Journal of Gerontology & Geriatric Research

Ryan et al., J Gerontol Geriatr Res 2015, 4:3
DOI: 10.4172/2167-7182.1000221

Case Report Open Access

Temporal Disorientation Base Rates in Alzheimer's Disease and Parkinson's Disease

Joseph J. Ryan[1], David S. Kreiner*[1], Jennifer S. Seeley[2] and Anthony M. Paolo[3]

[1]*Department of Psychological Science, University of Central Missouri, USA*
[2]*Department of Psychological Science, The University of Kansas, USA*
[3]*The University of Kansas Medical Center, USA*

Abstract

Base rates of impairment on the Temporal Orientation Scale (TOS; Benton et al.,) were reported for normal elderly (*n*=210) and patients with either Alzheimer's disease (AD; *n*=112) or Parkinson's disease (PD; *n*=189). The study hypothesis was that disorientation would be more frequent in ADs than in controls and PDs. Base rates for controls, PDs, and ADs were 1.00%, 22.22%, and 78.60% when disorientation was defined as ≥3 errors and 1.00%, 18.52%, and 72.30% when impairment was suggested by ≥4 errors. Receiver operating characteristic (ROC) analyses indicated excellent discrimination between controls and AD (AUC=0.919, 95% CI=0.879-0.958) along with good Sn and excellent Sp. Conversely, discrimination between control and PD groups was poor (AUC=0.642, 95% CI=0.587-0.697) with low Sn and excellent specificity.

Keywords: Temporal orientation; Alzheimer's disease; Parkinson's disease

Introduction

Intact time orientation is a feature of competent everyday functioning, whereas disorientation in time suggests adaptive impairment. Engelhart and Eisenstein [1] reported that temporal disorientation among psycho-geriatric patients was a better predictor of wandering behavior and placement in a locked ward than were formerly measured deficits in attention, memory, language, and/or abstract thinking. A test-retest investigation with an average test interval of 19 months indicated that non-demented adults with impaired temporal orientation at initial assessment were most likely to develop an organic dementia by the second assessment [2]. Along with general cognitive decline, temporal disorientation may be a marker for Alzheimer's disease (AD). Solomon and Pendlebury [3] reported that measures of temporal orientation, when included as part of a comprehensive neuropsychological test battery, are highly sensitive and specific to mild and moderate degrees of AD when compared to elderly controls. Temporal disorientation occurs rarely among normal elderly with estimated base rates of 0%, 2%, 6%, and 5% for the age ranges 65 to 69, 70 to 74, 75 to 79, and 80 to 84, respectively [4]. Disorientation in time is infrequently seen in other common neurological disorders such as Parkinson's disease [5], but we were unable to locate published base rates for temporal disorientation that characterize this disorder.

Among patients with chronic alcohol abuse, Varney and Shepherd [6] demonstrated that individuals with marked temporal disorientation were likely to show similar levels of impairment on tests of paired associates learning, visual retention, and serial digit learning. Based on these findings it was suggested that administration of standard memory tests to persons with severe time disorientation is likely an inefficient practice. A better approach would be to monitor cognitive status via repeated measurement of temporal orientation, delaying extensive memory testing until the patient's condition improves enough to allow for valid assessment. Repeated probes might be as simple as asking the patient to indicate the correct year. This single question had reported sensitivity of 0.86 and specificity of 0.94 when used to separate cognitively intact elderly patients from those with either dementia or delirium [7]. Ryan, Glass, Bartels, Bergner, and Paolo [8] generalized the findings of Varney and Shepherd to patients with AD and reported that the presence of temporal disorientation reliably predicted failure on a memory battery that included the California Verbal Learning Test [9] and the Logical Memory and Visual Reproduction subtests from the Wechsler Memory Scale-Revised [10]. It was suggested that the traditional memory component of a neuropsychological examination might be shortened or eliminated when the patient is disoriented for time.

Impairment in temporal orientation is typically seen in patients with bilateral brain disease [11,12], but the neuro pathological basis of this deficit has not been clearly defined. Nevertheless, available evidence suggests that it is associated with limbic-diencephalic or diffuse lesions [13] as well as neurofibrillary tangle densities in the Cornu Ammons area 1 field of the hippocampus and Brodmann's areas 7 and 23 [14].

