MUSIC PERCEPTION IN PATIENTS WITH DEMENTIA DUE TO ALZHEIMER'S DISEASE

Demetre Yannou[1], *Stavros Baloyiannis*[2], *Anastasia Kostaridou-Eukleides*[3]
Grigorios Kioseoglou[3], *Erifili Damianou-Marinis*[1], *Despina Klonari*[1]
Evangelia Nakopoulou[3], *Katerina Tzedaki*[4]

[1] Department of Music Studies, Aristotle University Thessaloniki, Greece
[2] 1st Department of Neurology, Aristotle University Thessaloniki, Greece
[3] Department of Psychology, Aristotle University Thessaloniki, Greece
[4] Department of Music – City University London

ABSTRACT

This study investigated the music perception of patients with probable Alzheimer's disease (AD). Although the clinical syndrome of AD is characterized by an acquired decline of cognitive functioning, current bibliography suggests that musical activities may be preserved while other cognitive functions fail. In our research, we tested the reaction of AD patients to simple music units and sound parameters as well as to complex music patterns and melodies. Three different groups of participants were tested: A group of 30 young adults (20-30 years old), a group of 16 individuals (67-77 years old) diagnosed as having probable Alzheimer's disease of mild to moderate levels, and a group of 30 normal elderly adults (67-77 years old) used as a control group. Moreover, all the elderly participants – healthy and patients- were tested as to their cognitive ability using the MMSE test. The experimental material consisted of eight tests divided into two levels that reflected the perceptual organization of simple and complex stimuli, respectively. The first level consisted of four tests that examined the participants' ability to perceive changes in frequency and timbre as well as changes in rhythmic and volume patterns. The second level consisted of four non-familiar melodies, which were composed so as to test ability of detecting disruptions in the continuity of rhythm, melody, volume, and timbre. A series of 3x4 mixed design ANOVAs performed on the data showed that AD patients had in general lower performance in the perception of music as compared to healthy adults. Furthermore, results suggested that the complexity of musical stimuli as well as music parameters, particularly rhythm and pitch, affected participants' performance. Finally, detailed analysis underscored the importance of the melodies nature on participants' ability to correctly identify music differentiations.

1. INTRODUCTION

Brain processing of music requires the engagement of multiple interconnected neural networks that can maintain specific musical functions, even when some kind of brain insult, results a severe global decline (Peretz, 2002). Yet, examination of amusic patients – regardless of the source of brain damage that causes the amusia –shows that music cognition is not affected in its entirety (Peretz & Hebert, 1995). This means that although the clinical syndrome of AD is characterized by a central auditory dysfunction and an acquired decline of cognitive functioning (Gates et al., 1996), we may hypothesize that some musical abilities may be preserved. Studies on music perception of AD patients are very few up to now and investigated only specific aspects of music cognition. Specifically, the research of Bartlet, Halpern, and Dowling (1995) tested AD patients' ability to recognize familiar from unfamiliar melodies of AD. It was found that AD patients were impaired relatively to controls in old/new recognition of highly familiar items, and they performed better in familiar tunes, put down as "traditional", than the than in novel ones. A case study reported by Aldridge (1998) presents a demented amateur pianist who knew many folk songs and was able to sing them alone, but she was unable to build a freely improvised melody from a selection of tones. She was also quite accurate in rhythm and melodic imitation but she needed often instructions about how to proceed. Electroencephalographic brain mapping during music perception conditions showed decreases of EEG power in Delta frequencies (Gunter et al., 1993), a positive effect that could possibly explain the remarkable responsiveness of patients to music (Aldridge, 1998). These findings suggest that AD patients may preserve some aspects of music perception although their overall performance declines. However, the extant studies are not detailed enough so as to identify which aspects of music perception are preserved and which suffer most. The present study aimed at investigating the perception, by patients in mild to moderate AD phases, of isolated simple music units and sound parameters as compared to their occurrence in complex music patterns and melodies.

