MARTA WYSOCKA
Maria Curie-Skłodowska University, Lublin
Department of Logopedics and Applied Linguistics

Disorders of Music Perception and Speech Prosody Perception (As Exemplified by Studies on Polish-speaking Six-Year-Old Children) *

SUMMARY

Many similarities between music and speech encourage observation of relationships between mechanisms of perception of the two phenomena. One of the ways of investigating them is to study patients afflicted with amusia related to difficulties in music reception and expression. Congenital amusia, the subject of the present article, is most often defined as a deficit in musical pitch perception. The latest research results suggest that it may also be related to auditory memory disorders, impairments in musical timbre perception, and their temporal organization. Because in speech prosody many items of information are encoded by means of changes in vocal pitch, temporal organization of prosodic features and timbre of voice, it is necessary to find out how perception disorders concomitant with amusia are related to the process of perception of prosodic structures.

The article presents the results obtained in tests for music perception and speech prosody perception by three six-year-old amusic girls, which were compared with the results obtained by the control group consisting of 10 six-year-old children (five girls and five boys) The results obtained confirm the relationship between amusia and a reduced ability of speech prosody perception.

Key words: speech prosody, congenital amusia, speech prosody assessment, development of prosody perception

1. INTRODUCTION

Studies on the relationship between language and music point out that there are many analogies between these phenomena. In ontogeny we have a natural ability to learn music and language by imitation. Language and music acquisition probably occurs through the same learning processes. Musical and language forms are determined by the participation in specific culture. Language and music are hierarchically organized systems which are constructed of a series of discrete

elements (phonemes or sounds) that make up higher structures. Both within language and music we are able to generate an infinite number of sequences, the manner of conjoining the elements being determined by strict rules. Like in language, phonological, syntactic, and semantic rules can be shown to operate in music. There are also suggestions that music and speech may come from certain functional properties of auditory perception. They use the same vocal features: pitch, intensity, timbre and duration of elements to mark and express relations between constituents (after: Patel et al. 1998; Shuter-Dyson, Gabriel 1986; Sloboda 2002; Zatorre et al. 2002).

In view of so many similarities between language and music, scholars have for years asked the question about the existence of common neural mechanisms responsible for the perception and expression of both of them. One of the ways of investigating them is to study patients suffering from amusia.

For the logopedist, of special importance is to characterize the impact of amusia on the possibilities of speech prosody perception by children in whom prosodic competence is only developing. It is impossible to achieve full communication skills without the appropriate formation of this competence.

2. AMUSIA

Amusia in a very broad sense is defined as disorders of music perception, memory and expression. Two kinds of amusia are distinguished: expressive and perceptive. Amusia can be acquired (it appears after damage to the right of left brain hemisphere, in the latter case the patient has problems in processing higher-organized musical structures) or congenital (related to impairments in the white and grey matter of the auditory cortex and frontal structures).

Congenital amusia is defined by most researchers as disorders of perception and expression of musical pitch and organized pitch contours i.e. tune. It is called tone deafness and affects about 4-5% of society. It is usually characterized as a developmental and neurogenetic disorder (Peretz et al., 2008, Stewart, 2008).

Results of perception tests show that patients with congenital amusia have problems with discriminating pitch, identifying pitch variations and the direction of melodic contours (Foxton et al., 2004; Hyde and Peretz, 2004). Some scholars also point out the impaired perception of tone timbre (Tillmann et al., 2009). Congenital amusia is not related to impairments of the hearing organ, cognitive and motor deficits, or lack of musical experience (cf. inter alia Jiang et al., 2010; Patel et al., 2008; Peretz et al., 2007, 2008, 2009; Stewart, 2008; Tillmann et al., 2009). The overwhelming majority of congenital amusics have a reduced ability to sing clearly, and have problems with vocal reproduction of pitch, melodic intervals and contours, and with maintaining pitch (Hutchins et al., 2010). Some amusic individuals do not, however, have those performance difficulties, which suggests

a separate character of neural processes related to musical perception and expression. (Dalla et al., 2009). Research results also suggest that individuals afflicted with tone deafness may have problems with receiving information encoded in the pitch structures of the sounds in their environment (Loui et al., 2012).

