Circadian Preference and Facial Emotion Recognition Among Rehabilitation Inpatients

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Objective: Examined the role of circadian preference on facial emotion recognition among rehabilitation inpatients. Design: 47 patients with stroke and 24 patients with orthopedic diagnoses were screened for circadian preference and assessed at preferred and nonpreferred times of day on a computerized task of facial emotion recognition. Results: Disproportionate effects of time of day, relative to individual circadian preference, were found among persons with stroke-related cognitive impairment, compared with orthopedic patients, on facial emotion recognition. These differences were independent of differences in visual perception, subjective mood, or sleepiness. Conclusions: The circadian preference effect can be understood in terms of cognitive reserve. Among persons with acquired brain injury, the ability to access cognitive reserve appears to be affected by environmental variables (e.g., time of day), suggesting an additional component to existing models of reserve. Limited ability to recognize facial emotional expression in this population may present behavioral, occupational, and interpersonal challenges to community reintegration poststroke. Understanding this time-of-day effect adds to existing knowledge of factors affecting successful postacute outcomes in stroke rehabilitation.

Keywords: circadian, emotion recognition, rehabilitation, stroke
Some relationships have also been found between emotional functioning and neurochemical correlates of SCN function (see Zhou et al., 2001). Thus, evidence from studies of both affect and SCN functioning support a role for circadian rhythms in emotional function.

There also is limited evidence for specific effects of circadian preference on mood. Drennan, Klauber, Kripke, and Goyette (1991) compared individuals diagnosed with depression with healthy controls and found that depressed patients were more likely to be evening oriented. An analog study with college students found a similar relationship between evenness and depressive symptoms (Chelminska, Ferraro, Petros, & Plaad, 1999).

Support for a potential relationship between circadian preference and emotional processing can be found in neuroanatomical, functional, and neurochemical spheres. Brain structures relevant to emotional processing (e.g., limbic system and orbitofrontal, dorsolateral, prefrontal, parietal, and temporal cortices; Gunning-Dixon et al., 2003) also play a role in cognitive function, and a number of theories posit anatomical (Erickson & Schulkin, 2003; Pecchinenda, 2001) and functional (Lewis & Haviland, 1993) integration of cognition and emotion. At least one neurochemical (serotonin) is known to be related to both cognition and emotion (Eglen, Wong, Dummuis, & Bockaert, 1995). This interdependence of cognitive and emotional processing suggests that both functions may be affected by circadian preference.

Cognitive changes such as those observed after brain injury and with advancing age may heighten circadian preference effects on emotional functioning. Deficits associated with aging have been noted in the ability to recognize facial expressions of emotion (see Calder et al., 2003; Moreno, Borod, Welkowitz, & Alpert, 1993). Similar to acquired brain injury, due in part to structural changes that occur in advancing age, older individuals may need to draw on reserves to maintain previous levels of functioning. This pattern of neural network recruitment has been documented in imaging studies of older and younger adults (Cabeza, Anderson, Houle, Mangels, & Nyberg, 2000; Langenecker & Nielson, 2003; Langenecker, Nielson, & Rao, 2004; Rypma, Prabhakaran, Desmond, Glover, & Gabriuelli, 1999). Stern (2003) posited that cognitive reserve—the efficiency with which individuals are able to recruit typical and alternate brain networks—is called upon when task demands increase. If the capacity to enlist such reserves is limited or compromised, then emotional processing, as well as cognitive performance, may be poorer at nonpreferred times of day.

Older patients with acquired brain injury may be especially vulnerable because the frequency and extent of circadian preference shifts substantially with age. In general, older persons tend to become increasingly morning oriented, with fewer individuals expressing an evening preference or no preference at all. Among middle-aged and older persons, the base rate of eveningness ranges from 3% to 15% (Mecacci, Zani, Rocchetti, & Lucioli, 1986; Pardeee et al., 2005; Zammit, 2000), whereas the base rate of morningness is as high as 75% (Yoon, May, & Hasher, 1999). Thus, older patients who have survived a stroke may be doubly challenged due to the combined influences of brain injury and more extreme circadian preference. Among stroke survivors, visual- and emotional-processing impairments are most commonly observed following right-hemisphere lesion (Harciarek, Heilman, & Jodzio, 2006; Heilman, Bowers, Valenstein, & Watson, 1986; S. D. Smith & Bulman-Fleming, 2005). Thus, these patients may evidence more performance decrements on such tasks at the nonpreferred time than either healthy older adults or persons who survived left-hemisphere stroke.