2. METHOD

2.1. Participants

The sample comprised a total of 76 non-musicians divided in three groups: 30 young adults – 15 male and 15 female, (Mean age = 21.66), 30 elderly adults – 12 male and 18 female – as the control group (Mean age = 69.96), and 16 AD patients – 9 male and 7 female (Mean age = 71.33) – diagnosed as having probable Alzheimer's disease by the medical staff of the 1st Neurological Clinic of of Aristotle University of Thessaloniki. All participants answered a specifically designed questionnaire that recorded their educational level, interests, origin and music background. They were also tested as to their peripheral auditory ability with a test battery, including pure-tone thresholds, speech audiogram and word recognition in a quiet room, to eliminate any possibility of inadequate hearing. Moreover, all the elderly participants – healthy and patients – were tested as to their cognitive ability using in the MMSE (Mini Mental State Examination).

ISBN 3-931852-67-9
ISSN 1617-6847

2.2. Material

The auditory material we used involved eight tests, divided in two levels. In Level 1, each of the Tests 1 to 4 measured the participants' ability to respond to 7 unexpected inserts that interrupted the continuous repetition of a standard simple listening pattern. Each test focused on a different parameter, namely, frequency, timbre, rhythmic patterns and volume patterns. Level 2 (tests 5 to 8), consisted of four simple monophonic melodies originally composed for this research. The melodies which were composed due to basic principles of tonal music, applied differently in each test. These tests, examined the participants' ability to perceive 7 disruptions in the continuity of each melody, based on the parameters mentioned above.

The frequency of all sounds used in the tests was within the range of the human voice as this is used in mixed choir arrangements (E2=82,407Hz – A5=880Hz). The number of repeated standard patterns before the occurrence of the first disruption was at least three and there were at least two standard pattern repetitions before a new disruption occurred. The number of repetitions of the standard pattern in each test, as well as the placing of the disruptions was created and checked using random function algorithms, in order to avoid any possibility of anticipation.

Audio files of Tests 1-4 were created by means of digital sound synthesis using 'c-mix' programming environment (Garton, 2003), while audio files of Tests 5-8 were created using synthetic sound resemblances of acoustic musical instruments. In this case a synthesizer controlled the transcriptions of the original tests (5-8) to midi files and the performance was recorded and stored as digital sound files. For the reproduction of the audio tests, a system using a NEXT cube computer, two pairs of high quality headphones and the relative software "Timeplay" -created by Brad Garton at Columbia University was used. This software which is both a sound player and a high precision timer, was used for sound reproduction and measuring the participants' time reaction.

2.3. Tests

First Level

Test 1: A sine wave sound (Frequency=440Hz, Duration=500msec, Attack time=50msec, Sustain time= 400msec, Release time= 50msec) was repeated every 1 second. The inserted sounds differed from the repeated one only in frequency.

Test 2: A synthesized sound (Frequency= 440Hz, Duration= 500msec, Attack time= 50msec, Sustain time= 400msec, Release time=50msec), was repeated every 1 sec. The Harmonic spectrum was: 1, 0.8, 0.2 (relative amplitudes of the first three component sine waves). The inserted sounds differed from the repeated one, only in timbre.

Test 3: A standard pattern, which consisted of white noise sounds (Attack time=500msec, Sustain time=0, Release time=500msec), was repeated every 2000msec. The inserted patterns differed only in relation to their amplitude envelope, which was chosen through random function procedures.

Test 4: The repeated standard pattern consisted of three sine wave sounds (F=440Hz). Tempo correlated to quarter note = 60. The duration of the sounds formed a rhythmic pattern consisted of an eighth-note followed by two sixteenth notes. The different rhythmic patterns, which disrupted the repetition of the standard pattern, were chosen through random function procedures.

Second Level

All tests in Level 2 consisted of originally composed melodies, where 7 randomly inserted disruptions according to timbre or volume or incompatible melodic and rhythmic patterns, affected the music continuity.

Test 5:The melody is in G major. The meter is in 3/4, the tempo indication is "quarter note = 90". Total duration: 1.38.

Test 6: The melody is in Bb major. The meter is in 2/4, the tempo indication is "quarter note = 104". Total duration: 1.57.

Test 7: The melody is C major. The meter is in 3/4, the tempo indication is "quarter note = 104". Total duration: 1.50.

Test 8: The melody is in C major. The meter is in 4/4, the tempo indication is "quarter note = 112". Total duration: 1.47.

