Time-of-Day Variations in Narrative Discourse in Normal Aging and Alzheimer’s Disease

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ABSTRACT

Purpose: The purpose of this study was to investigate whether language discourse followed a diurnal pattern across one 10-hour day in normal healthy aging individuals (NHA) and individuals with mild to moderate Alzheimer’s disease.

Method: 10 normal healthy aging (NHA); and 10 older adults clinically labeled with probable Alzheimer’s disease (AD) were recruited for this study. Measurements of language and cognition were collected across one day at 9:00am, 12:00pm, 3:00 pm, and 6:00pm. Language samples were evaluated for quantity and quality, mazes, abandoned utterances, total utterances, type token ratio, and words per minute.

Results: The NHA group performed significantly better on cognitive measures across the day than the AD group; cognitive performance was not correlated with any of the linguistic measures. Measures of narrative quality were significantly different between the groups with AD participants producing significantly more abandoned utterances. Diurnal effects appeared most prevalent in the NHA group, with declining performance across the day, while the AD group showed less variation across the day.

Conclusions: These findings suggest that some aspects of language are susceptible to changes in circadian rhythms, thus impacting therapeutic outcomes and diagnostic presentation.
INTRODUCTION

Language changes have been reported in normal healthy aging, while language impairments have been reported for those with in Alzheimer’s disease (AD). Researchers have found conversational discourse impairments in propositional content, grammatical complexity, syntactic complexity, naming, cohesion, coherence, and length in both healthy aging and in individuals with AD when compared to younger persons (Bayles and Tomoeda, 2007; Kemper, Thompson, & Marquis, 2001; Bowles & Poon, 1985; Drevenstedt & Bellezza, 1993). Researchers investigating discourse in individuals with AD and those with mild cognitive impairment have reported deficits including vague and empty language content, disruptions in cohesion and coherence, difficulties with turn-taking, decreases in number of utterances and total words, increases in use of mazes (i.e., a series of words that do not contribute to the meaning of language), and verbosity (Flemming & Harris, 2008; Dijkstra, Bourgeois, Allen, & Burgio, 2004; Carlomagno, Santoro, Menditti, Pandolfi, & Marini, 2005; Cherney & Canter, 1990; Glosser & Deser, 1990; Nicholas, Obler, Albert, & Helm-Estabrooks, 1985; Hier, Hagenlocker, & Schlindler, 1985).

The number of people diagnosed with AD in the US is predicted to reach 7.7 million by 2030, a more than 60% increase from the 5.1 million currently affected (Alzheimer’s Association, 2010). Therefore, identifying factors that contribute to cognitive and language change, is imperative to understanding healthy aging individuals and those with AD.

The current study looks specifically at language through the lens of spoken language discourse which refers to conversations or larger units of talking such as stories
or songs (Guendouzi & Muller, 2007). A specific type of discourse is narrative discourse that involves the recounting of an event or series of events in chronological order. Narratives are an important aspect of communication, as they often are used for entertaining, and are essential for social communication.

Production of narrative discourse requires the complex interface of linguistic, cognitive, and social abilities (Coelho, 1995). Narratives frequently have been studied, because they are considered a formulaic type of discourse due to their predictable structure. Such narratives follow a cognitively based, measurable, structured set of rules called story grammar, which are not dictated by the specific content of the message conveyed (Coelho, 1998). Recent interest in age-related changes has led to an increase in the number of investigations of the interaction among aging, discourse, and cognition. Cannizzaro and Coelho (2003) investigated the relationship between discourse and executive function by using narrative samples from healthy aging adult ages 18-98. Using story generation and story retelling, the results indicated that like previous studies, the elderly performed the poorest, and deficits were noted even in the highly educated. Furthermore, the authors reported a relationship between story grammar and measure of executive function in aging, where increasing age was correlated with decreasing grammar quality (Cannizzaro & Coelho, 2003). The authors suggested that investigating narrative performance might provide a more suitable scale to treat and assess performance of those with cognitive-communication difficulties as opposed to more targeted impairment-based treatments and assessments.
Studies previously investigating discourse in individuals with dementia have reported numerous deficits. (Cherney & Canter, 1990; Glosser & Deser, 1990; Nicholas, et al., 1985).