To our knowledge, no literature has examined the effects of circadian preference on emotional processing. This unaddressed issue has relevance for both cognitively impaired and nonimpaired populations. Emotional processing plays a central role in community reintegration after brain injury and is a crucial element of psychotherapy and the quality of interpersonal relationships (Weissman, Markowitz, & Klerman, 2000). The present study hypothesized that individuals would perform more poorly on a facial emotion recognition task at nonpreferred than at preferred times of day. Furthermore, time of day was expected to have greater adverse effects on emotion recognition among individuals with cognitive impairments (inpatient stroke survivors) than on those without cognitive impairments (inpatients with orthopedic injuries). Finally, based on combined predictions from compensation in cognitive reserve theory (Stern, 2003) and the high frequency of impairment in visual and emotional processing among persons with right-hemisphere stroke (Harciarek et al., 2006; Heilman et al., 1986; S. D. Smith & Bulman-Fleming, 2005), these adverse effects were expected to be greater among individuals with right-hemisphere lesions than among those with left-hemisphere lesions. Lastly, it was expected that these effects would be observed independent of fundamental visual perception of faces, mood state, and sleepiness at the time of testing.

**Method**

**Participants**

Morning-oriented participants were recruited from the inpatient units of a large midwestern rehabilitation hospital: right-hemisphere stroke (RH; n = 24), left-hemisphere stroke (LH; n = 23), and patients without cognitive impairment from the spinal cord/orthopedic injury unit (NCI; n = 24). Patients were compensated for their participation.

Table 1 presents demographic data for the three groups. The groups did not differ significantly in mean age, education, premorbid IQ estimate (Wide Range Achievement Test 3–Reading subtest [WRAT-3 Reading]; Wilkinson, 1993) or on scores on either the Morningness-Eveningness Questionnaire (MEQ; Horne & Östberg, 1976) or Benton Test of Facial Recognition (Benton, Sivan, Hamsher, Varney, & Spreen, 1994; all ps > .21). A trend was noted between groups on the Boston Naming Test (Kaplan, Goodglass, & Weintraub, 1983), with LH stroke patients performing more poorly than the noncognitively impaired patients (p = .063).

**Measures**

The MEQ (Horne & Östberg, 1976) is a 19-item self-report questionnaire that was used to assess preference for morning or evening activities. Test–retest reliability across a 2-month period was reported at .89 (Neubauer, 1992), C. S. Smith, Reilly, and Midkiff (1989) and Neubauer (1992) reported coefficient alphas for the scale ranging from .82 to .86. A previous study with a sample of patients from the same hospital as that in the present study observed a coefficient alpha of the MEQ of .80 (Paradee et al., 2005).
The WRAT-3 (Wilkinson, 1993) was used to estimate premorbid IQ. The Boston Naming Test (Kaplan et al., 1983) was used to assess naming deficits. The Benton Test of Facial Recognition (Benton et al., 1994) assessed basic facial perception ability to account for the possibility that any impairment in facial emotion recognition was due to fundamental deficits in facial perception.

Facial emotion recognition. To assess facial emotion recognition, NimStim Faces were used. The NimStim stimuli comprise 646 color photographs of facial expressions that have been validated for use with both children and adults (Tottenham, Borscheid, Ellertsen, Marcus, & Nelson, 2002). Facial expressions are posed by male and female actors from various ethnic backgrounds (European American, Latino American, African American, and Asian American).