2.4. Procedure

As soon as the participants completed the auditory testing and answered the questionnaire, they were ready to start the main experimental procedure. Elderly participants were also tested with the MMSE before taking part in the main tests battery. A small preliminary task was designed so that the participants got familiarized with the tests and the use of the ENTER key on the PC keyboard, which was covered with brightly colored tape. Participants were tested individually in a quiet room, where the computer operator was also present. A second researcher, who was sitting out of the participant's sight so as not to distract him/her, discretely watched and recorded additional comments and observations on a specially designed comments sheet. Instructions stated:

"Now, you will start listening to some stimuli. As soon as you hear something different you must press this button. You will be given an example to help you understand. In order to start, you have to press this button. You can start as soon as you feel ready".

After finishing the preliminary task, the participant was asked if he/she had any questions or needed explanations. If the participant made some mistake during the preliminary task the researcher indicated the correct response. Then, the main test began. Each participant was given the opportunity to start each test, as soon as he/she felt ready. This option was provided so that participants did not feel there was time pressure.

During the test, as soon as the participant perceived a change or a disruption of the stimulus he/she had to press immediately the ENTER key. The computer's timer recorded the participant's response. There was a short break of about 30 seconds between successive tests. Before starting the tests of Level 2, participants had the option of a longer break if they asked for it or if one of the

ISBN 3-931852-67-9
ISSN 1617-6847

two researchers had reasons to believe this was necessary for the participant. The total time of the main test was about 20 minutes. Each participant listened to the stimuli directly from the output of the computer on both ears, using high quality headphones.

Prior to the experimental procedure a pilot study was conducted where five participants of each group took part. Responses were recorded as correct alarm (i.e., correct identifications of changes in stimuli), false alarm (i.e., incorrect identifications of changes in stimuli) and miss (i.e., non perceived changes in stimuli).

3. RESULTS AND DISCUSSION

A series of 3 x 4 (groups x tests of the 1st level, groups x tests for each music parameter separately of the 2nd level and groups x music parameters of the 2nd level) mixed design ANOVAs performed on the data showed the following:

As expected, AD patients had in general lower performance in the perception of music as compared to healthy adults. Furthermore, AD patients exhibited poorer performance at both levels of stimuli organization in comparison to young and healthy elderly participants (see Table 1). Therefore, AD has a generalized effect on music perception. Yet, one of the basic findings was the significant difference in the number of correct answers between the 1st and 2nd level of musical tests [F (1,70)=112.98, p=. 000]. All groups of participants consistently provided less correct answers to the 2nd more complex level of musical tests (see Table 2). Thus it can be concluded that not only the existence of AD but also the complexity of musical stimuli can affect participants' music perception, as the results of the control groups indicate (see also, Rosner & Meyer 1982, Erickson 1982).

Separate analysis of the music/sound parameters of each level revealed the following:

1) With respect to the 1st level where each test represented a music parameter in isolation, all the participants and especially AD patients showed a decreased ability to perceive changes in the parameters of amplitude (Test 3) and rhythm (Test 4) (see Table 3). This suggests that music perception is affected by the nature of each parameter.

2) Regarding the 2nd level of tests, which consisted of more complex, non-familiar musical contexts, all the participants performed much better in perceiving differentiations regarding the parameter of timbre whereas in the case of pitch and rhythm their music discrimination ability seemed to deteriorate significantly (see Table 4). Thereafter, it seems that music perception is considerably influenced by music parameters, and particularly rhythm (see also Boltz, 1998).

More detailed analysis between the tests of the 2nd level for each parameter separately, underscored the importance of the melody's nature on participants' ability to correctly identify music differentiations. More specifically, with respect to pitch perception, apart from group differences due to age and Alzheimer's disease, young and healthy elderly participants showed a substantially improved performance on Test 8 in contrast to Test 6 where the number of their correct answers dropped significantly [F (4,14)=3.06, p=. 019]. Similarly, in the case of rhythm perception Test 5 appeared to pose problems to participants' perception of differentiations. On the contrary, Tests 7 and 8 enabled all groups to improve their performance [F (2,142)=16.78, p=. 000]. Following an almost similar pattern, amplitude perception deteriorated in Test 6 whereas it was enhanced in Test 7[F (2,142)=6.24, p=. 003]. We may hypothesize that Tests 7 and 8 are better perceived in comparison to Tests 5 and 6, due to their well-established tonality and symmetrical thematic structure (see also Lerdahl & Jackendorf, 1990), as well as their faster tempo.

Concluding, it can be suggested that future research needs to provide a more in-depth account of how the nature of melodies and music parameters correlate with the existence of a degenerative disease such as AD and have an effect on music perception.

