relies on pitch as one distinguishing factor for lexical meaning – as well as implications for the music-specific brain model that arise from said effect. A literary review was conducted, with a focus on literature published in the past decade. It was conversely found that congenital amusia affects tonal language processing, with the difficulties in musical pitch discrimination extending to language-related pitch discrimination. This finding provides further insight for the workings of the music-specific brain in that the overlaps between musical and lexical pitch could suggest either that pitch is fundamentally not a solely musical characteristic, or that tonal language has an inherent musical aspect. Future research on this subject should seek to clarify this understanding. Additional research in neighbouring fields, including cultural and emotional psychology, linguistics, and music therapy, is also discussed.

Keywords: Congenital amusia, tone deafness, tonal language, music-specific brain, pitch discrimination, music processing, semantic pitch

Introduction

It has long been understood that there is something “special” about music and the human relationship to it. Babies are born from the womb with the mechanisms that allow for basic pitch distinction (Mampe et al., 2009) and the ability to “feel the beat” (Winkler et al., 2009). As we grow from there, music only becomes more of a core factor accompanying the development of our cultural and personal identities (Folkestad, 2002). Clearly, music is a crucial component of the human experience, and everything down to our neural structure reflects this.

However, within such a musical world, there are a select few who are born without the ability to distinguish pitch, rhythm, or sometimes both. Individuals born with these musical disorders have what is known as congenital amusia. Affecting around 2% of the population, individuals with this disorder – amusics – are unable to distinguish pitch, rhythm, or other musical characteristics to the same precision that the majority of the population can (Peretz, 2016). What arises is a contrasting musical experience where, due to their difference in perception, amusics are unable to engage with and appreciate music to the same degree as their non-amusic peers (Omigie et al., 2012). This unique experience has led to extensive studies on those with congenital amusia to isolate the brain structures and pathways that allow for processing of musical elements. The confirmation of such structures would support the idea of a music-specific brain. However, within the substantial research to determine the underlying neural mechanisms of congenital amusia arises a lack of literature looking at the inherent expression of congenital amusia and how – or if – that expression is modified by other experiences. These experiences include speaking a tonal language from birth, which necessitates definitive understanding of specific differences in pitch in order to communicate clearly.

Under this precedent, this paper proceeded with the primary aim of finding the degree to which expression of congenital amusia is affected by speaking a tonal language, and a secondary aim of discussing the implications for the music-specific brain model that arise from said effect. A literature review was conducted to accomplish these aims, with the focus being on papers published in the recent 15 years (the recent quinquennial) in order to most accurately highlight the current state of research in this field.

Tonal and non-tonal languages

As previously mentioned, tonal languages require an understanding of specific pitch differences for communication. This, though, seems to raise a discrepancy in that technically both tonal and non-tonal languages use pitch for communication. However, the difference comes in the fact that tonal languages use pitch for a more particular and defined purpose than non-tonal languages.

The specific distinction between tonal and non-tonal languages is multifaceted. From a linguistic perspective, a tonal language is one that uses pitch to distinguish meaning and/or grammar (Yip, 2002). It is important to note that all languages, including non-tonal languages, have intonation, but only tonal languages have tone. In other words, all languages use pitch to communicate some form of meaning – for instance, rising tone to show a question – but only tonal languages use specific pitches to communicate specific meanings. In fact, tonal languages often have a concrete number of tones that words could take, where differing tones on the same sound signify a change in meaning. Examples of tonal languages can be seen in many Asian languages, including Mandarin, Vietnamese, and Cantonese, as well as African languages such as the Hausa language (Newman, 1996).

Accordingly, tonal and non-tonal languages are also distinct neurologically. In order to process intonation, all language speakers activate the right frontal area and left fronto-parietal regions (Figure 1). In tonal language speakers, however, brain activation is further seen in bilateral temporo-parietal semantic areas and subcortical regions (Chien et al., 2020). This region (Figure 2) seems to be exclusively activated for semantic pitch processing of language tones and is interestingly not a primary part of the circuit of musical pitch processing that is affected in congenital amusia.

