Emotional Interpretation of Music in Patients with Schizophrenia: A Literature Review

by

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Abstract

Schizophrenia is a complex disorder defined by a broad range of symptoms. One possible symptom is a deficit in sensory processing, which can impact patients' abilities to process both speech and music. This thesis is an in-depth literature review examining the connections between schizophrenia, musical deficits, and emotional processing. Research shows that music shares many characterisitcs with emotional human speech. Considering this connection, there is interest in how musical deficits, such as amusia (in essence, tone-deafness), may impact the ability of patients with schizophrenia to not only process emotion in music, but also in human prosodic speech. General findings include that patients with schizophrenia have higher rates of amusia, problems with melodic streaming, and deficits in pitch discrimination than healthy controls. Patients with schizophrenia also often show incongruence in their emotional responses to music compared to healthy controls. Additionally, due to similarities between music and emotional human speech, there has been some research exploring whether music could be used as an analogous measure to speech, since musical phrases are more complex than simple tone-matching tasks. A brief review on the research surrounding the experience of patients with schizophrenia in music therapy has also been conducted. Overall, it has been concluded that more research, especially longitudinal research, should be conducted on the connections between schizophrenia, musical deficits, and issues with emotional processing, as well as how these connections may impact treatment.

Keywords: *Schizophrenia, music, speech prosody, amusia, music therapy*

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Chapter One: Introduction

Schizophrenia is a severe, chronic disorder characterized by psychosis, or a loss of contact with reality (Torrey, 2019). Once referred to as "dementia praecox," an early form of dementia, the way schizophrenia has been defined and studied has changed multiple times over the years (Insel, 2010). The advent of anti-psychotic medications helped shift the way schizophrenia has been defined in both clinical and research settings. Though an exact cause of the disorder is still unknown, it is believed that schizophrenia has genetic, environmental, and neurological components (National Institute of Mental Health [NIMH], 2020). For example, one genetic factor that has been implicated for being a potential risk factor for schizophrenia is the 22q11.2 deletion, which has also been linked to other disorders, such as early onset Parkinson disease (Fung et al., 2015; Kim et al., 2011). Complications during birth, trauma, and substance use can be possible environmental risk factors (Stilo & Murray, 2019). Gender differences may also play a role, with men typically having an earlier age of onset (about 18-25 years compared to 25-35 years in females), as well as an increased risk of severe symptoms in men (Li et al., 2016; Ochoa et al., 2012). It is possible that genetic and hormonal differences between males and females contribute to this difference, although there are also other factors such as increased risk of substance abuse in men that may contribute to the gender differences observed in experiences of schizophrenia (Sommer et al., 2020).

Schizophrenia is not considered to be a high prevalence disorder, affecting only about 0.32% or 24 million people of the global population (World Health Organization [WHO], 2022). However, it is still considered to be a severe disorder that infrequently receives the attention it deserves: The 2016 global burden of disease studies found that only 31% of people in countries in low and middle income brackets receive treatment (Charlson et al., 2018). In addition, people

with schizophrenia are 2 to 3 times more likely to die earlier than the general population. This may be either from physical illness, or in approximately 10% of patients, suicide (Sher & Kahn, 2019; WHO, 2022).

In order to improve treatment outcomes and quality of life for schizophrenia patients, many researchers have become interested in defining and examining the different types of symptoms, usually broken down into positive, negative, and cognitive symptoms. Positive symptoms consist of new experiences that did not exist prior to onset of the disorder, such as hallucinations, delusions, and thought disorder, while negative symptoms involve a removal of a preexisting behavior or experience, such as loss of interest and motivations, lack of speech and social contact, and flat affect or reduced emotional expression (National Health Service, 2019; NIMH, 2020). Cognitive symptoms tend to involve issues with information processing, problem solving, and decision making (NIMH, 2020). Because of the differences in these types of symptoms, there is interest in different treatment types to address them. Anti-psychotic medications all tend to have similar effects on treating positive symptoms, though they tend to be less effective in treating negative symptoms (Tandon, 2011). Psychosocial therapies, such as family therapy, show some promise for treating negative symptoms. Combining different treatments to address each symptom type can be helpful for specializing treatment to the patient and ensuring each symptom is being managed (Elis et al., 2013).