For the present study, five types of facial expressions were used (happy, sad, angry, fearful, and neutral) in two test versions. Presentation of faces was accomplished using a procedure similar to that used by Rapport, Friedman, Tztelepis, and Van Voorhis (2002) and subsequently validated on depressed adults (Lange-kecker et al., 2004). Faces were presented on a laptop computer with a 13-in. (33-cm) monitor; distance between the patient and computer screen was 18 in. (46 cm). Each of 54 trials was preceded by a visual signal cue displayed for 500 ms in the center of the screen. A photograph was next displayed for 300 ms, followed immediately by a mask (100 ms). Participants were then presented with a forced-choice format to identify which of four categories of emotion was displayed (2,600 ms): fearful, happy, sad, or angry. To increase task difficulty, a neutral choice was not available; participants were forced to select an emotion for all presented faces, and responses for the neutral trials were coded according to the valence (negative, positive) of the emotion chosen by the participant. A four-key response box recorded participants’ responses.

In addition to the facial emotion recognition task, an animal recognition task, interspersed among facial emotion blocks, followed a similar format to assess basic visual processing skills independent of emotion processing. Categories for the animal condition comprised birds, cats, dogs, and primates. Again, stimuli were presented for 300 ms, followed by a 100-ms mask. Participants were presented with the four animal categories and asked to select the correct category for the displayed animal by making the respective response key selection (2,600 ms). Indices evaluated in the present study included the percentage correct for both the faces and animals tasks.

Current mood. Current mood was assessed with a 25-item scale, including 10 items from the short form of the Positive and Negative Affect Schedule (PANAS; Watson, Clark, & Tellegen, 1988), and 15 items from the circumplex model used by Affleck et al. (2000) that reflect the unique adjectives from each list. Participants were asked to rate how much each of 25 emotion words applied to them at the time of assessment on a 5-point scale ranging from 1 (very slightly or not at all) to 5 (extremely). Reliabilities of two scales reflecting positive (coefficient alpha preferred session = .88, nonpreferred session = .82) and negative (coefficient alpha preferred session = .76, nonpreferred session = .73) valence were acceptable.

Sleepiness. In order to account for the possibility that sleepiness could explain circadian preference effects, subjective sleepiness was measured using the Stanford Sleepiness Scale (SSS; Hoddes, Zarcone, Smythe, Phillips, & Dement, 1973). The SSS was administered twice at each testing session: once at the beginning and again at the conclusion of the session.

Procedure

Patients were identified as potentially eligible for the study by consultation with hospital psychology staff. Identified persons were then recruited individually and provided written consent for participation in the study per Institutional Review Board (IRB) guidelines. Participants were screened for circadian preference and completed the WRAT-3 Reading subtest, Benton Test of Facial Recognition, and Boston Naming Test in order to examine potential group differences. Only patients who scored in the moderate-to-extreme morning range on the MEQ were given the full test battery because we sought to eliminate the atypical older patient who has an evening preference. Each participant was assessed at bedside twice: once in the morning (approximately 7:00 a.m.) and once in the evening (approximately 7:00 p.m.). These bedside assessments consisted of facial emotion and animal recognition tasks, mood, and sleepiness, the latter of which was assessed both

<table>
<thead>
<tr>
<th>Variable</th>
<th>Right hemisphere</th>
<th>Left hemisphere</th>
<th>Noncognitive impairment</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
</tr>
<tr>
<td>Age (years)</td>
<td>63.5</td>
<td>13.6</td>
<td>59.8</td>
</tr>
<tr>
<td>Education (years)</td>
<td>11.7</td>
<td>2.1</td>
<td>11.2</td>
</tr>
<tr>
<td>Percent male</td>
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<td>66.7</td>
</tr>
<tr>
<td>Ethnicity</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>Percent African-American</td>
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<td></td>
<td>83.3</td>
</tr>
<tr>
<td>Percent Caucasian</td>
<td>12.0</td>
<td></td>
<td>16.7</td>
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<tr>
<td>MEQ total</td>
<td>63.4</td>
<td>4.0</td>
<td>62.0</td>
</tr>
<tr>
<td>WRAT-3 Reading</td>
<td>93.5</td>
<td>9.6</td>
<td>89.0</td>
</tr>
<tr>
<td>Boston Naming Test*</td>
<td>13.8</td>
<td>1.6</td>
<td>13.3</td>
</tr>
<tr>
<td>Facial Recognition Test</td>
<td>48.8</td>
<td>4.1</td>
<td>47.5</td>
</tr>
</tbody>
</table>

Note. MEQ = Morningness-Eveningness Questionnaire; WRAT-3 Reading = Wide Range Achievement Test 3–Reading subtest.