3. CO-OCCURRENCE OF AMUSIA WITH OTHER AUDITORY PERCEPTION DEFICITS

Dysfunctions termed *congenital amusia* exhibit relationships with other perception deficits. The subject of many studies is its co-occurrence with disorders of auditory memory. Studies by Williamson et al. (2010) suggest that amusic individuals have problems with discrimination of sound pitch, in particular when the time interval between the compared pitches increases, which indicates that underlying amusia there may be impaired mechanisms of short-term memory. Tillmann et al. (2009) investigated the relationship between memory for pitches, timbres of musical sounds, and memory for words. The results show that amusics are characterized by poorer results in tasks of memory for pitch and musical timbres, while their verbal memory remains unimpaired. Similar conclusions were arrived at by Williamson and Stewart (2010). Unimpaired verbal memory combined with a good skill in acquiring nonsensical words in adults with amusia was also demonstrated in the studies by Peretz et al. (2012).

Investigations on the relationship between music perception deficits and disorders of speech prosody perception constitute a large group among the studies devoted to the problem of amusia. Some scholars reported the absence of strong connections between amusia and the perception of prosodic structures. In 2002 an article was published by Ayotte et al., according to whom in the tests for intonation perception, and the tests for memory of texts and environmental sounds, amusic individuals achieved similar results as the control group, while decreased results were observed in tests for music pitch perception, for naming and identification of tunes, and for memory and performance of tunes.

At present, however, the effect of amusia on a decreased ability of speech prosody perception is generally demonstrated. Patel et al. (2008) studied the ability to discriminate, by English-speaking individuals with amusia, intonation contours: cadence and anticadence in two sentence types: statements and questions. The authors report that the subjects had problems with discriminating the direction of intonation changes (problems increased as the contour range decreased) and were unable to distinguish between falling and rising contours when pitch differences were comparatively small in their final parts. A similar experiment was conducted by Liu et al. (2010). Amusic subjects showed diminished results as compared with the control group in tasks of discrimination, identification and imitation of intonation contours in statements and questions. The mechanisms of

perception of intonation structures may thus show a connection with the processes of pitch perception in music. Disorders in the discrimination of the direction of pitch variations found in amusic individuals comprise both musical sounds and intonation structures.

The ability to discriminate between statements and questions by amusic users of a tonal language was studied by Liu et al. (2012). The results of their study show that the subjects obtained low scores for the tasks that used intonation contours with no text whereas for the tasks consisting in the discrimination between full statements and questions, complete both with respect to segmental and suprasegmental structures, the amusic subjects did not score as low as before in comparison with the control group. The authors believe that amusia only slightly impairs the process of language communication. In the complete structure of language, information is encoded not only through pitch variations but also through combinations of other acoustic features whose perception is not disturbed in amusia.

Jiang et al. (2010) verified the truth of the proposition which asserts that early exposure to a tonal language may improve the process of pitch perception in amusic individuals. The experiment was conducted with adult subjects who had used the tonal Mandarin Chinese language since their childhood. The results show that the subjects had problems not only with discrimination of musical pitches but also with tonal patterns and intonation structures. Amusia can therefore disturb communication in tonal languages, in which the meaning of lexical units depends on the tone height to a significantly greater extent than in non-tonal languages.

Despite the fact that scholars are interested in the relationships between congenital amusia and speech prosody perception, it should be emphasized that their attention focuses on adult language users. Studies devoted to the characterization of these relationships in children are few.

4. OWN STUDIES

The goal of my studies was to investigate the relationship between the processes of perception of music and speech prosody occurring in six-year-old children. Previous studies with the participation of non-amusic children aged 5-7 years (Wysocka 2007) showed that the development level of prosody and music perception competences is similar in particular age groups, which suggests that there are similar mechanisms responsible for the perception of these phenomena.