Problems in sensory processing may be linked to both positive and negative symptoms and cognitive deficits (Hatada et al., 2014). For example, there is evidence of a tie between auditory processing deficits, such as problems with pitch discrimination, and experiences of auditory hallucinations (McLachlan et al., 2013). According to one study, there were significant differences between hallucinating and not-hallucinating patients on monaural filtered speech

tests, where words were filtered into two different pitch ranges (McKay et al., 2000). One conclusion drawn from this is while many people with schizophrenia experience auditory processing issues, patients who experience hallucinations may have a higher degree of such deficits (McKay et al., 2000). Thus, it is possible that these lower level auditory deficits may contribute to problems in higher order processes, resulting in symptoms such as hallucinations (McLachlan et al., 2013). Another study found that 91.3% of patients experiencing formal thought disorder (i.e., disturbances in thought organization and expression common in schizophrenia) also presented with auditory processing disorder (Moschopoulos et al., 2020; Rivkin & Barta, 2017). Not only do such sensory deficits impact psychotic symptoms, but they can also have an effect on a patient's social life. One element of these deficits is the inability to interpret the emotions of others. Considering that one of the major defining symptoms of schizophrenia is an impairment of social function (Hooley, 2010), this connection between sensory deficits and emotional/social interactions is of particular interest.

Defining Music

Music has been a part of culture for most of human history. The earliest known musical composition is a Hurrian love song from approximately 1800 BCE that pre-dates all known forms of musical notation (Rastall, 1982). Even the form of Western musical notation that most people are familiar with today has its origins in the early church. The definition of pitches (think "do-re-mi" and so on) used today and the concept of writing music on a staff is attributed to the Italian monk Guido of Arezzo, who lived from around 995 to 1050 CE (Kelly, 2015; Rastall, 1982). However, despite being such an integral part of human history, music is variable in the ways it can be defined. There are many components that go into the composition of music such

as volume, timbre/tone colour, rhythm and tempo, and note duration, but one of the most critical components of music is pitch.

Pitch is one of the most basic ways through which auditory stimuli are perceived, and is often measured in Hertz units. In essence, it is how we hear differences in the frequency of a soundwave (Oxenham, 2012). The higher the frequency of a soundwave is, the higher the perceived pitch is, and the lower the frequency of a soundwave is, the lower the perceived pitch is (Pinel & Barnes, 2017). Pitch is one of the most critical elements of auditory perception, due to its influence on our understanding of consonance and dissonance, melody, emotional speech, and even the meaning of words in tone-based languages, such as Chinese (Oxenham, 2012).

Some important specific components of pitch are consonance and dissonance. Consonance is often defined as a pleasant sound produced by two or more notes, or pitches, being played simultaneously; contrarily, dissonance is the more unpleasant, discordant sound produced by different combinations of notes (Lots & Stone, 2008). Like many other elements of music, consonance and dissonance can produce complex perceptions and reactions in a listener, due to their inherently pleasant or unpleasant nature.

Despite the understanding that pitch is relevant to the perception of things such as melody, there is still debate over exactly how melody should be defined. Some musicologists have attempted to narrow melody into a set of definitions such as a simple succession of pitches, a sequence of pitched sounds with certain note durations, or a combination of all different musical components (Stefani, 1987). Unfortunately, each of these definitions presents with problems of potentially being too narrow or too broad, as well as having a confusing amount of overlap with other elements of music. Another important element that helps define melody and set it apart from other components of music is melodic contour, which is essentially the

"movement" between different pitched sounds, or notes. Melodic contours might be defined as "rising," "falling," or "stationary" based on the relative changes in pitch throughout the piece (Jeong & Ryu, 2016).

Whether considering melody to simply be a string of notes or a more complex musical structure, one thing that has become apparent is that melody is a useful tool for the expression and elicitation of emotion in music. One study found that vocal melodies in popular music played a role both in emotional arousal and valence, with the rhythmic quality of the melody being particularly important (Beveridge & Knox, 2017). Melody has also been frequently compared to human speech, especially emotional speech. Szabolcsi wrote in *A History of Melody* (1965) that elements of music such as rhythm, pitch, and even melody are all rooted in natural sounds, including that of human speech inflections. This claim has been supported by research comparing music to speech prosody. Melodic contours are similar to the prosodic elements of speech (Jeong & Ryu, 2016). For example, the melodic quality of a piece of music or speech may conflict with the actual language content of the lyrics or spoken sentence. This may present as a person stating with their words that, "I feel fine," but their vocal tone sounds sad (Vidas et al., 2020). In music, this might present as sounds typically perceived as happy, such as an upbeat tempo and major key signatures, but the lyrical content being about heavy, sad themes. When the melodic cues and verbal cues conflict, the listener must then decide which cue is correct (Vidas et al., 2020). Often, the melodic tone of music or speech can provide a clue as to the true emotion of a performer or speaker, regardless of what the verbal content is saying.