Numerous reports are available that focus on temporal disorientation among patients with AD [3,5,8]. However, to date no study has reported and compared actual base rates of impaired time orientation simultaneously in AD and PD and contrasted these figures to base rates in normal elderly. Using the Benton Temporal Orientation Scale, these were the goals of the present investigation which tests the hypothesis that rates of temporal disorientation will be higher in patients with AD than in elderly controls and persons with PD.

Method

Participants

Two hundred and ten elderly controls, 112 patients diagnosed with Alzheimer's disease (AD), and 189 patients diagnosed with Parkinson's disease (PD) served as participants. All clinical diagnoses were determined by board certified neurologists independent of neuropsychological test data using a clinical interview, the Dementia Rating Scale total score [15] and comprehensive physical, laboratory,

***Corresponding author:** David S. Kreiner, Dept. of Psychological Science, Lovinger 1111 University of Central Missouri Warrensburg, MO 64093-5089, USA, Tel: 660 543-8076; E-mail: kreiner@ucmo.edu

Received April 17, 2015; **Accepted** June 15, 2015; **Published** June 18, 2015

Citation: Ryan JJ, Kreiner DS, Seeley JS, Paolo AM (2015) Temporal Disorientation Base Rates in Alzheimer's Disease and Parkinson's Disease J Gerontol Geriat Res 4: 221. doi:10.4172/2167-7182.1000221

and neuroradiological examinations. For patients with AD, the diagnostic criteria were those of McKhann, Drachman and Folstein et al. [16] and a Clinical Dementia Rating [17] score ≥1. The diagnosis of PD was made when two or more of the following were present: resting tremor, bradykinesia, and rigidity. The data reported in the present investigation were collected as part of a National Institute of Aging grant under Institutional Review Board guidelines proposed by The University of Kansas Medical Center.

The 210 (119 females, 100 males) controls passed medical and neurological examinations and were judged to be free of psychiatric and neurological disorders. Means for age, education, and DRS were 73.60 years (*SD*=5.82), 14.77 years (*SD*=2.63), and 135.45 (*SD*=6.01), respectively. Two hundred and six were Caucasian, two were African American, and two were from other ethnicities. For the 112 patients with AD (60 females, 52 males), the mean age was 74.60 years (*SD*=5.39), mean education was 12.70 years (*SD*=3.17), and DRS was 93.03 (*SD*=28.91). Means for age of onset and duration of disease were 72.63 years (*SD*=5.71) and 2.19 years (*SD*=1.75). One hundred and four were Caucasian and eight were African American. Of the 189 patients with PD (63 females, 126 males), means for age, education, and DRS were 73.32 years (*SD*=5.23), 13.81 years (*SD*=3.10), and 121.52 (*SD* =21.78). The averages for age of onset and duration of disease were, respectively, 67.26 (*SD*=7.00) and 6.12 years (*SD*=4.70). One hundred eighty-two were Caucasian, four were African American, and three were from other ethnicities.

Instruments

The TOS measures recent memory based on responses to five questions about the year, month, day of the month, day of the week, and time of day. Incorrect answers are assigned penalty points that range from 1 to 113 (worst obtainable score). A perfect score is defined as zero errors. The scoring procedure is as follows: 10 points for each year off the actual year, with a maximum penalty of 60 points. For the month, 5 points are given for each month removed from the correct response, with a maximum score of 30 points. For the day of the month, 1 error point is assigned for each incorrect day, with a maximum point total of 15. For each day removed from the correct day of the week, 1 point is given up to a maximum of 3, whereas one point is assigned for each 30-minute deviation from the correct time with an error limit of 5 points. TOS norms are based on responses from 434 healthy adults living in Iowa (*n*=180) and New Jersey (*n*=254). The standard scoring is as follows: 0-2=normal, 3=borderline, 4 to 7=moderately defective, and ≥8=severely defective.

The DRS was designed as a brief measure to quantify the cognitive functioning of individuals with progressive neuro pathological disorders involving the brain. It consists of 36 items grouped into five categories that evaluate the behavioral changes associated with dementia syndromes. These scales or categories (i.e., attention, initiation and perseveration, constructional praxis, conceptualization, and memory) each contribute to a total score with a maximum value of 144 points. The rudimentary norms in the DRS manual are based on the performance of 85 healthy elderly individuals and suggest that a cut off total score of ≤122 is consistent with the presence of mild dementia.