**Circadian Rhythms and Language in Adults**

Many older adults complain of word-finding difficulty and mental fatigue at the end of the day. Circadian rhythms (CRs) are the patterns of arousal regulated by your internal clock. Research in the area of CRs has provided evidence that certain areas of cognition are susceptible to changes in arousal (May, Hasher, & Stoltzfus, 1993; May, Hasher, & Foong, 2005). However, it is not known if arousal patterns impact narrative discourse. The CR research has focused largely on diurnal changes in memory, attention, and inhibition as a function of age. Several investigators have reported time-of-day effects by measuring cognitive processes including attention, executive functioning, and memory in healthy aging participants (May, 1999; Yoon, et al., 1999; May, et al., 2005; Intons-Peterson, Rocchi, West, Mclellan, & Hackney, 1998). These studies suggest improved performance on complex tasks administered during periods of optimal peak arousal, as determined by self-reported preference and self-reported peak alertness (Hasher, Chung, & May; 2002; May, Hasher, & Foong; 2005; Wincour & Hasher, 1999). Research using self-report behavioral questionnaires has demonstrated a significant shift toward improved performance in the morning as a function of aging. This shift begins to appear around the age of 50 (Ishihara, Miyake, Miyasita, & Miyata, 1991), and may account for older adults reporting a morning preference for physical activities and cognitive engagement.
Although no studies have investigated diurnal patterns of language discourse across the day, smaller parts of language have been examined. Reinberg and colleagues (1988) examined healthy and language impaired children for diurnal patterns in pre-lexical access to syllables and sentences. Results indicated that while language impaired children did not demonstrate any consistent diurnal pattern of performance, healthy children showed peak performance on sentence comprehension near 9:00am and on syllabic repetition at 7:30pm. Oakhill (1986a, 1986b, 1988) has shown a relationship between text memory and circadian rhythms over several studies in adults. Results of these studies indicate that as the day progresses a shift from more superficial text processing to more meaning-based processing occurs. While their ability to remember exact wording was better in the morning, their ability to comprehend text was better in the evening; indicating a broadening of focus but a loss of detail. An earlier similar study by Folkard (1975) reported somewhat conflicting results stating that semantic processing degraded in the afternoon, while being superior in the morning hours.

Morton and Diubaldo (1993) examined identification of speech sound voicing in a time-of-day paradigm in young college-aged adults. Participants were superior at detecting voicing on particular sounds between 1:30-4:00pm, as compared to an early morning time. In another time-of-day paradigm, they examined spelling ability and found that more phonetic errors occurred in the afternoon (Morton & Diubaldo, 1993).

In a study examining word fluency, healthy aging participants (27-45) were asked to name items in categories for two minutes twice daily at 7-9:00am and again at 5-6:00pm (Yaretsky et al., 1995). Participants named significantly more items in the categories in the afternoon, indicating greater cognitive efficiency at that time (Yaretsky
et al., 1995). One potential flaw in this study is that the same questions were asked both in the morning and the evening, giving participants a chance to think of additional categorical items prior to the second testing sessions. In a follow-up study by Yaretsky and colleagues (1996), the same word fluency paradigm was used with participants possessing lower cognitive status, based on cognitive testing. The population showed no time dependency compared to those with higher cognitive status (Yaretsky et al., 1995). This result may indicate that diurnal variations in language are more likely to occur in those without cognitive dysfunction, because their systems are more vulnerable to the effects of changing circadian patterns because of their time dependency. The lower the cognitive status, the less likely language performance will be moderated by circadian rhythms because the distortion of cognitive functions is disrupting the time-of-day and performance link.