Defining Emotion

Emotion, much like music, is not easily defined, and its exact meaning is frequently debated. According to Fehr and Russell (1984), "Everyone knows what an emotion is until asked

to give a definition." Despite being something innate to the human experience, emotion can be surprisingly complicated. Multiple theorists have tried to define the different emotions and how they are experienced. Even Pixar Animation Studios tried to tackle the complex experience of emotion in its 2015 animated film, *Inside Out,* by illustrating certain basic emotions as personified characters in a way that made them easily understood by children (i.e., Joy is a bright yellow character who is always happy, Sadness is a blue character who is always mopey and prone to crying, etc.) (Zakrzewski & Marsh, 2015).

Basic emotion theory has attempted to narrow down a few fundamental emotions that are universal. For example, the theory of Ekman, Friesen, and Ellsworth defines the basic emotions as fear, joy, sadness, anger, disgust, and surprise (Gu et al., 2019). Each of these emotions are related to biological needs and can be linked to certain structures in the brain. For example, activation of the amygdala has been linked with reactions of fear (Gu et al., 2019). Additionally, in keeping with this example, fear has been shown to have adaptive purposes. Humans have demonstrated a tendency towards hyperawareness of potentially threatening stimuli, and reactions of fear may serve as protection by allowing us to flee or fight during a dangerous situation (Berdica et al., 2018). Other brain regions implicated in emotional experiences include the anterior cingulate cortex, which also deals with reward and punishment; specifically, this region manages emotional responses to actions (Rolls, 2019).

Another important element of emotional research is the distinction and measurement of arousal and valence. Arousal refers to the degree of activation experienced in response to an emotional stimulus, and valence is defined as the degree to which an emotional experience is characterized as pleasant or unpleasant (Wade-Bohleber et al., 2020). Interestingly, most of the primary emotions mentioned above (with the exception of joy) are negatively valenced. People

with schizophrenia show different responses to different emotional valences than controls (Lim et al., 2017).

Chapter Two: Symptomology of Auditory Deficits

Basics of Auditory Processing

The auditory system, like other sensory systems, is more complex than many people might initially think. The primary source of information for the auditory system is sound waves, which are essentially moving molecules that causes changes in air pressure (Peterson et al., 2021). Sound waves are filtered into our ears, vibrate the membrane of the eardrum, and then transfer through the inner ear to the cochlea. There, the information begins to be translated into neural energy by receptors known as hair cells (Peterson et al., 2021). The ear itself is a complex organ consisting of multiple small parts (including the smallest bones in the human body), which all must work together to allow auditory information to be received by the brain. However, the complexity of the system does not stop at the ear.

For pitch processing specifically, there is some debate as to the exact mechanisms in the brain involved, with some claiming a single brain region is responsible for understanding pitch, and others suggesting that it is instead a more complicated system (Kumar et al., 2011). The latter seems more likely, considering that fMRI studies have demonstrated that there is activation of multiple brain areas during pitch perception. One such study examining adults and children, both with and without musical training, found that the inferior frontolateral cortex, inferior ventrolateral premotor cortex, anterior and posterior temporal lobe structures, orbito frontolateral cortex, and anterior insula were all activated when presented with unfamiliar chords (Koelsch et al., 2004). These regions make sense considering that, for instance, the temporal lobe deals with auditory processing, with the posterior temporal lobe being linked to language comprehension and the anterior temporal lobe being linked to social and emotional processing (Crinion et al., 2003; Wong & Gallate, 2012). In fact, four different potential cortical networks for processing

musical sounds were identified, and these activations remained similar across both adults with no musical training and children (Koelsch et al., 2004).