*Significant group difference at p < .03 (left hemisphere < noncognitive).
at the start and end of each session. Test sessions (morning or evening) were counterbalanced within each of the three patient groups to control for practice effects and test version. Thus, the morning assessment was administered first in 46%–50% of each group.

Results

Prior to analysis, the data were screened for violations of the assumptions associated with the parametric model (Tabachnick & Fidell, 2001). Outlying data points (Z > 3) were winsorized using the procedure recommended by Tabachnick and Fidell (2001), which reduced skew to within acceptable levels. No variable had more than one outlying data point. One case identified as an outlier (Z > 3) on multiple cognitive variables and as a multivariate outlier on the processing task (p < .001 criterion) was deleted from the analyses (LH group), leaving 23 patients in this group.

Mixed-model repeated measures analysis of variance (ANOVA) was performed for facial emotion/animal recognition accuracy scores, with impairment group (right hemisphere [RH], left hemisphere [LH], and noncognitive impairment [NCI]) as the between-subjects factor and test session (preferred vs. nonpreferred) and task (faces, animals) as the within-subjects factors.

Results of the ANOVA for the facial emotion and animal category recognition tasks are presented in Table 2. Table 3 presents the descriptive statistics for the cell means. The three-way (Group × Task × Test Session) interaction was significant and medium in effect size according to Cohen’s (1977) standards, F(2, 67) = 3.32, p = .042, η² = .09. As can be seen in Figure 1, which depicts the change in the percentage correct from the preferred to the nonpreferred testing time on the faces and animals tasks, the interaction reflects a disproportionate adverse effect of testing at the nonpreferred time on the faces task among the RH and LH groups as compared with the NCI group. Post hoc tests of interest were conducted using t tests to explicate the interaction. The post hoc tests indicated that, although all three groups performed numerically worse on the faces task at the nonpreferred time, the RH (mean difference = −6.6%, p < .001) and LH (mean difference = −7.2%, p = .006) groups showed significant drops in performance, whereas the difference in performance between the preferred and nonpreferred times in the NCI group was smaller and not significant (mean difference = −2.1%, p = .13). In contrast, the LH and RH groups did not show significant decline on the animals task at the nonpreferred time (mean change 0%–2.2%, ps > .14). The NCI group performed worse on the animals task at the nonpreferred time (mean difference = −2.9%, p = .017), which likely reflects the high score they achieved at the preferred time. Lastly, although the RH group performed more poorly than the LH group on the faces task at both the preferred (p = .028) and nonpreferred testing times (p = .035), the discrepancies in performance across the testing times (i.e., circadian preference effect) did not differ between the RH and LH groups (see Figure 1).

Thus, both the RH and LH groups had more difficulty identifying facial emotions at a nonpreferred versus a preferred time (see Figure 1). Although the NCI group also evidenced performance decrements at the nonpreferred test session, the magnitude of the effects was small when compared with the cognitively impaired groups. All three groups were able to identify animals with a high degree of accuracy (93.1%–98.6%) at both testing times.

An exploratory analysis tested whether the groups differed in the percentage of neutral face trials designated as negative mood. The mixed-model ANOVA, with impairment group as the between-subjects variable and time of testing as the within-subject variable, was not significant, F(2, 67) = 2.12, p = .127, η² = .06.

Mood Ratings

In order to examine potential effects of mood state on facial emotion recognition, we used a mixed-model ANOVA to test differences in intensities of positive and negative moods (valence) between the groups endorsed at the preferred and nonpreferred testing times. The three-way (Group × Emotional Valence × Test Session) interaction was not significant (p = .96), nor was the two-way Group × Valence interaction (p = .871). The analysis indicated significant main effects of group, F(2, 67) = 3.17, p = .048, η² = .09, and mood valence, F(2, 67) = 39.20, p < .001, η² = .37, as well as two-way interactions for Group × Test Session, F(2, 67) = 4.35, p = .017, η² = .11, and Test Session × Valence, F(2, 67) = 41.45, p < .001, η² = .38. Examination of the marginal means indicates that the Group × Test Session interaction reflected that, although all three groups endorsed higher levels of both negative and positive mood at the nonpreferred time (RH M = 4.32, SE = .07; LH M = 4.35, SE = .07; NCI M = 4.50, SE = .07), the RH group (RH M = 2.95, SE = .11) endorsed lower intensity of emotions than did the LH (M = 3.38, SE = .11) and NCI (M = 3.25, SE = .11) groups at the preferred time. Positive