The tests described in the article were conducted with the participation of three six-year old amusic girls (mean age 6.3), in whom hearing loss, cognitive and motor deficits, or lack of musical experience were not found.

4.1. The Investigation Tool and Test Procedure

The children were studied with tests devised by the author, which comprised:

1. The test for perception of instrumental tunes, made up of tune discrimination tasks (consisting of two-, three-, or seven-elements) and identification of tune contour direction.

2. The intonation perception test consisting of intonation structure discrimination tasks in speech (in two- and three-syllable words and in seven-syllable utterances and in their vocalic forms) and identification of intonation contour direction.

3. The test for perception of tune in singing, made up of tune discrimination tasks (two-and three-syllable words, a seven-syllable utterance, and their vocalic forms) and identification of tune contour direction.

4. The rhythm perception test, made up of tasks of rhythmic contours discrimination.

5. The accent perception test in rhythm composed of tasks of determination and discrimination of accent position in two-, three-, and four-syllable rhythmic-accentual structures.

6. The accent perception test in instrumental tune, consisting of tasks of identification and discrimination of accent position in two-, three-, and four-element tunes.

7. The stress perception test in a sentence consisting of tasks of identification and discrimination of stress position. Each sentence was composed of four stress groups. In successive realization variants presented here, a different group was stressed.

8. The emotional prosody perception test composed of tasks of emotion determination and discrimination in speech. Particular realization variants contained realized utterances that were emotionally unmarked, or marked with joy, anger and sadness.

The testing of each child took place within two weeks, during several individual sessions, which lasted 10–20 minutes each. Their duration depended of the possibilities of the child's concentration. The tests were conducted with the elimination of outside acoustic stimuli that could disturb the signals presented in the tests. After the instruction was given and explained, prerecorded material was presented, and repeated at the child's request if the need arose or when it was observed that the child did not concentrate during the presentation.

The girls tested were seated at the distance of one meter from the loudspeakers, this position permitting simultaneous perception of the signal by two ears. The volume of the signal was adjusted to their preferences; special care was taken to make the volume level sufficient for accurate hearing of the signals played. The series run in a given test was always preceded by a preliminary trial run accompanied by the explanation of how to perform a task.

It was assumed that alternation of musical and prosodic tasks would be conducive to a better concentration of attention and would reduce fatigability of the subjects.

The obtained scores were compared with the results of the control group, which consisted of five girls and five boys aged six (mean age 6.2).

4.2. Results of the Tests

The tested girls scored worse in all the tests as compared with the control group of children (cf. Fig. 1. and 2.)

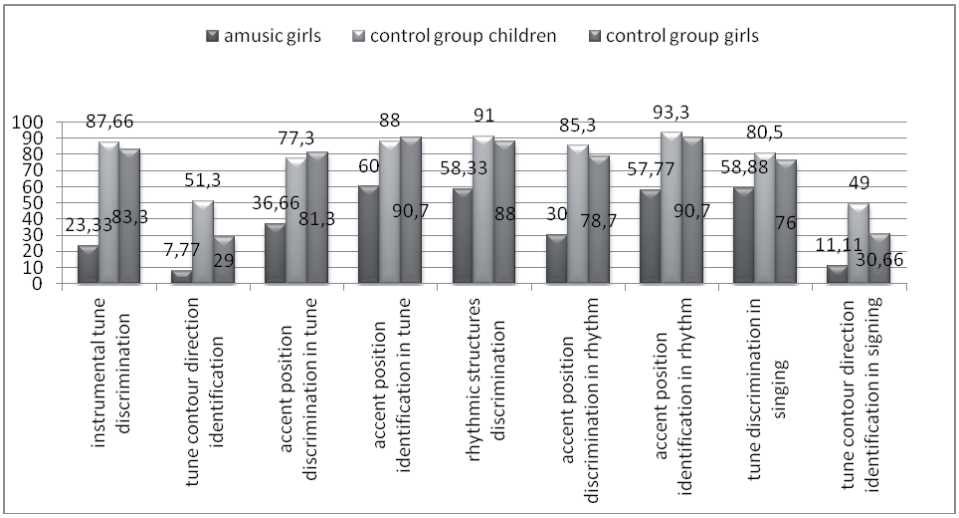

Fig. 1. Correct answers in the experimental and control groups in musical tests [%].