Having such a complicated sensory system seems appropriate considering the complex perceptions the brain is capable of creating when processing pitch. Not only does pitch perception allow people to understand meaning and emotion in speech, but it is also possible to perceive subtle musical differences. In music, those with at least a basic understanding of musical intervals (pitch differences) and notes can possess both relative and perfect pitch perception. Relative pitch refers to the ability to perceive differences in intervals and sound qualities, and perfect pitch refers to the ability to identify notes purely by ear (Boone & Schonbrun, 2017). In relation to other components of music, there is evidence of some common reactions and perceptions. For instance, a study examining infants' reactions to music found that, much like adults, infants show affective preference for consonant tones over dissonant ones (Trainor & Heinmiller, 1998). There is also interest in the examination of melodies as a way to measure auditory perception. For example, one study examining infants' abilities to recognize melodic changes found that they could discriminate transformed melodies (i.e., changes in pitch of tones or changes in the ordering of the melodic contour) from a melody they were previously exposed to (Trehub et al., 1984). It appears that musical understanding is implicit in human psychology across the lifespan, much like knowledge of one's native language (Rohrmeier & Cross, 2013). These similarities may relate to the idea of protolanguage theory, which states that musical form and tone developed early in our evolution, before any semantic meaning would have been added (Kantrowitz et al., 2014). Though healthy people, even those without musical background, show complex functioning of pitch processing, there has been evidence that some patients with schizophrenia have a reduced ability for such sensory processing.

Tone Matching and Prosody in Schizophrenia

A common method of measuring deficits in auditory processing and sensory memory is the use of tone matching tasks (Javitt et al., 2000). In such tasks, patients are presented with a series of pairs of tones and must determine whether the tones are the same or different (Dondé et al., 2019). In general, patients with schizophrenia have been shown to need larger differences in pitch than controls in order to distinguish tones (Javitt et al., 2000). A meta-analysis conducted by Dondé et al. (2017) found that schizophrenia patients were significantly impaired in the percent of correct responses on the tone matching task compared to controls. Additional risk factors for severity of these deficits are variable across the literature. For example, McLachlan et al. (2013) found that patients who experienced auditory hallucinations showed poorer discrimination of pitch in a tone matching task. Severity of illness may also play a role. One study found that patients with schizophrenia in long-term residential care required a 20% difference in pitch between tones in order to discriminate a difference in pitch, while patients without active symptoms, outpatients, and controls only needed a 3-5% difference in pitch in order to discriminate the difference (Rabinowicz et al., 2000). There have also been examinations of the influence of distractor stimuli on performance on tone-matching tasks. Rabinowicz et al. (2000) found that all groups (stable patients, outpatients, residential patients, and controls) showed decreased performance once distractors were introduced. Notably, when including distractors, everyone does poorly on the tone-matching tasks; thus, other factors influencing performance should be examined in future research.

Regardless of varying risk factors, impairments in pitch discrimination can be linked to an understanding of vocal prosody, which is the rhythm and intonation of speech that helps convey emotion (Matsumoto et al., 2006). Thus, patients experiencing deficits in prosodic

discrimination may struggle in social situations, since their ability to interpret emotions being conveyed by other people via speech is impaired (Javitt & Freedman, 2015).

Prosody has been shown to be incredibly important for communicating with other people. Even subtle differences in tone, pitch, and rhythm can convey whether another person is safe or not to be around, whether another person has good or bad intentions, and whether another person can be trusted (Ponsot et al., 2018). A deficit in the ability to recognize these subtle differences thus may be part of the cause for the social struggles often observed in the schizophrenia syndrome. Research has supported the idea that problems with affective prosody are associated with abnormalities in auditory processing, though it is uncertain whether this is caused by early processing issues or later problems with attention (Jahshan et al., 2013). Another study conducted by Leitman et al. (2010) found that schizophrenia patients had a harder time using pitch related cues to identify emotion than controls. On the other hand, their ability to use intensity related cues was not affected by their disorder. What was interesting about patients' use of intensity cues, though, was that they tended to overuse voice intensity as a way to read emotion. It is possible that this is an attempt at compensating for the lack of pitch cues (Leitman et al., 2010). Patients also had some capability of using voice quality (timbre) to identify emotion, but overall they did show lower performance than controls (Leitman et al., 2010). Because of these varying elements that can influence prosodic processing, it is possible that tone matching tasks simply assessing pitch discrimination may not be sufficient to fully understand prosodic deficits in schizophrenia.

