Listening to Classical Music Ameliorates Unilateral Neglect After Stroke

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OBJECTIVE. We determined whether listening to excerpts of classical music ameliorates unilateral neglect (UN) in stroke patients.

METHOD. In this within-subject study, we recruited and separately tested 16 UN patients with a right-hemisphere stroke under three conditions within 1 wk. In each condition, participants were asked to complete three subtests of the Behavioral Inattention Test while listening to classical music, white noise, or nothing. All conditions and the presentation of the tests were counterbalanced across participants. Visual analog scales were used to provide self-reported ratings of arousal and mood.

RESULTS. Participants generally had the highest scores under the classical music condition and the lowest scores under the silence condition. In addition, most participants rated their arousal as highest after listening to classical music.

CONCLUSION. Listening to classical music may improve visual attention in stroke patients with UN. Future research with larger study populations is necessary to validate these findings.


Unilateral neglect (UN), in which patients fail to respond or orient to stimuli presented in contralesional space, is a common syndrome after a right-hemisphere stroke (Heilman, Watson, & Valenstein, 2003). This syndrome is relatively heterogeneous and has been attributed to attentional deficits, both spatial attention and general arousal or sustained attention impairments (Heilman et al., 2003; Husain & Rorden, 2003; Robertson et al., 1997). UN is an important predictor of poor functional outcome. Compared with patients without UN, patients with UN have longer hospital stays and more intensive therapeutic intervention (Gillen, Tennen, & McKee, 2005; Kalra, Perez, Gupta, & Wirzink, 1997), have diminished abilities to perform activities of daily living (ADLs; Katz, Hartman-Maeir, Ring, & Soroker, 1999; Paolucci, Antonucci, Grasso, & Pizzamiglio, 2001), and place increased burdens on families (Buxbaum et al., 2004). Because of the clinical significance of UN, over the past 2 decades a variety of rehabilitation treatments have been developed to remediate this syndrome; intervention that targets arousal deficits through listening to music is one possible novel technique.

A growing body of evidence has shown that when healthy people listen to music, various cognitive processes improve, such as spatial abilities (Rauscher, Shaw, & Ky, 1993; Thompson, Schellenberg, & Husain, 2001), memory (Mammarella, Fairfield, & Cornoldi, 2007; Schellenberg, Nakata, Hunter, & Tamoto, 2007), and attention (Ho, Mason, & Spence, 2007; Schellenberg et al., 2007). The positive effect of music on cognition has generally been
explained using the arousal and mood hypothesis, which postulates that an increase in arousal and positive mood evoked by pleasant music leads to better cognitive performance (Schellenberg et al., 2007; Thompson et al., 2001). Converging evidence from neuroimaging and neurophysiological research has also demonstrated that listening to pleasant music activates brain regions associated with both visual attention and positive emotional states (Blood & Zatorre, 2001; Mitterschiffthaler, Fu, Dalton, Andrew, & Williams, 2007). Therefore, listening to music has been widely used as a therapeutic tool in different clinical populations (Gregory, 2002; Guérit, Soua, Voiriot, Picot, & Hérisson, 2009; Johnson, Shaw, Vuong, Vuong, & Cotman, 2002; Sacrey, Travis, & Whishaw, 2011; Salvatore, Librando, Esposito, & Vingolo, 2011; Trappe, 2010).

For stroke rehabilitation, clinical studies (Forsblom, Librando, Esposito, & Vingolo, 2011; Trappe, 2010; Cotman, 2002; Sacrey, Travis, & Whishaw, 2011; Salvatore, Librando, Esposito, & Vingolo, 2011; Trappe, 2010). For stroke rehabilitation, clinical studies (Forsblom, Librando, Esposito, & Vingolo, 2011; Trappe, 2010) have reported that listening to music can positively influence a stroke patient’s cognitive and emotional recovery by improving focused attention and verbal memory, which in turn reduces the symptoms of depression and otherwise improves mood. However, the potential benefits of listening to music for improving visual attention in stroke patients with UN have not yet been fully explored.

To our knowledge, only three studies have assessed the effects of listening to music on UN. Hommel et al. (1990) first reported that nonverbal auditory stimuli, such as classical music and white noise, significantly improved drawing performance in stroke patients with UN. They proposed that nonverbal auditory stimuli typically activate the right hemisphere and increase arousal, which contributes to the improvement of neglect. They did not, however, differentiate between the effects of classical music and white noise. In addition, only one nonstandardized drawing test was used for evaluating UN, which may not completely represent the heterogeneous symptoms of UN.