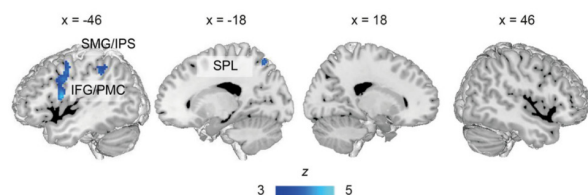


Figure 1. Right frontal area and left fronto-parietal regions activated in language speaking (Chien et al., 2020).

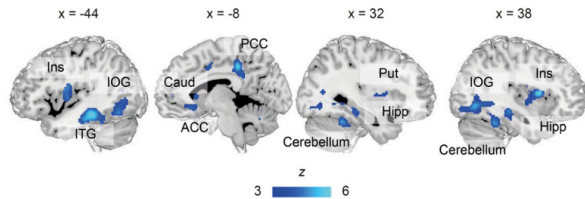


Figure 2. Bilateral temporo-parietal areas activated in tonal language processing (Chien et al., 2020)

Congenital amusia and the music-specific brain

Fundamentally, congenital amusia is a disorder of music perception. Peretz (2016) defines congenital amusia as any “lifelong musical [disability] that cannot be attributed to intellectual disability, lack of exposure, or brain damage after birth”. It should be noted that the term ‘congenital amusia’ itself is more of an umbrella term than a specific disorder. It covers any musical disability, among them the disorders of pitch perception and of rhythm perception. These two variants – pitch-related and rhythm-related congenital amusia – are currently the two most well-understood types of congenital amusia. For the purpose of comparing tonal language with congenital amusia, this paper focuses only on the pitch-based variant – however, it should not be overlooked that rhythm-based congenital amusia has also been studied extensively, particularly in the recent quinquennial, and has resulted in an equally intriguing collection of research.

The study of congenital amusia has, notably, allowed significant development of the music-specific brain model. Spearheaded by Isabelle Peretz (Peretz et al., 2002; Peretz and Hyde, 2003; Peretz, 2013), the model poses that there are structures in the brain with the sole function of processing music independently of other mental processes. As such, the study of pitch-related congenital amusia – a disorder of musical pitch perception – has helped researchers isolate possible musical pitch-specific structures in the brain. These structures have been collated to, specifically, the right inferior frontal gyrus or right IFG (Hyde et al., 2010). Additionally, there is evidence pointing to the possibility that the pathway between the right IFG and the auditory cortex is also implicated in musical pitch processing based off of the study of the brains of amusics (Peretz, 2016). Both of these structures can be seen in Figure 3.

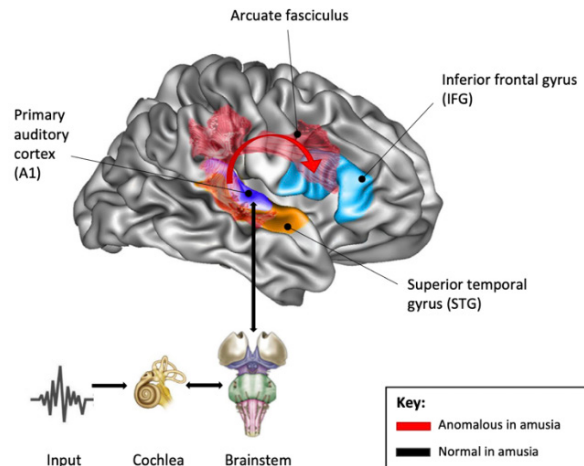


Figure 3. Outline of structures implicated in pitch-based congenital amusia (Peretz, 2016).

Tonal language modification of congenital amusia expression

The biological basis

The core justification behind the modification of congenital amusia expression by tonal language speaking is the biological proximity. As previously described, the primary neural structure activated in tonal language speakers specifically for language tone processing is the bilateral temporo-parietal areas (Chien et al., 2020), and the structures most implicated in the disorder of musical pitch perception in amusics are the right inferior frontal gyrus (Hyde et al., 2010) and the pathway between that area and the auditory cortex (Peretz, 2016). With such similar functions and close proximity, there must be some interaction between the three areas. Finding the direction of the interference, however, requires a deeper look at studies that focus on specific cognitive functions relating to music and tonal language perception.