Procedure

All participants were administered the Temporal Orientation Scale and DRS as part of an extensive battery of psychological and neuropsychological tests. For the initial statistical analysis, disorientation was defined as an error score of ≥3 and then redefined for subsequent analysis as ≥4. This methodology was employed in order to gain an appreciation for the meaning of borderline TOS performance. Testing was completed at The University of Kansas Medical Center Department of Neurology in comfortable, well lit rooms by trained neuropsychology technicians under the supervision of a licensed psychologist.

Results

Mean TOS error scores were 0.46 (*SD*=4.20) for controls, 7.53 (*SD*=20.56) for patients with PD, and 45.91 (*SD*=43.48) for patients with AD. Correlations of TOS scores with age and education were computed for the combined sample (*N*=511) and were 0.122 and -0.153, respectively. As the correlations were small in magnitude, explaining less than 3% of the variance in TOS scores, it is unlikely that these demographic variables explain any differences between diagnostic groups. Table 1 reports percentages of normal and impaired temporal orientation using error cutoffs of ≥3 and ≥4 separately for the control and patient total samples as well as across four age groups. Total impairment base rates for controls, PDs, and ADs using the ≥3 cutoff were: 1%, 22.22%, and 78.60%. When the ≥4 cutoff was utilized, total impairment base rates were: 1%, 18.52%, and 72.30%, respectively. Proportional analysis indicated that, compared to controls and regardless of which cutoff was applied, temporal disorientation occurred at significantly higher frequencies among patients with PD ($p<0.0001$), and patients with AD ($p<0.0001$). With both cutoffs, temporal disorientation occurred at a significantly higher frequency among patients with AD than among those with PD ($p<0.0001$).

The diagnostic ability of the TOS was analyzed as a test for cognitive impairment in general (combined AD and PD) and then separately to distinguish the AD and PD groups from controls. Three receiver operating characteristic (ROC) analyses were performed to obtain classification rates. Table 2 reports base rates for clinical diagnoses along with figures for sensitivity (Sn), specificity (Sp), positive predictive value (PPV), and negative predictive value (NPV). For discrimination between intact and impaired cognitive functioning in general, there was a fair degree of group separation (AUC=0.745, 95% CI=0.703-0.787) with fair Sn and excellent Sp. There was excellent (AUC=0.919, 95% CI=0.879-0.958) discrimination between controls and patients with AD along with good Sn and excellent Sp. Conversely, discrimination between control and PD groups was poor (AUC=0.642, 95% CI=0.587-0.697) with low Sn but excellent specificity.

Finally, to determine whether the frequency of temporal disorientation changed as the duration of illness increased, Pearson Product-Moment correlations were computed separately for the AD and

	Age Ranges				
	65-69	**70-74**	**75-79**	**≥ 80**	**Total**
≥ 3 errors Controls	0.00 (*n*=57)	0.01 (*n*=76)	0.02 (*n*=44)	0.00 (*n*=33)	0.01 (*n*=210)
Alzheimer's disease	72.72 (*n*=22)	74.19 (*n*=31)	79.49 (*n*=39)	80.00 (*n*=20)	78.60 (*n*=112)
Parkinson's disease	16.00 (*n*=50)	15.71 (*n*=70)	33.33 (*n*=45)	33.33 (*n* =24)	22.22 (*n*=189)
≥ 4 errors Controls	0.00 (*n*=57)	0.01 (*n*=76)	0.02 (*n*=44)	0.00 (*n*=33)	0.01 (*n*=210)
Alzheimer's disease	72.72 (*n*=22)	67.70 (*n*=31)	74.40 (*n*=39)	80.00 (*n*=20)	72.30 (*n*=112)
Parkinson's disease	12.00 (*n*=50)	11.40 (*n*=70)	31.11 (*n*=45)	29.17 (*n* =24)	18.52 (*n*=189)

Table 1: Percentages of impaired temporal orientation scale scores for controls and patients with Alzheimer's disease or parkinson's disease using cutoffs of ≥3 and ≥4 errors.