Musical Issues in Schizophrenia

When it comes to recognizing melodies, patients with schizophrenia have been found to be impaired in melodic streaming. Melodic streaming refers to separating sequences of pitches

into categories, or streams (McLachlan et al., 2013). For example, if presented with two tones, people may hear them as either a single, integrated stream or as two separate sequences (especially when presented with a low tone and high tone, as low pitches will be perceived separately from high pitches) (Barniv & Nelken, 2015). When examining melodic streaming capabilities of patients with schizophrenia who experienced hallucinations, Nielzén and Olsson (1997) presented 13 tones in increasing and decreasing scales to participants. It was found that five of the 17 patients assessed did not experience streaming at all, and the rest of the patient group experienced differences in streaming from the control group (such as hearing streaming too early or hearing it when the control group did not). Another study by Ramage et al. (2012) also found that people with schizophrenia are less likely to perceive two distinct auditory streams compared to controls. This deficit was present in more complex frequencies as well as pure tones. It is possible that abnormalities in the auditory cortex may influence these streaming deficits (Ramage et al., 2012). For example, Heschl's gyrus has been shown to be active in response to pitch cues during streaming (Schadwinkel & Gutschalk, 2010). However, it is unknown whether this deficit is caused by a lifelong issue resulting from schizophrenia, or is a secondary symptom that develops later in life (Nielzén & Olsson, 1997). There is some evidence that the reason schizophrenia occurs when it does is a result of inappropriate neural pruning during adolescence. Connections are made and pruned all throughout the lifespan, and if those connections are not pruned correctly, it may contribute to schizophrenia onset (Johns Hopkins Medical Institutions, 2010). Therefore, it is possible that the auditory deficits observed in schizophrenia are a result of this ongoing inappropriate neural pruning, though more research to determine this possible relationship is needed.

Amusia

Amusia, a disorder of pitch processing and musical perception, is an uncommon disorder that affects only about 4% of the general population. People with amusia, whether it is congenital or acquired, typically have normal hearing abilities, but struggle with melody recognition and pitch detection (Chen & Yuan, 2016). However, despite low prevalence of amusia among the general population, amusia appears to be more common among patients of schizophrenia. Some sources cite the prevalence of amusia in schizophrenia patients as being between 45-62% (Kerkova, 2018).

The most common measure of amusia is the Montreal Battery for Evaluation of Amusia (MBEA), which consists of various piano melodies intended to measure scale, contour, interval, and rhythm. To perform the task, participants must listen and identify whether melodies are different or the same (Toledo-Fernández et al., 2018). The MBEA also measures musical memory, or how well a participant can recognize and recall a melody that was played earlier in the test (Kantrowitz et al., 2014). Kantrowitz et al.'s (2014) study showed that patients with schizophrenia showed lower total scores on the MBEA than controls, with all three domains (melody, rhythm, and memory) being impacted. Another study found that patients with schizophrenia performed worse than controls on the overall score on the MBEA, as well as on the rhythm, meter, and memory subscales (Wen et al., 2014). However, there were no significant differences on the scale, contour, and interval subtests (all of which relate more to melody and pitch). This is interesting, considering the deficits in pitch perception previously mentioned in relation to tone-matching tasks, as well as in Kantrowitz et al.'s (2014) study. It seems likely that the sensory and musical deficits present in schizophrenia go beyond simple pitch discrimination issues.

There has also been research into the connection between illness severity and amusia. Hatada et al. (2014) found that all patients with schizophrenia had lower scores than controls on all of the subscales of the MBEA. However, lower negative symptoms and psychopathology scores on the Positive and Negative Syndrome Scale and higher scores on the Global Assessment of Functioning were correlated with higher global scores on the MBEA. There was also a lack of relationship between the use of anti-psychotic medications and the MBEA global score, since anti-psychotics typically are more effective at treating positive symptoms than negative symptoms (Hatada et al., 2014). However, one possible limitation cited by the researchers was that a larger study is needed to fully examine the impact of different types of medication, especially considering some medications treat negative symptoms better than others (Hatada et al., 2014).