Cermak, Trombly, Hausser, and Tiernan (1991) subsequently examined the treatment effects of lateralized tasks on 5 patients with left UN. The lateralized tasks were designed to activate the right hemisphere and included a haptic perception task with abstract shapes, a jigsaw puzzle, and listening to classical or jazz music. Their results did not show positive effects on a line-bisection task, and the combination of three activities during a single treatment session did not allow for the effects of listening to music to be identified.

Soto et al. (2009) found that pleasant music positively affected stroke patients with UN. Their patients showed markedly improved spatial attention to targets on the neglect side under a preferred pleasant music condition compared with unpleasant music and silence conditions. They hypothesized that the positive emotion and optimum arousal level evoked by pleasant music increases attentional resources and then reduces symptoms of UN. Their study was the first to systematically examine the effects of pleasant music on several tasks—perceptual reports, detection, star cancellation, line bisection, and reading—but they assessed only 3 patients; thus, their preliminary findings still need to be validated.

Because the current evidence to support the notion that listening to music positively affects UN is limited, we specifically designed this study to confirm the beneficial effects of listening to classical music on ameliorating UN in stroke patients. We chose classical music because it is one of the most beneficial music genres for cardiovascular health, improvement of concentration, and assistance with depression (Trappe, 2010). Moreover, in addition to using traditional paper-and-pencil assessments of UN, we used a behavioral test to examine the effect of listening to music on visual attention in a simulated functional activity. Finally, we included a white-noise condition to explore the differences between the effects of classical music and white noise on symptoms of UN. The specific research questions of this study were, first, Is UN ameliorated when participants listen to classical music excerpts and white noise and, second, Is classical music more beneficial than white noise?

Method

Research Design

We used a within-subjects repeated-measures design in which each participant’s visual attention was assessed using the three subtests of the Behavioral Inattention Test (BIT; Wilson, Cockburn, & Halligan, 1987) under three separate conditions (classical music, white noise, and silence) within no more than 1 wk. The order of conditions and the presentation of tests was counterbalanced across participants with a Latin-square design. This study was reviewed and approved by the Human Experiment and Ethics Committee of National Cheng Kung University Hospital. All participants provided written informed consent.

Participants

We recruited a convenience sample of stroke patients with UN from one medical center and three rehabilitation clinics. Inclusion criteria were (1) had a first stroke with a right hemisphere lesion, (2) showed UN in the Star Cancellation Test (SCT; Wilson et al., 1987) with a score...
of ≤51, (3) had adequate cognitive abilities and no signs of dementia on the basis of Mini-Mental State Examination (MMSE) scores (Guo et al., 1988), and (4) had normal or corrected-to-normal vision and hearing.

**Audio Stimuli**

We used two sets of audio stimuli: classical music and white noise. The classical music came from Mozart’s Sonata for Two Pianos in D major, K. 448, and Vivaldi’s Concerto No. 1 in E major ("Spring" from The Four Seasons). Both musical excerpts were chosen because they are well known and have been used in many experiments (Ho et al., 2007; Johnson et al., 2002; Mammarella et al., 2007; Salvatore et al., 2011; Thompson et al., 2001). They are fast-tempo pieces in a major key and can induce happy emotional responses (Hunter, Schellenberg, & Schimmack, 2007; Johnson et al., 2002; Mammarella et al., 2007). Both musical excerpts and white noise were played on a computer through speakers at a listening volume comfortable for each participant. In addition, we included a silence condition as a control.

**Assessments**

**Neglect Assessments.** We used three subtests of the BIT as measures of neglect performance in each condition, including two conventional subtests, the SCT and the Line Bisection Test (LBT), and one behavioral subtest, the Picture Scanning Test (PST). We also used the SCT as a screening tool for neglect syndrome.

The SCT contains 54 targets pseudorandomly interspersed with 75 distractors. Participants are required to scan and cross out as many target stars as possible; the maximum score is 54.

The LBT consists of three horizontal lines in a staircase arrangement across the paper. Participants are asked to estimate and mark the center of each line. The test is scored by measuring deviations from true midpoint; the maximum score is 9. The actual deviation error away from the true midpoint of each line was measured in centimeters; positive values indicated rightward deviations, and negative values indicated leftward deviations.