Table 1. Differences in means of participants' correct answers at both levels.

		Level 1		Level 2		Total		Statistics		
	N	Means	St.d.	Means	St.d	Means	St.d	F	df	Sig.
Young	30	27.13	1.38	21.33	3.67	48.46	4.18	43.60	2	.000**
Healthy elderly	29	25.41	3.80	18.48	3.82	43.89	6.43			
AD patients	14	14.85	8.16	10.28	7.22	25.14	14.18			

** p<.001

Table 2. Means of correct answers at the musical tests in both levels.

	N	Means	St. Dev.
Level 1	73	24.09	6.28
Level 2	73	18.08	6.07

Table 3. Differences in means of correct answers at musical tests of the 1st level.

	1st level tests			Statistics		
	N	Means	St. Dev.	F	df	Sig.
Timbre	74	6.55	1.28	27.72	3	.000**
Amplitude	74	5.58	2.18			
Rythm	74	5.51	2.19			

** p<.001

Table 4. Differences in means of correct answers regarding the music parameters of the 2nd level.

	2nd Level			Statistics		
	N	Means	St. Dev.	F	df	Sig.
Timbre	74	6.05	1.66	64.06	3	.000**
Pitch	74	3.02	2.25			
Rythm	74	3.93	1.75			

** p<.001

ISBN 3-931852-67-9
ISSN 1617-6847

4. REFERENCES

1. Aldridge, D. (1998). Music therapy and the treatment of Alzheimer's disease, in the *Journal of Clinical Geropsychology*, 4, p. 17-30.

2. Bartlet, J., & Halpern, A., & Dowling, J. (1995). Recognition of familiar and unfamiliar melodies in normal aging and Alzheimer's disease, in *Memory and Cognition*, 23(5), 531-546.

3. Boltz, Mg. (1998). Tempo discrimination of musical patterns: effects due to pitch and rhythmic structure, in *Perceptual Psychophysiology*, 60 (8), p. 1357-73.

4. Erickson, R. (1982). New Music and Psychology, in D. Deutsch (ed.) *The Psychology of Music*, Academic Press, p. 517-536.

5. Gates, G., & Cobb, J., Rees, T., Wolf, P., & D'Agostino, R. (1996). Central auditory dysfunction, cognitive dysfunction and dementia in older people, in *Archives of Otolaryngological Head and Neck Surgery*, 122(2), p. 161-167.

6. Gardon, B. (2003). What is C-mix? http://www.music.princeton.edu/winham/cmix. Retrieved 21/3/2003 from the World Wide Web:

7. Gunther, W., Giunta, R., Klages, U., Haag, C., Steiberg, R., Satger, W., Jonitz, L., Engel, R. (1993). Findings of electroencephalographic brain mapping in mild to moderate dementia of the Alzheimer type during resting, motor and music-perception conditions, in *Psychiatry*, 50(3), p.163-176.

8. Lerdahl, F. & Jackendorf, R (1990). *A Generative Theory of Tonal Music*, MIT Press.

9. Rosner,B & Meyer, L.(1982). Melodic Processes and the Perception of Music, in D. Deutsch (ed.) *The Psychology of Music*, Academic Press.

10. Peretz, I., & Hebert, S. (1995). Music processing after brain damage: The case of rhythm without melody. In R. Steinberg (ed.), *Music and the mind machine*. New York: Springer-Verlag , p. 127-138.

5. ACKNOWLEDGMENTS

This paper is based on a research project supported by a grant of the Research Committee of the Aristotle University of Thessaloniki – Greece. The authors would like to thank: Brad Garton (Columbia University) for allowing the research team to use TIMEPLAY and C-MIX software, Dr. Thanassis Rikakis for the motivation he gave for the realization of this project and for his helpful comments and contribution during the pilot phase, Professor J. Daniilidis- MD, director of the Clinic of Otolaryngology of the Aristotle University for the facilities providing during the realization of the project, all the staff of the Audiology and Speech Center of the Clinic of Otolaryngology and especially Dr. G. Tsaligopoulos, Dr. S. Virvilis and Dr. K. Zafiris, research associates to the 1st Department of Neurology for their valuable assistance in examining and evaluating the AD patients and all the collaborators who assisted in testing subjects and contacting families. Last but not least, we would like to thank all the participants, especially the patients and their families.

ISBN 3-931852-67-9
ISSN 1617-6847