These musical deficits have remained consistent across different forms of tests. One study presented participants with new melodies composed for the study, and had them describe how complex the compositions sounded, how interested they were in the music, and their personal opinions about the music (Chung et al., 2016). It was found that patients with schizophrenia perceived the melodies' complexity as lower than healthy controls. The patients also selected a different melody as the most complex than the one selected by controls. There was no overall difference in interest in the music, but the patients with schizophrenia were more inconsistent in their patterns of interest (Chung et al., 2016). There was also no overall group difference in preference, though the patients with schizophrenia chose a different melody as their favorite than the controls. The researchers concluded that patients with schizophrenia have trouble perceiving musical changes such as rhythmic patterns, melodic contour, and chord progressions (Chung et al., 2016). In light of the prevalence of all the musical and prosodic

deficits observed in patients with schizophrenia, there has been interest in what this implicates for overall symptomology, functioning, and quality-of-life for patients.

Chapter Three: Impact of Musical Deficits on Emotional Interpretation

While music, like most art, is largely subjective in how it can be reacted to and interpreted, there are some commonalities in how people perceive emotions when listening to music. Often, a composer will have an intended emotion they wish to evoke, and research has shown that listeners tend to be sensitive to said emotion. One study examining reaction to musical cues across music from different cultures found that listeners had the intended reaction to the music even when they were unfamiliar with a different culture's tonal system (Balkwill & Thompson, 1999). For example, musical cues such as fast tempo, low rhythmic complexity, and low melodic complexity were associated with feelings of joy, while a slower tempo, high rhythmic and melodic complexity, and low pitch were associated with sadness. This demonstrates that not only do people rely on social and cultural cues to react to music, but there are psychophysical cues present in the composition that allow the songwriter to evoke the intended emotions in an audience (Balkwill & Thompson, 1999). There are also brain regions implicated in the emotional experience of music. Studies of electrodermal activity have shown that the orbito frontolateral cortex and the amygdala (which are regions related to emotion) are activated in response to certain musical chords (Koelsch, 2006).

Just as people with schizophrenia may show deficits in their ability to properly recognize tones and other musical elements in and of themselves, they also show deficits in emotional responses to music. Abe et al. (2017) used different chord progressions—C minor and C major—to examine emotional responses in participants. Major chords are most commonly associated with positive emotions, while minor chords are usually associated with negative emotions. Likewise, dissonance is associated with discomfort and unpleasant feelings (Abe et al., 2017). After being exposed to the musical stimuli, participants were asked to identify the emotion

associated with each chord. Only 37.9% of the participants with schizophrenia identified the minor chord as sad, compared to 96.6% of the healthy controls. Patients with more severe symptoms had an increased number of incorrect responses (Abe et al., 2017). Another study conducted by Lim et al. (2017) used more complex musical samples than just chords, instead selecting musical pieces that possessed the correct psychophysical cues for each intended emotion. For example, happy music consisted of fast tempo, major keys, and varied instrumentation, while sad music consisted of slow tempo, minor keys, and emphasis on string instrumentals (Lim et al., 2017). Overall, the schizophrenia group had lower rates of concordance when it came to the identification of the intended emotion compared to controls. Additionally, patients with schizophrenia perceived the intensity of emotion as lower than the controls. Positively valenced emotions were easier to identify than negatively valenced emotions. There was some difference in perceived emotions between patients with different symptom types as well. Patients experiencing more negative symptoms perceived the angry-sounding music as more intense. All patients perceived happy music as more intense than sad music. It is important to note, however, that in this particular study, the participants' familiarity with the musical pieces (many of which were from film scores) were not taken into account (Lim et al., 2017).

To address this possible confound of familiarity, some researchers compose original pieces to use as the musical stimuli, as seen in the Chung et al. (2016) study mentioned above. Others will create variations on preexisting pieces. In Burge and Siebert's 2010 study, four different variations of J.S. Bach's *Invention #13 in A Minor* were created through computer-generation for use as musical stimuli. Through self-reports and EEG recordings, the emotional reactions of patients with schizophrenia were measured. It was found that people with schizophrenia generally reported more positive reactions to the music than controls, and that the

patients were more attracted to music overall (Burge & Siebert, 2010). This is interesting, considering the musical deficits observed in many people with schizophrenia. Despite having incongruent responses to musical emotions and trouble with perception, people with schizophrenia still tend to be drawn to music and enjoy it, if not moreso than healthy controls. Considering evidence in some studies that people with schizophrenia more easily recognize positively valenced emotions than negatively valenced ones, this may contribute to this increased attraction to music (Lim et al., 2017).