4.2.1. Tests for Perception of Tune and Intonation

Tone deafness impairs perception of musical pitches and melodic structures: their discrimination and the perception of variations occurring within them; that is why a particularly high disproportion of results between the experimental group and the control one was found in tasks of instrumental tune discrimination (23.33% versus 87.66% obtained as the mean result in the control group of six-year-old boys, and 83.3% scored by six-year-old girls) and in tune contour direction identification tasks (7.77% versus 51.3% and 29% respectively in the control group).

Amusic girls scored higher in the tests for perception of the tunes of sung words and sentences as compared with the test for perception of instrumental tunes. In the tune discrimination tasks their score of correct answers was 58.88% (in the control group 80.5% and 76%). Better results were reported in tasks tune discrimination in words and sentences (65.55%); in contrast, in the tasks using

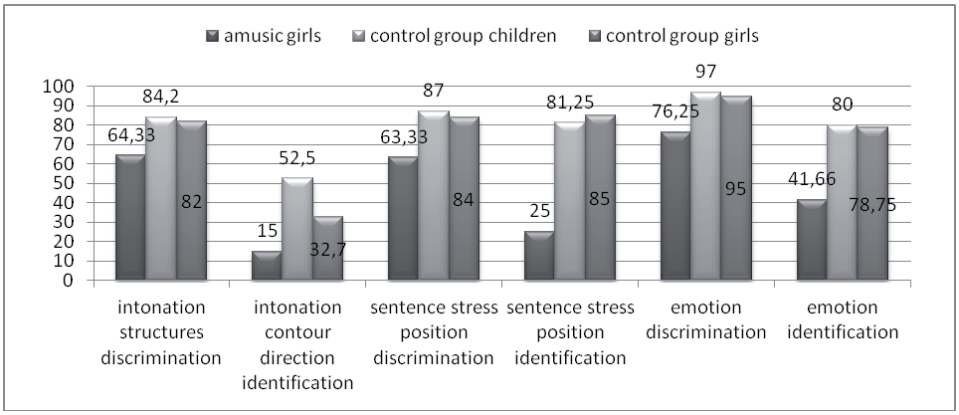

Fig. 2. CORRECT ANSWERS IN THE EXPERIMENTAL AND CONTROL GROUPS IN PROSODIC TESTS [%].

vowel structures, in which the subjects had to rely exclusively on the pitch of the vowels sung there was a decrease in the score of correct answers – 52.22%. For the tasks of direction identification in sung tunes the amusic girls gave equally correct answers both for text and vowel tasks at the level of 11.11% (versus 49% and 30.66% in the control group).

A slight increase in answer accuracy as compared with the previous tests was reported in the intonation perception test (in intonation discrimination tasks, amusic children scored 64.33% in answer accuracy: 65.55% for text tasks and 63.33% for vowel tasks). In the control group the mean percentage of correct answers was 84.2% (with the girls in this group scoring 82%). In tasks of intonation contour identification, the correctness percentage in amusic girls was 15% (16.66% for text tasks, and 13.33% for vowel tasks). In the control group, mean accuracy was 52.5% (for girls – 32.7%).

The results obtained show that intonation perception and tune perception is worse in amusic children than in their peers not suffering from this deficit. The tasks that proved to be most difficult were those based exclusively on musical material, while the easiest were those that tested the perception of speech prosody, in particular the text tasks. In the perception of singing the amusic girls achieved intermediate scores, approximating, however, the results of prosody perception tests. It may be thus surmised that during the perception of singing the tested girls (possibly using the deficit compensation mechanism) applied the strategy for speech perception. Worth noting is the fact that non-text tasks, in which the subject had to take only pitch variations into account, were performed with lower correctness only in the tasks of discrimination of sung tunes, in the remaining tasks these differences were negligible or not present at all.