The mixed results obtained in these studies seem to indicate that some aspects of language (e.g. sentence comprehension, text processing) may be vulnerable to changes in circadian rhythms, while others may not (e.g., word fluency, syllable perception). Also, evidence exists in the cognitive literature that cognitive performance is better during self-reported peak arousal times. For those cognitive functions that are in part affected by CRs, research has shown that younger adults will generally improve in their cognitive task performance across the day, while older adults will generally show diminishing performance (May & Hasher, 1998). This outcome is important in the scope of the current investigation, because if language discourse is susceptible to CRs, then a predictable pattern of performance on language tasks may arise based on the time-of-day of testing. However, no research has investigated whether changes in CRs have an
impact on spoken language discourse. The current investigation into language change in healthy aging adults and adult with AD allows for insights into how this dynamic process changes due to both underlying cognitive declines and the effects of conversation.

The purpose of the current study was to investigate if narrative discourse follows a diurnal pattern across a single 10-hour day in healthy aging individuals and those with Alzheimer’s disease. Experimental questions:

1. Is there a significant relationship between measures of cognition and narrative discourse across 4 times in one day?
2. Is there a significant difference between NHA and AD groups’ narrative discourse quality?
3. Is there a significant difference between NHA and AD groups’ narrative discourse quantity?

METHOD

The current study is a prospective, quasi-experimental mixed methods design measuring both quality (i.e., mazes, abandoned utterances and type token ratio) and quantity (i.e., total utterances and words per minute) of narrative language discourse. This study received approval from the Institutional Review Board at Louisiana State University.

Participants

Twenty volunteer participants were recruited from Baton Rouge and surrounding communities. All participants: (a) were native English speaker; (b) had no history of clinically diagnosed depression or major psychiatric disorders; (c) had at least 8 years of formal education; (d) passed a bilateral pure tone hearing screening at 45 dB HL; (e)
passed a vision screening; and (f) achieved at least 80% accuracy on the speech discrimination subtest of the *Arizona Battery for Communication Disorders in Dementia* (ABCD; Bayles & Tomoeda, 1993).

Group 1 consisted of 10 normal healthy aging adults (NHA) aged 65–89 years. All participants in this group scored a 28 or higher on the *Mini Mental State Examination* (MMSE; Folstein, Folstein, & McHugh, 1975) to exclude the presence of cognitive dysfunction and had no history of neurological disease or damage (See table 1). Group 2 consisted of 10 adults, ages 65–89, clinically labeled by their physicians as having probable Alzheimer’s disease. Participants in this group had to score an 11–25 on the MMSE. According to Bayles and Tomoeda (2007), early stage AD lasts from 2 to 4 years and is associated with average scores on the MMSE from 16–24. Middle stage AD is associated with MMSE scores from 8–15. Groups were not deliberately matched for age and gender; nevertheless, groups were similar in composition. The average ages of the two groups were not statistically different ($t(28) = 0.9762, p < 0.3419$), nor was the gender composition ($\chi^2 (1) = 0.6392, p < 0.6392$). All of the participants expressed a preference for morningness, based on the *Morningness-Eveningness Questionnaire* (MEQ; Horne & Ostberg, 1976) and passed the speech discrimination test. As expected, the NHA group achieved MMSE scores that were significantly higher than those of the AD group ($t(18) = 10.182, p < 0.0001$).

** Procedures **

Inclusionary Screening

All participants were assessed individually in their typical daily setting (i.e. house, care facility) over two days by the investigator. During the first visit, consent was
obtained and general identifying information, such as health status, education, and medication use, was collected using an intake questionnaire. The MMSE was administered to assess relative cognitive status, and all participants had to score 80% or better on the speech discrimination subtest of the ABCD. A hearing and vision screening was conducted at this time to ensure adequate sensory ability for the tasks. All screening and experimental task sessions were recorded using an audio digital recorder, which was placed on the table between the participant and examiner (approximately 2-3 feet). Those recordings were used for scoring and data analysis.