The PST contains three large photographs (35.7 cm × 27.8 cm) of a meal, a wash basin and toiletries, and a large room with pieces of furniture and hospital aids. Participants are instructed to name the main items in each picture. Omissions were recorded and then converted to a score; the maximum score is 9. We also calculated the total number of each item reported for analysis.

Both conventional and behavioral subtests of the BIT have good test–retest reliability (r = .83 and .97, respectively) and interrater reliability (both r = .99; Halligan, Cockburn, & Wilson, 1991). The BIT also has good construct and criterion validity (Halligan et al., 1991; Jehkonen et al., 2000). In addition, the sensitivity of the SCT, the LBT, and the PST for UN patients with right-brain damage is 100%, 65%, and 65%, respectively (Halligan et al., 1991).

**Visual Analog Scale.** Participants were asked to use a visual analog scale (VAS) to evaluate their arousal and mood at the beginning of the experiment and after condition manipulation to examine whether a change in arousal or mood was caused by any effect of the audio stimuli. The VAS approach provides a simple technique for measuring subjective experience and has been established as valid and reliable in a range of clinical applications (McCormack, Horne, & Sheather, 1988), including some used to measure mood states in stroke patients (Arruda, Stern, & Somerville, 1999; Stern, Arruda, Hooper, & Wolfner, 1997).

Each VAS contained a 10-cm vertical line anchored by word descriptors at each end. For the first VAS, participants were instructed to mark the point on the line that best indicated their arousal or mood state. The VAS score was determined by measuring the distance from the bottom end of the line to the point that the participant marked; possible scores ranged from 0 to 10 (Wewers & Lowe, 1990). A second VAS was used to rate the participants’ level of enjoyment of the classical music excerpts.

**Procedure**

Participants were tested individually in a quiet room. At the beginning of each condition, participants were first asked to rate their arousal and mood states using the VAS as baseline measurements (VAS1). In the classical music and white noise conditions, the music or white noise was played throughout the entire experimental process. When participants heard 1 min of classical music or white noise, they were asked to rate their arousal and mood states again (VAS2) to measure the change in mood and arousal evoked by the audio stimuli. Participants were also required to provide VAS ratings for how much they enjoyed listening to the classical music.

After completing the VAS measures, participants completed three neglect assessments. To ensure that the participants had comparable experimental time across conditions, in the silence condition participants were asked to be silent and do nothing for 1 min and then to provide their VAS2 for mood and arousal before the neglect assessments started. The neglect assessments were administered in roughly counterbalanced order. Each condition lasted for at most 20 min.

**Statistical Analysis**

The data were analyzed using SPSS Version 17.0 (SPSS, Inc., Chicago). Significance was set at p < .05. Repeated-measures...
analyses of variance (ANOVA), with condition as a within-subject factor with three levels (classical music, white noise, silence), were done to compare test scores. Post hoc Bonferroni tests were used for pairwise comparisons between each condition. The effect size was measured using partial \( \eta^2 (\eta_p^2) \). The \( \eta_p^2 \) values of .01, .06, and .14 have been suggested to represent small, medium, and large effect sizes, respectively (Cohen, 1992).

**Results**

**Participants**

We recruited 21 participants with UN. Seventeen participants provided written informed consent and were enrolled; 1 withdrew from the first condition, and 16 completed all three conditions. The mean age of the final 16 participants was 64.4 yr (SD = 7.9). There were 6 (37.5%) men and 10 (62.5%) women, and the average time between stroke onset and admission to this study was 13.8 mo (SD = 4.3), and the mean MMSE score was 25.4 (SD = 3.6). The average score of participants on the National Institutes of Health Stroke Scale was 12.1 (SD = 4.9), a moderate level of stroke severity (Brott et al., 1989).

**Neglect Assessments**

Participants tended to have higher scores when listening to classical music than when listening to white noise or silence (Table 1), but the repeated-measures ANOVAs showed no significant effect of condition on the total scores of all three tests. However, the LBT and the PST effect sizes reached medium level. The mean total scores for both tests in the classical music condition were somewhat higher than those in the other two conditions. In addition, the repeated-measures ANOVA showed a significant effect of condition for the total number of items reported in the PST with a large effect size. Pairwise comparisons showed that participants reported significantly more target items while listening to classical music than while listening to white noise (\( p = .044 \)) or silence (\( p = .003 \)). The number of items reported while listening to white noise was also significantly greater than that reported while listening to silence (\( p = .032 \)).