Table 2
Analysis of Variance: Visual Processing Task

<table>
<thead>
<tr>
<th>Variable</th>
<th>F</th>
<th>df</th>
<th>p</th>
<th>Partial η²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Impairment group</td>
<td>7.60</td>
<td>2</td>
<td>.001</td>
<td>.18</td>
</tr>
<tr>
<td>Test session</td>
<td>22.23</td>
<td>1</td>
<td>&lt;.001</td>
<td>.25</td>
</tr>
<tr>
<td>Test Session × Impairment</td>
<td>0.66</td>
<td>2</td>
<td>.520</td>
<td>.02</td>
</tr>
<tr>
<td>Task</td>
<td>305.50</td>
<td>1</td>
<td>&lt;.001</td>
<td>.82</td>
</tr>
<tr>
<td>Task × Impairment</td>
<td>8.97</td>
<td>2</td>
<td>&lt;.001</td>
<td>.21</td>
</tr>
<tr>
<td>Test Session × Task</td>
<td>8.30</td>
<td>1</td>
<td>.005</td>
<td>.11</td>
</tr>
<tr>
<td>Test Session × Task × Impairment</td>
<td>3.32</td>
<td>2</td>
<td>.042</td>
<td>.09</td>
</tr>
</tbody>
</table>

Note. Impairment group = right-hemisphere stroke, left-hemisphere stroke, noncognitive impairment; test session = preferred and nonpreferred; task = facial emotion and animals.

Table 3
Descriptive Statistics of Facial Emotion/Animal Category Perception Tasks at Preferred and Nonpreferred Testing Times

<table>
<thead>
<tr>
<th>Variable</th>
<th>Preferred</th>
<th></th>
<th>Nonpreferred</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>M</td>
<td>SD</td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>Right hemisphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of faces correct</td>
<td>78.1</td>
<td>12.7</td>
<td>71.5</td>
<td>13.0</td>
</tr>
<tr>
<td>Percentage of animals correct</td>
<td>93.1</td>
<td>9.1</td>
<td>93.3</td>
<td>8.0</td>
</tr>
<tr>
<td>Left hemisphere</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Percentage of faces correct</td>
<td>84.7</td>
<td>9.7</td>
<td>77.5</td>
<td>8.2</td>
</tr>
<tr>
<td>Percentage of animals correct</td>
<td>97.4</td>
<td>4.1</td>
<td>95.5</td>
<td>4.1</td>
</tr>
<tr>
<td>Noncognitively impaired</td>
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<td></td>
</tr>
<tr>
<td>Percentage of faces correct</td>
<td>88.1</td>
<td>11.1</td>
<td>86.0</td>
<td>9.8</td>
</tr>
<tr>
<td>Percentage of animals correct</td>
<td>98.6</td>
<td>3.5</td>
<td>95.6</td>
<td>6.8</td>
</tr>
</tbody>
</table>
emotions were endorsed more than negative emotions (i.e., main effect of valence); however, the Test Session × Valence interaction reflected that across all three groups, negative emotions were endorsed with greater intensity at the nonpreferred time ($M = 4.34, SE = .04$) than at the preferred time ($M = 2.87, SE = .07$), whereas endorsement of positive emotions showed less difference at the preferred ($M = 3.51, SE = .09$) and nonpreferred ($M = 4.44, SE = .04$) times. Although the ANOVA indicated that subjective mood was related to time of testing, the mood ratings showed no relation to performance on the faces and animals visual processing tasks ($r = -.01-.15$).