Group	Base Rate	Sn	Sp	PPV	NPV
≥ 3 Errors/ ≥ 4 Errors Controls *vs.* AD + PD	59.0	38.5/38.5	99.0/99.0	98.3/98.3	53.0/53.0
Controls *versus* PD	47.0	22.2/18.5	99.0/99.0	95.4/95.0	58.6/57.1
Controls *versus* AD	34.8	8.2/72.3	99.0/99.0	97.8/97.6	89.6/87.0
Sn: Sensitivity; Sp: Specificity; PPV: Positive Predictive Value; NPV: Negative Predictive Value					

Table 2: Base Rates, Sensitivity, Specificity, Positive Predictive Value, and Negative Predictive Value Stratified by Diagnosis for TOS Cutoffs of ≥3 and ≥4.

PD groups between TOS scores and time since recorded disease onset. For patients with AD the correlation was small but significant, $r=0.276$, $p=0.004$, indicating that the frequency of temporal disorientation increased as duration of illness increased. Conversely, the correlation for patients with PD did not achieve statistical significance, $r=0.121$, $p=0.097$, indicating a lack of meaningful association between temporal disorientation and duration of illness.

Discussion

The hypothesis of the investigation was confirmed since base rates of temporal disorientation were significantly higher in patients with AD than in elderly controls and persons with PD. Also, temporal disorientation tended to increase with disease duration in the AD sample but not in the PD sample. The Sp of temporal disorientation was excellent (0.99) when controls were compared to AD + PD as well as to the AD and PD groups separately. However, Sn to the cognitive sequelae of PD was poor, whereas Sn to the cognitive deficits seen in AD was moderately high. The implication of these findings for clinical practice is that TOS error scores ≥3 or ≥4 should prompt careful investigation because they are likely to be associated with impaired everyday functioning [1] and deficient performance on measures of auditory and visual memory, especially with error scores ≥8 [8].

In the present sample of healthy elderly, the base rate for an impaired TOS error score (≥3 and ≥4) was only 1%. This figure is below the base rates reported by Benton et al. [4] for healthy Midwesterners in the age ranges 70 to 74 (2%), 75 to 79 (6%), and 80 to 84 (5%). It is unlikely that these differences resulted from discrepant educational attainment or socioeconomic status [18,19] since both studies utilized predominantly well-educated, Caucasian volunteers living in relatively close geographical proximity. However, there are differences between the two investigations that may have contributed to the observed base rate differences. Participants in Benton et al. were included in the study if they claimed to be in good health and denied a history of psychiatric disorder and/or neurological disease. No medical or neurological examinations were administered. Conversely, our elderly controls actually passed medical and neurological assessments prior to inclusion in the study. Perhaps the later sample was healthier than the one in the Benton et al. study which may have inadvertently included some participants with undetected mental deterioration. Another difference between the two investigations is that the current sample was composed of 46% males, whereas only 21% of the Benton et al. participants were male. Future research is needed to determine if gender is related to performance on the TOS.

We were unable to locate any studies that reported temporal disorientation base rates in patients with PD. However, it is noted that the present base rates of 22.22% and 18.52% are similar to the 23.60% reported by Levin and Benton [20] for nonaphasic patients with documented brain disease. Intact temporal orientation requires both semantic (concept of calendar) and episodic (recalling the current date) memory and disorientation is extremely rare among normal elderly. Therefore, any patient with PD who earns a TOS error score ≥4 should be referred for neuropsychological evaluation to rule out dementia and a reduced capacity to acquire new verbal and visual material [6,8]. With respect to global cognitive functioning, when the current sample of patients with PD were designated as oriented (TOS error scores ≤3) versus disoriented (TOS error scores ≥4), a highly significant difference between groups emerged on the DRS [15]. Patients displaying intact orientation earned a mean composite of 128.21 (SD=11.48), whereas those with temporal disorientation had a mean of 92.26 (SD=30.61). These group scores were reliably different, t (187)=35.95, $p<0.0001$, d=1.90, and the mean for the disoriented patients was substantially below the recommended cutoff score (≤123) for identifying dementia in PD [21].