Additionally, there were some differences in EEG activation at posterior electrodes, with patients showing less activation in the left hemisphere than controls. Overall, people with schizophrenia show different emotional and physiological reactions to music than controls (Burge & Siebert, 2010). Another study played short excerpts of Western classical-inspired music intended to invoke specific emotions (Feingold et al., 2016). Overall, patients with schizophrenia showed lower emotional recognition accuracy than controls. All participants showed better recognition when presented with more complex tones rather than simple ones (Feingold et al., 2016). Overall, people with schizophrenia show different reactions to music than healthy controls, indicating that there is not only an auditory processing issue at play, but that this also impacts the emotional processes that are intended to happen in response to musical stimuli.

Chapter Four: Using Music For Research and Treatment

Music as a Measure

As mentioned previously, simple tone matching tasks may not be sufficient to fully assess the complex deficits of auditory or emotional processing present in schizophrenia. Some studies have compared simple tones to complex tones, and found that responses are more accurate in both patients and controls when the tones are more complex (Feingold, 2016). Additionally, comparisons between music and speech show similar responses. Matsumoto et al. (2006) used verbal and musical tasks to measure pitch and rhythm. People with schizophrenia failed to discriminate pitch differences in both the musical and verbal tasks. Patients with more severe symptoms were also found to have greater difficulty with verbal prosody. This study suggests that music could potentially be used as an analogue for verbal measurements since performance between the verbal tasks and the musical tasks were similar (Matsumoto et al., 2006). This may be evidence of the possible protolanguage connection mentioned previously. Though it is clear that musical tasks have more complexity than simple tone-matching, this gap could also be filled by more complex verbal tasks to measure prosody. However, as previously discussed, music appears to be something inherent in human nature. Every culture has some form of music, and it is believed that music is either a need or a consequence of human biology (Jacoby et al., 2019). Thus, by measuring patients with schizophrenia with musical tasks, the issues of prosody and musical interpretation can be addressed simultaneously.

Impact of Musical Deficits on Music Therapy

Schizophrenia can be a difficult disorder to treat, considering the broad range of possible symptoms. Most anti-psychotics have similar efficacy in treating positive symptoms, while their effects on negative symptoms tend to be more variable (Tandon, 2011). Some atypical anti-

psychotic medications, such as clozapine, olanzapine, and amisulpride, have been shown to have some effect on negative symptoms, and there are newer drugs that have shown some promise in treating negative symptoms (Căpățînă et al., 2021). However, there is interest in alternative forms of treatment due to the possibility of side effects of pharmacological treatments, as well as the variable effectiveness of said drugs. One such form of therapy is music therapy. Music therapy is a form of therapy in which music is used to help improve and maintain the health of patients. This therapy can involve a number of activities, including listening to and performing music, as well as composition and improvisation (Wheeler, 2015). One major use of music therapy is for emotional expression, and utilizing the role of music in expression can help patients heal and develop (Wheeler, 2015).

Music therapy has been shown to be effective in treating both physical and psychological symptoms of various disorders. According to a summary of multiple meta-analyses, it was found that music therapy helped to improve gait in Parkinson's patients, as well as generally improving sleep and depression (Kamioka et al., 2014). More relevant to the topic at hand, music therapy was found to improve both global and social functioning in schizophrenia (Kamioka et al., 2014). Another meta-analysis found that music therapy, when combined with standard treatments, improved both positive and negative symptoms of schizophrenia (Tseng et al., 2016). It may come across as surprising to see such benefits of music therapy considering the evidence of incongruent emotional interpretation of music present in some patients. However, as mentioned above, people with schizophrenia can have increased attraction to music and may perceive more positive than negative emotions in music (Burge & Siebert, 2010; Lim et al., 2017). Thus, music therapy may still show benefits despite differences in musical ability and responses.