**Sleepiness Ratings**

Paired-samples $t$ tests were performed to evaluate whether the groups differed in sleepiness ratings at preferred and nonpreferred testing sessions. As expected, participants reported significantly more sleepiness at the nonpreferred session, whether the ratings were made immediately before testing began, $t(72) = -3.86, p < .001$, or at the end of the testing session, $t(72) = -5.37, p < .001$. However, no significant between-group differences were found at any measurement point (all $ps > .33$). Additionally, sleepiness ratings were not associated with accuracy on the faces or animals visual processing tasks ($r = -.07-.11$).

**Discussion**

The present study extends the findings of earlier studies of circadian preference and neuropsychological performance to include facial emotion recognition. More important, the findings of the present study, along with previous studies (Adan, 1991; Casal et al., 1990; Horne et al., 1980; Intons-Peterson et al., 1999; Pardee et al., 2005; Petros et al., 1990), converge to support the hypothesis of disproportionate effects of time of day among persons with cognitive impairment on multiple aspects of cognitive function. Specifically, these effects are not limited to commonly assessed domains of cognitive function (e.g., memory, executive function, attention) but can be extended to include performance decrements in basic tasks of emotional processing. Emotional processing, in particular, is affected by time of day among both cognitively and noncognitively impaired individuals. As expected, this effect is most pronounced among persons with acquired brain injury.

In the present study, we found a strong relationship between accurate facial emotion recognition and time of testing, relative to individual circadian preference, independent of differences in fundamental visual perception and time-of-day differences in subjective mood or sleepiness. The groups did not differ on a standard task assessing simple facial recognition (i.e., in the absence of emotion), and neither subjective mood nor sleepiness can account for the pattern of results. These findings are consistent with theoretical predictions that persons with cognitive impairment show greater reactivity to the additional task demands of nonpreferred time of day than do their counterparts without cognitive impairment. In the present study, the performance of persons with cognitive impairment on a facial emotion recognition task was significantly worse at the nonpreferred than preferred testing times. This
was not true, however, for those without cognitive impairment. Contrary to prediction, although the patients with RH stroke performed more poorly on emotion processing than patients with LH stroke at both the preferred and nonpreferred testing times, these two groups showed an equivalent circadian preference effect, in that the magnitude of drop in performance between the testing times did not differ.

The findings of heightened negative subjective mood at the nonpreferred time are consistent with prior reports of circadian influence on emotional functioning (e.g., Watson, 2000); however, they extend this phenomenon by indicating that circadian preference may play an important role in the level and nature of emotional experience during different times of day. The lack of association between subjective mood and accuracy on visual/emotion-processing tasks suggests that the shift in mood observed across participants appears to be a parallel phenomenon of circadian preference and not an explanatory mechanism for the drop in performance.

The circadian preference phenomenon can be understood in the context of cognitive reserve and compensation. Stern (2002) posited that cognitive reserve is called upon in normal individuals when task demands increase; increased task difficulty creates increased demands on integrative cognitive abilities. Similarly, a cognitive impairment resulting from brain damage can diminish cognitive resources, rendering the person more vulnerable to additional demands upon those now limited resources. Neuroimaging with cognitively healthy individuals has suggested that increased task difficulty commonly results in increased activation of normal task circuits and/or recruitment of additional structures or networks (Cabeza et al., 2000; Grady & Craik, 2000; Grady et al., 1996; Grasby et al., 1994; Rypma et al., 1999; Stern et al., 2003), and results of the present study were consistent with this finding. Of note, recruitment of activation to circumvent poor performance can occur in bilateral homologues in older adults when additional neural capacity is required (Langenecker & Nielsen, 2003; Nielsen, Langenecker, & Garavan, 2002), a strategy that is likely not possible with unilateral stroke.

Among persons with cognitive impairment, the attempt to maximize performance by using alternate brain structures or neural networks is conceived of as compensation (Stern, 2003). Although persons with cognitive impairment may recruit additional resources to compensate for a relatively heightened demand, the amount of reserve available is limited relative to adults without brain damage (Satz, 1993; Stern, 2003). In addition to the increase in relative demand-to-resource ratio required of persons with cognitive impairment to complete a task, testing at a nonpreferred time also increases the relative difficulty of a task. Persons with cognitive impairment may have adequate reserve to meet increased demands that arise during ideal environmental conditions (i.e., optimal testing time); however, the added tax imposed by an nonoptimal testing time may exceed available reserve to meet the increased demand. Alternatively, it may be that the diminished resources available, or loss of efficiency in neural networks during nonpreferred times, places the individual below the critical minimum of resources needed to perform well.