The present study is the first to compare TOS scores of elderly controls and a sample composed exclusively of patients with AD. Using this design, the TOS produced good sensitivity (0.78 and 0.72) and excellent specificity (0.99) based on the recommended cutoffs for identifying normal to borderline temporal orientation. This is consistent with the results of previous investigations that used the TOS as part a brief screening battery to differentiate controls from patients with AD [3] or clinical referrals representing a wide variety of common etiologies of dementia [22]. The TOS error scores considered "normal" and "borderline" in the present analysis are not etched in stone and may fail to provide optimal detection of disorientation in some clinical situations. Therefore, it has been suggested that an error score ≥6 be utilized in order to reduce the commission of false positive errors during mental status assessment [23]. When the proposed cutoff was applied to the present TOS error scores, the result was a slight decline in Sn to temporal disorientation when differentiating controls from patients with PD (Sn=15.90) and those with AD (Sn=70.53). Since all three cutoffs resulted in excellent Sp (99.00), it appears that the Benton et al. interpretive approach is appropriate for most clinical applications.

Sn and Sp are group statistics and are helpful in deciding whether or not to use a test (e.g., TOS) for clinical assessment. However, once a TOS has been administered and scored the Positive Predictive Value (PPV) and Negative Predictive Value (NPV) associated with the score become the primary concern [24]. These values indicate the probabilities that the individual is either disoriented (PPV) or oriented (NPV) for time. The PPVs in the present study were consistently excellent and suggested that when the individual exceeded either of the above cutoffs (≥3 or ≥4 errors), the probability was extremely high that temporal disorientation was present in the context of PD or AD. However, the NPVs based on comparisons of controls with the combined patient sample and controls with the PD sample were relatively poor. Thus, normal and borderline TOS scores do not rule out the presence of marked memory and/or cognitive deficits, including problems with time orientation. In these situations it appears that the TOS is more effective in identifying the occurrence of temporal disorientation than in determining the absence of the condition. Conversely, comparison of controls and patients with AD yielded a good NPV along with an excellent PPV. One can be confident that if a patient with AD exceeds the TOS cutoffs, time disorientation is present whereas a normal score reflects only a reasonable probability that time orientation is intact. Because PPV and NPV are influenced by the base rate of the target disorder in the population under study, the present findings may not generalize to situations where the base rates vary markedly from those reported above. In situations where the disorder of interest has a high base rate the PPV will tend to be high

and NPV low; when the prevalence of the disorder in a population is low the PPV will decrease and NPV will increase. Table 2 illustrates that as the base rate decreases the NPV of the TOS score increases. Finally, Streiner [25] offered the following suggestions to keep in mind when using a test score to identify a symptom or condition: a) when the base rate of the symptom/condition is low, use the test scores to rule out the symptom/condition of interest and b) when the base rate is high use the test score to rule in the symptom/condition of interest.

Results of this investigation support the clinical utility of the TOS for reflecting abnormal mental decline in patients with PD, and especially in those with AD [26]. They also reinforce the fact that temporal disorientation is not part of the normal aging process [4] even thought is commonly seen in delirium, a variety of dementia syndromes, and in the very early stages of AD. It is hoped that future investigations will collect temporal disorientation base rates in other clinical groups such as patients with Huntington's disease and those with frontotemporal dementia. It may also be informative in future investigations to determine if the frequency and intensity of temporal disorientation differs across ethnicities, educational levels, gender, and the individual's degree of acculturation to American society [27]. The present sample was predominately Caucasian and generally well-educated. This fact may limit the generalizability of the findings to ethnically diverse populations and to those with less than a high school diploma. The present study and that of Benton et al. [4] did not find meaningful associations between TOS scores and educational attainment. However, one study suggested that responses to the TOS need to be interpreted differently for residents of New Jersey with ≤12 years of formal schooling and those with some college training [19]. Another limitation is the fact that the data utilized in this study came from an archival source. It would have been ideal to examine individual items from the TOS, but this was not possible because only the composite score was recorded for each participant.