Experimental Task Data Collection

During the experimental procedure, language samples were taken at four points across the day by the investigator: at approximately 9:00am, 12:00pm, 3:00pm, and 6:00pm. See Figure 1 for a visual representation of the experimental procedure. On average, each session lasted 20 minutes. Using an interview format, narrative samples were taken from each participant. One narrative question from a corpus of four questions were asked in randomized order across time and participants, and included, “tell me about 1) your day, 2) family, 3) last vacation, and 4) careers.” The examiner encouraged the participant to continue to talk for at least 2 minutes, and prompted them for more information using the phrase “tell me more” if the participant stopped talking. This time frame was deemed appropriate based on norms for words per minute (WPM), conversational analysis, and total utterances (Guendouzi & Muller, 2007).

In addition to the narrative language sample taken at each time period, participants were assessed for cognitive status. Since studies investigating normal healthy aging and recent investigations into time-of-day changes have indicated that
visual-spatial abilities are vulnerable to arousal changes, the shortened version of the 
*Benton Judgment of Line Orientation Test* (BJLO; Benton, Varney, & Hamsher, 1978) 
(even-odd forms) was administered to measure cognitive status changes. The BJLO was 
also chosen based on its ability to largely test cognition devoid of overt linguistic 
interference. The administration of these tasks was randomized across each participant 
and each session. Randomization for all tasks was done using *Research Randomizer*, a 

**Language Sample Analysis**

Language samples were typed and coded into *Systematic Analysis of Language 
Transcripts* (SALT; Miller & Chapman, 2000) from the recordings by the investigator 
and two trained graduate assistants. The narrative samples were analyzed in the SALT 
software for linguistic variables, which included total utterances, abandoned utterances, 
type token ratio, wpm, and use of mazes. These variables are defined as follows:

- **Total Utterances**: the total count of utterances produced during the 
  structured task (i.e., an independent clause and its modifiers)
- **Abandoned Utterances**: utterances in which the speaker stopped mid-
  utterance resulting in a sentence fragment
- **Type Token Ratio**: Percent of different words to total words
- **Words Per Minute**: The number of wpm of sample
- **Percent of Mazes used**: Percent of maze words used as a percent of total 
  words. Mazes include fillers (e.g., “uh”), repetitions, and revisions.
Intra-judge reliability was derived by the examiner randomly choosing and rescoring 25% of the discourse samples. Point-to-point agreement was 96%. For inter-judge reliability point-to-point agreement of 98%.

**Data Analysis**

Using SPSS 16.0 (2007), means and standard deviations were calculated for all of the linguistic and procedural variables. Correlations were calculated between the cognitive and linguistic measures.

The first aim of the study was to determine if there were relationships between cognitive function, discourse production, and time-of-day. The relationships between cognitive function and time-of-day were assessed via a two-subject group by four time-of-day mixed model ANOVA calculated for BJLO scores. It was further hypothesized, as part of the first aim of the study that measures of discourse would be affected by the declining cognitive function across the day. Correlation coefficients were calculated to assess the strength of the relationships between the difference in cognition from the first to last time-of-day and the differences from first to last time-of-day for each of the discourse measures.

The second aim of the study was to determine if the two participant groups differed in the manner in which the quality of their narrative discourse changed across the day. This possibility was assessed using MANOVA to compare the participant groups using the multiple dependent measures of change from 9:00 to 6:00 scores in abandoned utterances, percent utterances mazed, and type token ratio. If the MANOVA revealed a significant group difference at the \( p < 0.05 \) level, it was followed by ANOVAs comparing the two groups for gains in each independent variable. The third aim was to determine if
the two participant groups differed in the manner in which the quantity of their narrative discourse changed across the day. This aim was evaluated using the same sequence of statistical procedures as the second aim applied to the quality measures derived from narrative samples.