To clarify whether this increase was related to improving visual attention toward the left-side space or in general, we conducted repeated-measures ANOVAs separately to compare the total number of items reported by three item locations (left, middle, and right) in each photograph in the three conditions and found no significant condition effects. We further analyzed the raw data of each participant and found great variability; that is, while listening to music, some participants reported more left-side items than right-side items, some participants reported no change in the number of left-side items but did report more middle items than right-side items, and 3 participants reported more right-side items but no change in the number of left-side or middle items.

Finally, the effect of condition on the deviation error of the LBT was not significant, but the effect size was large. Pairwise comparisons showed a tendency for lower deviation errors only between the classical music and silence conditions. These findings indicate that classical music improved the overall visual attention performance of participants in a simulated functional visual search activity and reduced their rightward bisection performance, and classical music seemed to be more effective than white noise.

**Visual Analog Scale Measurements**

The mean classical music enjoyment rating for all participants was 6.6 (SD = 1.9), with a range from 5 to 10, which indicated that participants enjoyed both music

<table>
<thead>
<tr>
<th>Measure</th>
<th>Classical Music</th>
<th>White Noise</th>
<th>Silence</th>
<th>( F(2, 30) )</th>
<th>( p )</th>
<th>( \eta_p^2 )</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCT total score</td>
<td>28.87 (14.1)</td>
<td>27.36 (16.9)</td>
<td>25.61 (15.1)</td>
<td>0.79</td>
<td>.463</td>
<td>.050</td>
</tr>
<tr>
<td>LBT</td>
<td>3.12 (3.2)</td>
<td>2.82 (2.9)</td>
<td>2.02 (2.8)</td>
<td>0.9</td>
<td>.139</td>
<td>.123</td>
</tr>
<tr>
<td>Total score</td>
<td>0.44 (0.29)</td>
<td>0.32 (0.31)</td>
<td>0.37 (0.28)</td>
<td>3.08</td>
<td>.061</td>
<td>.170</td>
</tr>
<tr>
<td>Deviation error, cm</td>
<td>0.1–0.8</td>
<td>0.1–0.8</td>
<td>0.1–0.9</td>
<td>3.08</td>
<td>.061</td>
<td>.170</td>
</tr>
<tr>
<td>PST</td>
<td>2.45 (2.4)</td>
<td>2.21 (2.1)</td>
<td>1.93 (1.8)</td>
<td>1.16</td>
<td>.328</td>
<td>.076</td>
</tr>
<tr>
<td>Total number reported</td>
<td>20.43 (7.2)</td>
<td>18.97 (7.5)</td>
<td>17.22 (8.0)</td>
<td>8.71</td>
<td>.001</td>
<td>.384</td>
</tr>
<tr>
<td>Change in VAS score for mood</td>
<td>0.06 (1.8)</td>
<td>0.15 (1.2)</td>
<td>0.56 (0.7)</td>
<td>2.04</td>
<td>.147</td>
<td>.120</td>
</tr>
</tbody>
</table>

Note. LBT = Line Bisection Test; M = mean; PST = Picture Scanning Test; SCT = Star Cancellation Test; SD = standard deviation; VAS = visual analog scale.

* Medium effect size. \( \ast \) Large effect size.

\( * \ p < .01. \)
while listening to classical music. It is possible that such
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the classical music condition, which indicated that partici-
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Robertson, Mattingley, Rorden, & Driver, 1998). Although
alerting stimuli may sharpen the impaired spatial atten-
tional system of patients with UN (Robertson, 2001;
findings of prior studies (Hommel et al., 1990; Soto et al.,
listening to classical music improved on the LBT and PST. The content of
music and even hoped to receive the same intervention
again. None of the participants said that they disliked
music.

These findings generally agree with and extend the
findings of prior studies (Hommel et al., 1990; Soto et al.,
2009) and support the beneficial effects of classical music
on UN because participants who listened to classical
music improved on the LBT and PST. The content of
the PST is designed to simulate everyday visual search
situations, and our findings therefore suggest that listening
to classical music may be beneficial for increasing stroke
patients' visual attention in functional visual search activi-
ties. Although we found that, compared with silence, white
noise also seemed to alleviate UN, it was less effective than
classical music.