Thus, individual differences in functioning appear to be related not only to premorbid reserve and compensatory recruitment abilities (Satz, 1993; Stern, 2003) but also to the presence of relevant environmental factors that may affect the accessibility of cognitive reserves. This additional component to the theory of cognitive reserve was suggested by Paradee et al. (2005) and is further supported by the findings of the present study.

The ability to recognize facial emotional expression correctly is a crucial task in social behavior and a key skill in community reintegration post brain injury. Inappropriate behavioral responses to others’ emotions can eventually lead to isolation, as others withdraw from interactions with the patient. Such behavioral missteps may strain family relationships, occupational standing, and friendships. Poor community reintegration has been associated with poorer recovery after brain injury and disability generally (Charlifue & Gerhart, 2004; Man et al., 2004; Ponsford, 2004). Thus, understanding factors that may influence successful emotion decoding is an important focus for clinicians and researchers. Persons with acute stroke have more difficulty interpreting emotional facial expressions at nonpreferred than at preferred times of the day, irrespective of general visual discrimination or facial recognition skills. This finding is important for both assessment and intervention.

When assessing patients’ cognition and emotion processing skills, clinicians should be mindful of the influence of time of day as it relates to circadian preference, whether striving to obtain a patient’s optimal performance or documenting the variability of performance across the day. Formal or informal screening for circadian preference might enhance the utility of assessment results and inform recommendations for acute and postdischarge therapy.

Patients undergoing inpatient rehabilitation for stroke must adjust to multiple changes, including the fact of the stroke, cognitive and physical deficits, hospital routines and demands, and separation from friends and/or family. Emotionally challenging, these changes may lead to anxiety, depression, and confusion. Inappropriate behavior may sometimes result from poor recognition of cues, including interpretation of others’ emotions. Recognizing the role that circadian preference plays in patients’ functioning may enable staff to minimize inappropriate behavior and emotional interference by providing additional support at nonpreferred times of day.

Patients might also be taught to associate tone of voice with facial expression. This could be done during individual therapy sessions or as part of a group training/education curriculum. It is possible that using multiple channels of emotional expression could improve accuracy in emotion decoding at preferred and nonpreferred times. Allowing adequate time for decoding of emotional stimuli may also improve accuracy of facial emotion recognition. Additionally, interventions targeted at teaching such skills may be more effective if taught at preferred times of day. Finally, teaching family members and significant others to consider time of day when interacting with the patient might help mitigate problems and maximize connectedness in interpersonal interactions.

Limitations and Future Directions

The most notable limitation of the present study is the relatively small sample size. The technique used to assess facial emotion perception was a gross measure that tapped a very focal aspect of the larger domain of emotional perception. Future studies may target other channels of emotion perception (e.g., lexical and...
auditory). The use of alternative cognitive networks for other receptive channels may result in differential patterns of strengths and deficits. Similarly, the incorporation of multiple channels may provide a basis for compensatory strategies for emotional perception. Consistency of the present findings with previous findings regarding cognitive tests (Paradee et al., 2005) provides strong support for the validity of the relationship between circadian preference and performance. Circadian preference effects have been shown in performance on cognitive tasks, neuropsychological tests (Paradee et al., 2005), and, as demonstrated here, facial emotion recognition. However, further replication of these findings is needed.

A further limitation of the present study is the lack of evening-oriented participants. Due to the low base rate of eveningness among an older population, such as were enrolled in this study, it was not feasible to examine these effects among evening-oriented persons. Thus, these findings cannot be generalized beyond their observed effects on morning-oriented persons.

Although the findings of the present study suggest important factors for consideration in treatment and discharge planning for persons with stroke, the study was conducted with an acute population. Potential circadian effects on a postacute population are presently unknown.

References


Received March 8, 2007
Revision received June 21, 2007
Accepted September 7, 2007