RESULTS

Research Question 1: It was hypothesized that changes in discourse elements would show a positive correlation with changes in the BJLO for both normal healthy aging participants and individuals with AD based on the literature. Figure 2 shows the average participant group scores as a function of time-of-day with associated standard error of estimates. The healthy aging group demonstrated an initial drop from 9AM to 12PM that flattened out for the rest of the day. The AD group showed a more rapid decline extending across the whole day (see table 2).

A 2 x 4 (Participant Group [NHA, AD]) x Time-of-day [9:00, 12:00, 3:00, 6:00]) mixed model analysis of variance showed that the decline in BJLO performance as a function of time-of-day was significant, $F(3,16) = 3.564, p < .020, \eta^2 = .38$. However, the Participant Group by Time-of-day interaction failed to reach significance, $F(1,18) = 1.778, p < .162, \eta^2 = .37$, indicating that the BJLO scores of both groups were not falling at different rates. As expected, the overall difference between participant groups was significant, $F(1,18) = 5.082, p < .037, \eta^2 = .21$.

Correlation coefficients were calculated between the difference in BJLO scores between 9 o’clock and 6 o’clock and the change that occurred over this time period in the linguistic measures. From highest to lowest these correlations were Abandoned Utterances ($r(18) = .303, p < .194$), Total Utterances ($r(18) = .206, p < .383$), Percent
Mazed ($r(18) = .165, \ p < .487$), Type Token Ratio ($r(18) = .133, \ p < .577$), and Words per Minute ($r(18) = -.081, \ p < .733$). None of these correlations reached statistical significance.

Taken together, these results indicate that BJLO scores drop as a function of time-of-day for the AD group, while the NHA group remained relatively stable. The drops in BJLO were not significantly correlated with the change across the day in any of the linguistic measures.

Research Question 2: It was hypothesized that measures of abandoned utterances, mazes, and TTR in narrative discourse would increase across the day for both groups but that the AD group would show a steeper decline. This prediction was partially upheld. See Tables 2 and 3. Two of the positive indicators of discourse structure, Total Utterances and Type Token Ratio both appear to decrease in frequency during the day. Total Utterances decline between 3:00 PM and 6:00 PM. Type Token Ratio declines between 9:00 am and 12:00 PM. Words per Minute vary up and down throughout the day. The two negative indicators of discourse production, Abandoned Utterances and Percent Mazing, appear to increase between 9:00 AM and 12:00 PM.

A one-way multivariate analysis of variance (MANOVA) was conducted to determine the effect of Participant Group on the change in measures of linguistic quality from the 9:00 test period to the 6:00 test period (i.e., abandoned utterances, type token ratio, and percent mazes used). Significant differences were found between the NHA and AD groups for the combined dependent measures $F(3,16) = 5.91, \ p = .007, \ \eta^2 = .52$ with the NHA group demonstrating a greater change in linguistic quality across the day.
Follow up ANOVAs for each gain score revealed a significant group difference for Abandoned Utterances, $F(1,18) = 8.777, p < .008, \eta^2 = .34$, but not Type Token Ratio, $F(3,16) = 2.30, p = .116, \eta^2 = .302$, or Percent Mazes, $F(1,18) = 1.529, p < .232, \eta^2 = .101$. Figure 3 shows the average scores of the two groups across time-of-day for abandoned utterances, percent of utterances mazed, and type token ratio. The NHA group increased their production of abandoned utterances while decreasing their use of mazing and lowering their type token ratio. The individuals with AD lowered their use of abandoned utterances, percent mazes, and type/token ratio.

Research Question 3: It was hypothesized that measures of total utterances and words per minute would decline across the day in narrative discourse for both groups, but that the AD group would show a steeper decline than the NHA group. This hypothesis was not substantiated. A MANOVA was conducted to determine the effect of group membership on measures of linguistic quantity across the day. No significant differences were found between the two groups on the dependent measures $F(2,17) = .516, p = .074, \eta^2 = .264$. Since the MANOVA was non-significant for these measures of quantity, no follow-up tests were conducted. The NHA group produced more total utterances and words per minute as expected, but there was no significant trend across the day. Variables remained relatively unchanged across the day for both groups (see Figure 4).