References

1. Engelhart CI, Eisenstein N (1996) Determination of closed ward placement for chronic geropsychiatric patients: cognitive and behavioral factors. J Nerv Ment Dis 184: 190-191.
2. Jones RD, Tranel D, Benton A, Paulsen J (1992) Differentiating dementia from "pseudodementia" early in the clinical course: Utility of neuropsychological tests. Neurology 13-21.
3. Solomon PR, Pendlebury WW (1998) Recognition of Alzheimer's disease: the 7 Minute Screen. Fam Med 30: 265-271.
4. Benton AL, Eslinger PJ, Damasio AR (1981) Normative observations on neuropsychological test performances in old age. J Clin Neuropsychol 3: 33-42.
5. Jefferson AL, Costentino SA, Ball SK, Bogdanoff B, Leopold N, et al. (2002) Errors predicted on the Mini-Mental Status Examination and neuropsychological test performance in Alzheimer's disease, ischemic vascular dementia, and Parkinson's disease. Journal of Neuropsychiatry and Clinical Neuroscience 1: 311-320.
6. Varney NR, Shepherd JS (1991) Predicting short-term memory on the basis of temporal orientation. Neuropsychology 13-16.
7. O'Keeffe E, Mukhtar O, O'Keeffe ST (2011) Orientation to time as a guide to the presence and severity of cognitive impairment in older hospital patients. J Neurol Neurosurg Psychiatry 82: 500-504.
8. Ryan JJ, Glass LA, Bartels JM, Bergner CM, Paolo AM (2009) Predicting neuropsychological test performance on the basis of temporal orientation. Neuropsychol Dev Cogn B Aging Neuropsychol Cogn 16: 330-337.
9. Sota TL, Heinrichs RW (2003) Sex differences in verbal memory in schizophrenia patients treated with "typical" neuroleptics. Schizophr Res 62: 175-182.
10. Adult Version. San Antonio, TX: Psychological Corporation.
11. Wechsler D (1987) Wechsler Memory Scale? New York: Psychological Corporation.
12. Benton AL (1968) Differential behavioral effects in frontal lobe disease. Neuropsychologia 53-60.
13. Benton AL, Vanallen MW, Fogel ML (1964) Temporal Orientation In Cerebral Disease. J Nerv Ment Dis 139: 110-119.
14. Damasceno BP (1996) Time perception as a complex functional system: neuropsychological approach. Int J Neurosci 85: 237-262.
15. Giannakopoulos P, Gold G, Duc M, Michel JP, Hof PR, et al. (2000) Neural substrates of spatial and temporal disorientation in Alzheimer's disease. Acta Neuropathol 100: 189-195.
16. Mattis S (1988) Dementia Rating Scale (DRS). Odessa, FL: Psychological Assessment Resources.
17. McKhann G, Drachman D, Folstein M, Katzman R, Price D, et al. (1984) Clinical diagnosis of Alzheimer's disease: report of the NINCDS-ADRDA Work Group under the auspices of Department of Health and Human Services Task Force on Alzheimer's Disease. Neurology 34: 939-944.
18. Hughes CP, Berg L, Danziger WL, et al. (1982) A new clinical scale for the staging of dementia. British Journal of Psychiatry 140: 566-572.
19. Kington J, Stewart R (2011) Temporal orientation in a national community sample of older people. Int J Geriatr Psychiatry 26: 144-149.
20. Natelson BH, Haupt EJ, Fleischer EJ, Grey L (1979) Temporal orientation and education. A direct relationship in normal people. Arch Neurol 36: 444-446.
21. Levin HS, Benton AL (1975) Temporal orientation in patients with brain disease. Appl Neurophysiol 38: 56-60.
22. Liebaria G, Pagonabrraga J, Kulisevsky J, Garcia-Sanchez C, Pascual-Sedano B, et al. (2008) Cutt-off of the Mattis Dementia Raing Scale for screening dementia in Parkinson's disease. Movement Disorders 2: 1546-1550.
23. Eslinger PJ, Damasio AR, Benton AL, Van Allen M (1985) Neuropsychologic detection of abnormal mental decline in older persons. JAMA 253: 670-674.
24. Lezak, MD, Loring, DW (2004) Neuropsychological assessment (Fourth Edition). New York: Oxford.
25. Smith GE, Cerhan JH, Ivnik RJ (2003) Diagnostic validity. In D. S. Tulsky et al. (Eds.). Clinical interpretation of the WAIS? III and WMS? III: 273-301.
26. Streiner DL (2003) Diagnosing tests: using and misusing diagnostic and screening tests. J Pers Assess 81: 209-219.
27. Solomon PR, Hirschoff A, Kelly B, Relin M, Brush M, et al. (1998) A 7 minute neurocognitive screening battery highly sensitive to Alzheimer's disease. Arch Neurol 55: 349-355.