One study that combines a cognitive and biological research approach to find a direction of interference is Zhang et al. (2017). In this study, 11 Cantonese-speaking amusics and 11 Cantonese-speaking non-amusics participated in Cantonese tone distinction and musical stimuli processing tasks while being scanned with fMRI. The experiment resulted in two main findings. Firstly, the amusic group performed worse in both the tone distinction and musical processing tasks. Secondly, the right superior temporal gyrus (part of which is associated with the temporo-parietal area activated during language tone processing) was shown to be deactivated in amusics but activated in non-amusics during these tasks. It was concluded that the “neural deficits in tonal language speakers might differ from those in non-tonal language speakers, and overlap partly with the neural circuitries of lexical tone processing (e.g. right STG)”. The result implies that, biologically, tonal language speaking is affected by congenital amusia, and not the other way around. However, with such a small sample size, this statement will need triangulation from other studies to become more established.

The cognitive basis

The cognition-based literature is much more varied and much more conflicting. There are, in fact, two groups of papers: those that either directly or indirectly support the idea that tonal language speaking should mediate the expression of congenital amusia, and those that either directly or indirectly support the idea that conversely, it is the presence and expression of congenital amusia that adversely impacts tonal language processing. Both groups have a significant amount of research supporting them;

however, as will be further explained, it is the latter that seems to be the most likely circumstance.

Argument 1: tonal language mediates congenital amusia

There is a vast amount of research indirectly supporting Argument 1, most of which is research on tonal language speakers without amusia. Many studies, including Bidelman et al. (2013), Peng et al. (2013), and Pfordresher and Brown (2009) have shown that tonal language experience increases pitch discrimination ability in non-amusics.

Interestingly, Bidelman et al. (2013) conducted a three-way comparison between musicians', Cantonese-speaking non-musicians', and English-speaking non-musicians' performance on various auditory perception tasks. Their study found that, as suspected, musicians performed the most accurately, but Cantonese speakers also showed “comparable perceptual enhancements” in comparison to the performance of the English-speaking participants. As such, the results of Bidelman et al. (2013) support that tonal language speaking, even without musical experience, is enough to enhance musical perception in non-amusic adults. With a participant size of 54 (18 in each category), this study alone isn't strong enough to prove this idea, but the experimental design allows for extremely valuable isolation of the specific tonal-language and musical perception relationship.

The notion that tonal language experience can help develop greater pitch distinction ability is further corroborated by Peng et al. (2013) and Pfordresher and Brown (2009). The former conducted an extensive

analysis of hundreds of Mandarin-speaking and non-Mandarin-speaking musicians and non-musicians, finding that “language experience affects auditory perception” and that native tone-language-speaking musicians were more likely to have perfect pitch. The latter, similarly, found that native tonal language speakers performed better than native non-tonal language speakers in pitch discrimination and reproduction tasks.

The literature supporting Argument 1 is promising but is missing an incredibly crucial focus. All of the aforementioned studies have compared tonal language speakers with non-tonal language speakers in pitch discrimination, but none have studied tonal-language-speaking amusics. By missing this direct comparison between tonal-language-speaking amusics and non-tonal-language-speaking amusics, only hypotheses and indirectly possibilities can be concluded. Among these indirect possibilities, however, include the possibility that tonal language experience mediates congenital amusia symptoms, since it can be seen from the above evidence that tonal language experience increases pitch distinction ability in non-amusics.

Argument 2: congenital amusia disrupts tonal language processing

On the contrary, there are also many studies that show the amusic group performing worse than the non-amusic group despite a tonal language being spoken. Some studies that support Argument 2 include Nan et al. (2010), Liu et al. (2012), and Tillmann et al. (2011). In one way or another, all of these studies show that congenital amusia-related musical pitch processing deficits may be

extending to language pitch processing. Both Nan et al. (2010) and Liu et al. (2012) focused their experiments on Mandarin speakers. Nan et al. (2010), out of a participant pool of 117 Mandarin speakers, matched 22 non-amusics and 22 pitch-related amusics in both rhythm and pitch processing tasks, finding that the amusics still showed a pronounced deficit in pitch processing “despite early exposure to speech-relevant pitch contrasts”. On top of that, six of the amusics had difficulty discerning lexical tones, showing symptoms akin to lexical tone agnosia. Liu et al. (2012) undertook a similar design, matching 13 non-amusics to 13 amusics, having participants complete a more language-focused set of tasks including word discrimination and tone distinction. They found that amusics performed equally to non-amusics on all tasks, except for those that “relied mainly on pitch sensitivity”.