These results indicate that the groups differed only in production of abandoned utterances. The NHA group tended to abandon utterances at an increasing rate while the AD group abandoned utterances at a steady rate across the day. Though trends in the
data were observed in narrative quality no other significant differences were found across group or time.

DISCUSSION

The purpose of this study was to investigate if language discourse followed a diurnal pattern across a single 10-hour day in aging individuals and individuals with AD. Although this appears to be the first study to explore this topic, it was expected that some linguistic elements would be susceptible to changes in diurnal patterns, and that individuals with AD might show a steeper decline across the day than normal healthy individuals. In summary, the BJLO was not found to be correlated with any linguistic variables, but did have a significant linear effect over time differentiating the two groups. A significant difference was found between the groups in narrative quality, specifically in the number of abandoned utterances across the day. No significant differences were found between the groups in narrative quantity. These results are described below for each research question.

In research question 1 it was hypothesized that a relationship would exist between measures of cognition and discourse across the day, but results indicated that while cognitive status, as measured by the BJLO scores, was highly positively correlated with group membership, but not with other linguistic measures. The literature indicates that people with AD maintain relatively functional communication skills until later stages of the disease process (Bayles & Tomoeda, 2007; Hamilton 1994a, 1994b). As the cognitive skills of the individuals with AD declined, these studies suggest that those with AD were still able to maintain relatively functional discourse.
One possible reason for the current findings is that the measures used were not sensitive enough to detect changes across the day. Longer-form assessment could be utilized to get a better picture of cognitive health. Another possible explanation for the failure to find a relationship between narrative discourse and time of day is that language and cognition are separate capacities that can function relatively independently of one another during this stage of decline. Language may also have been maintained, because it is relatively robust and/or relies heavily on previously learned scripts and schemas, such as narratives.

The NHA group produced little change in BJLO across the day, while demonstrating changes in several linguistic measures. The individuals with AD group showed the opposite pattern, with declining BJLO scores but little change in performance on linguistic measures. The NHA group averaged 9.5 out of 15 at 9:00am and declined to only 8.9 by 6:00pm. By contrast, the individuals with AD group started out performing less well and showed a steeper decline, with an average score of 7.2 at 9:00am that declined to 4.6 by 6:00pm (see Figure 2). This represented a significant linear trend for the BJLO across the day, which suggests that cognitive performance decreased at a relatively stable rate across the day. These results are consistent with a literature documenting cognitive decline individuals with AD as compared to healthy aging peers (e.g., Bayles & Tomoeda, 2007; Kemper et al., 2001). This result indicates that the cognitive function necessary to perform on the BJLO, such as visual-spatial processing, declines across the day in the NHA population without a corresponding decline in linguistic skills. This again supports the idea that various linguistic skills and
cognitive functions remain somewhat separate and changes in circadian rhythms can have a derogating effect.

In research question 2 it was hypothesized that measures of narrative quality (i.e., abandoned utterances, mazes, and type token ratio) would decrease across the day for both normal healthy aging participants and individuals with AD; however, the results indicate that the groups differed only in production of abandoned utterances. The AD group’s abandoned utterance scores remained relatively unchanged. Conversely, the NHA group showed a steady increase in the number [or was it proportion?] of abandoned utterances across the day. An increase in abandoned utterances contributes to the diminished quality of discourse (Guendouzi & Mueller, 2008; Ripich, et al., 2000). The increase in abandoned utterance scores in the NHA group may substantiate the literature that reports increased word-finding difficulty at the end of the day in older people (Bayles & Tomoeda, 1991). No significant differences were found between the groups in the measure of mazes across the day. Nearly 30% of the NHA group’s utterances contained mazes at 9:00am, while the individuals with AD groups contained 52% mazed utterances. Across the day, the individuals with AD group did not statistically change; this may support the notion that the AD group was preforming at their relative floor across the entire day. The NHA group was being negatively impacted by changes in arousal as evidenced in the increased production of abandoned utterances. This further supports the theory that circadian rhythm changes have a disproportionate impact on those with higher cognition.