The possible mechanism underlying the benefits of
listening to classical music might be ascribable to its ability
to heighten listeners’ arousal levels. Researchers have sug-
gested that stimulating general arousal using external
alerting stimuli may sharpen the impaired spatial atten-
tional system of patients with UN (Robertson, 2001; Robertson, Mattingley, Rorden, & Driver, 1998). Although
we found no significant differences in the change in VAS
scores of arousal ratings between the three conditions in this
study, the average change score had a positive value only in
the classical music condition, which indicated that partici-
pants generally experienced slightly increased arousal levels
while listening to classical music. It is possible that such
increased arousal leads to an improvement in spatial
attention, as proposed by the arousal-and-mood hypo-
thesis (Schellenberg et al., 2007; Thompson et al.,
2001). Moreover, the classical Yerkes–Dodson law illus-
trates that very high or very low levels of arousal hinder
cognitive performance, whereas moderate arousal levels
improve performance (Husain, Thompson, & Schellenberg,
2002). Therefore, we hypothesize that classical music
modulates arousal to an optimal level and then allevi-
Listening to classical music might modulate general arousal levels and attentional control in patients with UN. Listening to classical music might ameliorate the symptoms of UN on the LBT and the PST subscales of the BIT. White noise also might alleviate UN, but it was less effective than classical music.

To sum up, this study provides preliminary evidence for the benefits of listening to classical music for improving visual attention in stroke patients with UN. We suggest that listening to classical or other pleasant music is a promising addition to the rehabilitation of UN. Future research is warranted to validate this study’s findings.

Implications for Occupational Therapy Practice

Our findings have the following implications for occupational therapy practice:

- Classical music and white noise have differential effects on ameliorating UN, and listening to classical music might have more benefits for UN patients.
- Listening to classical music is one type of intervention based on bottom-up mechanisms for UN, which involve using sensory stimulation to improve visual attention on the neglect side and may be more appropriate than other treatments for UN patients without explicit awareness of their symptoms (Frassinetti, Angeli, Meneghello, Avanzi, & Lådavas, 2002).
- Listening to classical music is noninvasive, inexpensive, and more cost-effective than other treatments for UN. It is a feasible treatment modality and can easily be used in a clinical setting or at home to improve visual attention performance of UN patients.

Limitations and Future Research

The limitations of this study are associated with the assessment tools of arousal and mood and with the music selection. First, we used only subjectively self-reported VAS score for measures of changed arousal and mood induced by classical music. However, listening to music also produces objective physiological responses such as changes in heart rate, blood pressure, respiration, and galvanic skin response (Iwanaga, Ikeda, & Iwaki, 1996). Although Husain et al. (2002) suggested that measures based on self-reports may be more appropriate than measures based on physiological variables, we believe that future research can include both subjective and objective measures to more precisely examine the changes in arousal and mood elicited by music.

Second, we chose only two classical music excerpts commonly used in related research to explore the ameliorative effects of classical music on UN. Future studies may benefit from taking into account the participants’ familiarity with the music and allowing them to select classical music or other music genres, to investigate whether listening to their own preferred pleasant music can induce a higher level of arousal and a more positive mood, thereby increasing the positive effects of alleviating UN.

Replication of this study with a larger population or in randomized controlled trials is needed to validate our preliminary findings. In addition, future research could attempt to investigate both the effects of listening to classical music on the real daily functions of patients with UN and the possibility of combining listening to music with other therapies for UN to increase their effectiveness. Finally, future research should also endeavor to develop a standard and routine intervention using classical or other pleasant music and examine its potential long-term effect on stroke patients with UN.

Conclusion

We examined the positive effects of listening to classical music on stroke patients with UN. Our major findings were as follows:

- Listening to classical music might modulate general arousal levels and attentional control in patients with UN.
- Listening to classical music might ameliorate the symptoms of UN on the LBT and the PST subscales of the BIT.
- White noise also might alleviate UN, but it was less effective than classical music.

To sum up, this study provides preliminary evidence for the benefits of listening to classical music for improving visual attention in stroke patients with UN. We suggest that listening to classical or other pleasant music is a promising addition to the rehabilitation of UN. Future research is warranted to validate this study’s findings.

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