Tillmann et al. (2011) took a slightly different approach to their research, instead focusing on non-tonal-language-speaking amusics. In this study, participants (amusics and matched controls, both non-tonal-language-speakers) were asked to distinguish between different tones in Mandarin and Thai, two tonal languages. Results showed that amusics consistently performed worse than non-amusics, leading the researchers to conclude that even non-tonal-language-speaking amusics might have a compromised “ability to process and learn tonal languages”.

Like in the Argument 1 group, the literature under Argument 2 is also missing research directly comparing tonal-language-speaking amusics with non-tonal-language-speaking amusics. Without this comparison, it is impossible to make a direct correlation,

much less a causal statement, about the true effects of tonal language speaking on congenital amusia. However, Argument 2 still seems to be the stronger argument for two reasons. Firstly, the research under this group does directly compare tonal-language-speaking amusics and non-amusics – one step further than the Argument 1 research; and, secondly, Argument 2 is corroborated with concrete biological evidence from the earlier mentioned Zhang et al. (2017).

Implications

One through-line shared between both Argument 1 and Argument 2 is the idea that tonal language speaking and musical pitch perception are overlapping functions. Under Argument 1, this can be seen in the studies assuming – and proving – that experience with semantic pitch can translate to enhanced musical pitch perception. Under Argument 2, studies showed that a deficit in musical pitch perception, such as that of pitch-based congenital amusia, can interfere with semantic language tone processing as well.

The results of these studies show that there might be some aspect of pitch that is shared neurologically between music and tonal languages. For the music-specific brain model, this has two conflicting implications. For one, this may mean that tonal language is thus inherently musical. Alternatively, though, it may mean that pitch is not a solely musical characteristic at all, but rather a human one that is used in both music and tonal language communication. Nan et al. (2010) makes note of this too, stating that their “observed association between the musical disorder and lexical tone difficulty indicates that...

congenital amusia is not specific to music or culture but is rather general in nature”. From the current literature (including that covered in this paper), it is still unclear which, if any, of these implications is the most likely. As such, future research should focus more specifically on the nature of tonal language within amusics – in other words, comparing tonal-language-speaking amusics with non-tonal-language-speaking amusics, as described previously. By doing so, a greater understanding can be achieved regarding both the nature of the congenital amusia-tonal language relationship and the nature of these implications.

In addition, one of the most promising aspects of this field is the potential for interdisciplinary research. Aside from the neurological approach, research looking at the nature of musical and language-related pitch can be approached from psychological, linguistic, or music therapy lenses as well. For instance, research on this topic through cultural psychology could study tonal-language-speaking cultures to see if those of such cultures show a different relationship with music. The results of such a study would provide greater clarity as to whether or not musical pitch is inherently intertwined with semantic pitch, thus supporting or contradicting one of the aforementioned implications.

Conclusion

This paper aimed to look at the expression of pitch-related congenital amusia, how said expression is influenced by tonal language speaking, and the implications for the music-specific brain model from that connection. The relationship between tonal

language and congenital amusia was analyzed from both biological and cognitive lenses. From the biological lens, it was shown that the proximity of the three structures involved in language tone processing and congenital amusia – the bilateral temporo-parietal areas, right inferior frontal gyrus, and the pathway between the right IFG and the auditory cortex – means that there must be some interference, and Zhang et al. (2017) suggested that the deficits in congenital amusia-related structures extend to language tone-processing structures. Cognitively, literature on either side was explored – Bidelman et al. (2013), Peng et al. (2013), and Pfordresher and Brown (2009) supported the notion that tonal language mediates congenital amusia, and Nan et al. (2010), Liu et al. (2012), and Tillmann et al. (2011) supported the notion that congenital amusia conversely disrupts tonal language processing. The latter argument, due to corroboration from Zhang et al. (2017) and having studies with more focused experimental designs, seems to be the most likely circumstance.

From these findings, possible implications for the music-specific model include either tonal language being inherently musical or pitch being not a musical characteristic but a human one. In future research, whether in this field or in neighbouring fields, investigating these implications further can both serve as valuable starting points and provide crucial clarity to our understanding of this topic.

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