Measures of TTR also indicated no significant trends across the day. However, contrary to the hypothesis, NHA participants demonstrated a lower TTR across the day.
than the individuals with AD group. At 9:00am, the NHA group had a TTR of .56 versus the individuals with AD group at .59. These scores declined to .52 and .57, respectively by 6:00pm. This result is not consistent with Buck, Singh, Cuerden, & Wilcock (2000), who suggested that NHA participants produce richer speech, based on higher TTR. On the other hand, it is possible that individuals with AD produced more linguistically diverse narratives because they skipped from topic to topic (Bayles & Tomoeda, 2007; Garcia & Orange, 1996).

In Research Question 3 it was hypothesized that measures of narrative discourse quantity would decline across the day for both normal healthy aging participants and individuals with AD, with the individuals with AD participants showing a steeper decline than normal participants showed. The data did not support this hypothesis. No significant differences were found between the groups. This included measures of total utterances and words per minute (wpm).

Both groups visually showed a decline in the number of total utterances produced across the day though not significant, with the NHA group demonstrating a steeper decline. On average, the NHA group produced 30 utterances at 9:00am and 27 at 6:00pm. Individuals with AD showed less decline across the day, with an average of 21 utterances at 9:00am and 19 at 6:00pm. These data conflict with Ripich and colleagues (1988), who found that individuals with AD demonstrated fewer overall utterances than aging participants.

WPM showed a relatively flat pattern of performance across the day for both groups. On average, the NHA group produced 130 wpm while individuals with AD produced only 108 wpm. The group difference was consistent across the day. This
failure to see a difference may be because the AD group had not yet reached a severity
where their speech had become wholly impoverished, often reported in later stages of the
disease.

In summary, the results of the narrative measures across the day indicated that the
percent of abandoned utterances variable was susceptible to changes across the day.
Abandoned utterances may represent a stronger link to processes affected by changes in
arousal because they represent a failure of integration of the multiple cognitive systems
necessary for planning and executing statements. Individuals with AD produced fewer
utterances, and these utterances were not as diverse, more aborted, and less fluent.
However, it appeared as though people with mild to moderate deficits in the current study
still had enough preserved ability to complete the task.

The mounting evidence that cognitive functions are affected by circadian rhythms
(Schmidt et al., 2007) motivated the current study. Since language processing involves
other cognitive processes to function adequately, it seemed appropriate to hypothesize
that circadian rhythms might also affect the language system. Few studies have
attempted to examine language processing or production for diurnal patterns. The studies
examining such changes have reported mixed results indicating that some aspects of
language may be vulnerable to circadian rhythms (Reinberg et al., 1988; Oakhill 1986a;
1986b; 1988), while others appear to remain relatively stable (Folkard, 1975; Morton &
individuals with dementia and reported that word fluency measures were tied to a diurnal
pattern, but only for those individuals without severe cognitive deficits. The results of
the current study corroborate these results. In addition, circadian rhythms may exert a larger effect on individuals with higher cognitive status.

**Clinical Applications**

The results of this study add to a long line of evidence showing cognitive change in Alzheimer’s disease. In particular they suggest that the performance on the BJLO and narrative discourse quality are susceptible to changes in circadian rhythms. Evidence from this study could contribute to the small but growing body of literature documenting changes in language across a day. Professionals and families interacting with elderly patients overall and those with AD in particular may need to be aware of such fluctuations as they monitor and report patient status.

To our knowledge, this is the first study to investigate how diurnal patterns might affect language discourse across a single day. Perhaps most importantly, this study may provide further evidence about the effects of diurnal variation on some language skills as cognition declines.