4.2.2. Rhythm and Accent Perception Tests

In the case of the three amusic girls lower scores were also reported in the test for rhythmic structure discrimination (58.33% versus 91% scored by all the control children, and 88% by the girls in this group). This suggests that in the amusic subjects deficits in pitch perception may occur with rhythmic organization disorders.

Far lower results scored by the amusic girls were also reported in the test for accent perception in a tune. For the tasks of accent position discrimination the subjects achieved the correctness level of 36.66% (the mean score in the control group being 77.3%, for the girls in the control group – 81.3%). For the tasks of accent position identification in a tune the result obtained was already better – 60% (in the control group all children scored 88%, with girls scoring 90.7%).

Similar results were achieved in the test for accent perception in rhythm. For the tasks of accent discrimination, the accuracy of answers of the amusic girls was 30% (for the control group 85.3 % and 78.7%) respectively) while for the tasks of accent position identification in rhythmic structures this score was 57.77% (with respective 93.3% and 90.7% correctness in the control group). The better result for the tasks of accent position identification was probably influenced by the fact that the subjects used, more eagerly than in discrimination tasks, the available cards which symbolized individual elements of the melodic structure, which also involved visual perception and proved helpful in identifying accent positions.

In the test for stress perception in sentences this tendency reversed. The amusic girls obtained the lowest scores for the tasks of stress position identification (25% versus 81.25% and 85% scored in the control group), for the tasks of stress position discrimination the correctness of their answers was 63.33% (all six-year-olds in the control group achieved 81.25% of correct answers, with girls in the group obtaining – 85%). The low result for the tasks of stressed word identification can be attributed to the fact that in the test material a stressed word stood out above the remaining words by an increased voice pitch, consequently tone-deaf persons might have found it difficult to identify it.

4.2.3. Tests for Emotional Prosody Perception

Very interesting results characterize the test for emotional prosody perception. For tasks of emotion discrimination the amusic girls achieved a 76.25% correctness of answers while their peers in the control group achieved an average score of 95% (girls 95%). Even lower results were reported for the tasks of emotion identification (41.66% versus 80% and 78.75% obtained in the control group).

The encoding of emotions in prosodic structures is performed by means of combinations of many features of speech sounds, in particular syllabic vowels: pitch, volume, articulation duration, and timbre essential in emotional prosody. The results of some studies (Tillmann et al. 2009) show that amusic patients may

also suffer, apart from tone deafness, from disorders of timbre perception. These deficits may perhaps underlie the impaired perception of emotional prosody. This problem seems certainly to require further investigation.

RECAPITULATION

The obtained results confirm the effect of perception disorders concomitant with congenital amusia on the perception of speech prosody. The studied children obtained the lowest results in the tasks based on musical, in particular melodic material, which required the skill of pitch discrimination and identification of variations within tunes. They also had serious problems with the tasks of accent position discrimination in a tune and in rhythm. In the test for rhythmic structure perception the scores obtained by the amusic girls are also far lower than in the control group. In the tests for speech prosody perception the results of the control group are higher than those achieved by the amusic children in all types of tasks, in particular in the tasks that required identification and determination of prosodic structures.

Difficulties in the perception of music and speech prosody by patients afflicted with amusia are undeniably related to disorders of pitch discrimination but also, as the obtained results suggest, they may be caused by the impaired perception of timbre (the test for emotional prosody perception) and, although to a far lesser extent, by the impaired perception of the temporal organization of rhythmic structures (rhythm perception test).

It follows from the presented test results that the perception mechanisms of music and speech prosody are interrelated. This allows the utilization of music in stimulating the development of prosodic competence and the treatment of prosodic disorders but only in the case of patients who are able to perceive musical structures. For amusic patients this solution may prove ineffective, that is why when conducting therapy it is necessary to use the supporting methods meant for amusia treatment.

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