It is possible that the type of music therapy plays a role in the benefits experienced by patients. One systematic review examined differences in types of therapy, which included active music therapy (where patients play music), receptive music therapy (where patients listen to music), and combined music therapy (Chung & Woods-Giscombe, 2016). Combined music therapy was found to be the most effective, and active music therapy was the least effective. It is possible that this is because of the previously discussed pitch perception issues, making the act of playing music more difficult and less beneficial. However, it should also be noted that effectiveness was also dependent on the length of music therapy sessions. Active-type therapy sessions tended to be shorter on average than the other types of therapy, which may have impacted its effectiveness (Chung & Woods-Giscombe, 2016).

Overall, music therapy shows evidence of improving symptoms of schizophrenia, especially when used in conjunction with other treatments. However, due to the previously mentioned pitch perception deficits and the differences in the interpretation of music in patients with schizophrenia, more research is needed to examine how these deficits might impact the benefits of music therapy.

Chapter Five: Discussion

Schizophrenia is a complicated disorder with a broad range of deficits that can impact multiple facets of life. At the heart of many of these symptoms are sensory processing problems, which can influence not only positive symptoms such as auditory hallucinations, but may also play a role in negative and cognitive symptoms such as social difficulties and deficits in emotional interpretation (Javitt & Freedman, 2015; McLachlan et al., 2013). It has been demonstrated in the literature that patients with schizophrenia show deficits in pitch perception, and that patients have difficulty with using pitch-related cues to identify emotion (Leitman et al., 2010). Patients with schizophrenia also show deficits in melodic streaming and higher rates of amusia, which likely connects to this pitch perception deficit (Kerkova, 2018; Nielzén & Olsson, 1997; Ramage et al., 2012). This carries over to identifying emotion in music, as patients with schizophrenia tend to perceive emotional music differently than their healthy counterparts. Whether it is an incongruence in identifying the intended emotion of a musical piece, a lessened perception of the emotional intensity of a piece, or a tendency to be drawn to different emotional valences in music, it is clear that patients with schizophrenia experience music differently (Abe et al., 2017; Lim et al., 2017). These musical deficits are important due to their connection to speech prosody; since melodies tend to have similarities to emotional human speech, impairments in recognizing pitch and musical emotion may have implications for patients' ability to recognize similar emotions in speech (Matsumoto et al., 2006).

Because of these similarities between music and speech, it is possible that music could make a more effective tool to measure prosodic deficits than simple tone-matching tasks, especially considering that responses are better when tones are more complex (Feingold et al., 2016). Additionally, this examination of musical differences and deficits is important when

considering the treatment of schizophrenia via music therapy. Notably, the musical deficits observed in patients with schizophrenia do not appear to impact people's desire for music, as people with schizophrenia showed greater attraction to music (Burge & Siebert, 2010). This means that music therapy is still helpful for many patients with schizophrenia in improving symptoms, though it is important to consider what types of music therapy might be most suitable, especially if a patient is demonstrating musical deficits.

Overall, there is a need for further research on musical deficits in people with schizophrenia, as well as how this might impact prosodic interpretation and music therapy. There are still gaps that need to be filled in the knowledge of this topic, such as examining possible confounding variables such as the impact of different anti-psychotic medications and cultural differences that may impact musical ability. Some newer anti-psychotics are more effective for treating negative symptoms, which could impact results on musical tasks, and individual exposure to different types of music and music education could also play a role (Căpățînă et al., 2021; Hatada et al., 2014).

In order to treat not just musical issues but schizophrenia symptoms in general, it is important to further examine to what degree dosage versus type of music therapy is best for treating schizophrenia (Chung & Woods-Giscombe, 2016). Additionally, identifying the causes of musical deficits such as melodic streaming or amusia may help with narrowing down the best treatments for patients presenting with these deficits. One other question that remains is whether these deficits are consistent across the lifetime and at different points in the course of the disorder; thus, more longitudinal studies examining musical deficits in people with schizophrenia should be conducted. Examining this issue of musical differences in people with schizophrenia across different cultures would also be helpful.

Music is a complex phenomenon that appears to be a part of our very nature. Although exact reasons remain difficult to pinpoint, it is clear that music has some sort of biological root in humans (Jacoby et al., 2019). Furthering the research on the impact of musical deficits on schizophrenia symptomology will not only open the way to improving the social and emotional well-being of patients and help identify the most effective therapies for treatment, but it may also help patients better connect with this crucial piece of our humanity.

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