**Limitations and Future Directions**

Limitations to this study include the small number of participants and the possible influence of external variables (i.e., mealtimes, naptimes, shift work, medication schedules, and exercise) on the measures. Follow-up studies should include larger and more homogenous groups, in terms of daily schedule. Future studies could also include the correlation of physiological measures to linguistic ones. For example, measures of blood pressure, temperature, and heart rate have been used to indicate subtle changes in circadian rhythms (Schmidt, Collette, Cajochen, & Piegneux, 2007); this could provide a clearer picture on individual variations in the rhythms themselves. The inclusion of
added cognitive measures to track cognition could provide further information about the overall status of cognition. Though the BJLO was chosen based on its ability to largely test cognition devoid of overt linguistic interference, additional measure might provide information on other cognitive processes such as memory and divided attention. Finally, the investigation into other types of discourse, such as conversation, could provide valuable information to the real-life performance of NHA and individuals with AD across the day. This is an area ripe for interdisciplinary study among those interested in the physiology, neurocognitive and language performance of individuals with AD. Further research is needed in these areas to identify factors that contribute to cognitive and language change, information it is imperative for us to have if we are to meet the cognitive and communicative needs of an aging population.
REFERENCES


VISUAL REPRESENTATION OF EXPERIMENTAL PROCEDURE

Figure 1. Visual representation of experimental procedure illustrating 2-day procedure and tasks associated with each day of testing. Narrative sample and BJLO administration were given in a randomized fashion to eliminate order effects.
DIURNAL PATTERN OF BJLO SCORES IN AGING AND ALZHEIMER’S DISEASE

Figure 2. Results of BJLO performance across the day in NHA and individuals with AD with standard error bars. There was a significant group difference on performance and a significant linear effect. The BJLO did not correlate with any linguistic measure used within the study.
Figure 3. Average performance across the day on measures of narrative quality (abandoned utterances, percent of mazes, TTR) in NHA and individuals with AD with standard error bars. A significant difference was found between the two groups on measures of quality. Follow-up tests revealed that performance on abandoned utterances was significantly different across groups. Percent mazes used and TTR were not found to differ between the groups.
Figure 4. Average performance across the day on measures of narrative quantity (total utterances, wpm) in aging and individuals with AD with standard error bars. No statistical differences were found.
Table 1

Participant Characteristics

<table>
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<tr>
<th>Subject</th>
<th>Age</th>
<th>Gender</th>
<th>MEQ</th>
<th>MMSE</th>
<th>Speech</th>
<th>Education</th>
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| AD 1    | 79  | Male   | Morning | 20   | Pass   | 16        |
| AD 2    | 87  | Female | Morning | 20   | Pass   | 10        |
| AD 3    | 80  | Female | Morning | 21   | Pass   | 12        |
| AD 4    | 88  | Female | Morning | 15   | Pass   | 14        |
| AD 5    | 80  | Female | Morning | 23   | Pass   | 16        |
| AD 6    | 82  | Female | Morning | 20   | Pass   | 12        |
| AD 7    | 72  | Female | Morning | 22   | Pass   | 12        |
| AD 8    | 79  | Female | Morning | 19   | Pass   | 8         |
| AD 9    | 82  | Male   | Morning | 23   | Pass   | 14        |
| AD 10   | 85  | Male   | Morning | 24   | Pass   | 10        |
| Mean    | 81.4|        |        | 20.7 |        | 12.4      |
| Std. Dev.| 4.62|        |        | 2.58 |        | 2.63      |

Note. MEQ=Morning-Eveningness Questionnaire (Horne & Ostberg, 1976); MMSE = Mini Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975)
Table 2

Descriptive Statistics of Linguistic Narrative Variables of the Aging group

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<thead>
<tr>
<th>Variable</th>
<th>Minimum</th>
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<th>Mean</th>
<th>Std. Dev.</th>
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