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Marlyn Colon

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How Contrast Sensitivity Affects Daily Living Skills in Alzheimer’s Disease Patients

MARLYN COLON

Alzheimer’s disease (AD) is a progressive brain disorder that gradually destroys an individual’s mental functioning and social capabilities, including the ability to carry out everyday activities. Although memory deficits affect AD patients’ ability to perform these activities, research suggests that visual perception impairments also contribute. One impaired visual perception ability, contrast sensitivity, enables one to distinguish an object from its immediate surroundings. The present project measured contrast sensitivity in a real-world task by having AD patients find a pill of various shades of gray on a tiled background. Results were compared to young and elderly control participants. Participants also filled out a questionnaire examining activities of daily living (ADLs). Results demonstrated that impairments in contrast sensitivity were observed both as a function of normal aging and as a result of AD. Performance correlated with the ADLs of household care and travel for both groups. Increasing contrast in environmental settings may aid these individuals, especially AD patients, in living a more independent lifestyle.

Research Question
How does the manipulation of contrast affect Alzheimer’s disease patients’ ability to detect a pill on a white-tiled surface? Do these findings relate to problems in activities of daily living experienced by these patients?

Introduction

General Introduction. Alzheimer’s disease (AD) is a progressive brain disorder that gradually destroys an individual’s mental functioning and social capabilities, including memory, reasoning, decision-making, communication, and the ability to carry out everyday activities. According to the Alzheimer’s Association, AD affects approximately 4.5 million Americans annually. By the year 2050, this number is expected to increase to 11.3 to 16 million. Although memory deficits are a primary symptom of AD and the one most often researched, other abilities including those in visual perception are also impaired (Cronin-Golomb, A., 1995; Gilmore, G. C., Cronin-Golomb, A., Neargarder, S., & Morrison, S. R. 2005; Mendola, J. D., Cronin-Golomb, A., Corkin, S. & Growdon, J. H., 1995; Neargarder, S. 2005). One impaired ability known as contrast sensitivity has direct implications for the ability of AD patients to carry out everyday activities. Contrast sensitivity is defined as the smallest difference in intensity that a person can resolve between an object and its immediate surroundings. For example, what shade of gray would an
Background. A number of research studies have identified contrast sensitivity impairments in AD patients (Cronin Golomb, Growden, & Corkin, 1995; Cronin-Golomb, Gilmore, Neargarder, Morrison, & Laudee, 2007). Results from these studies were obtained in a laboratory setting using a series of clinical vision charts such as the Vistech and the FACT (Functional Acuity Contrast Test). These tests allow one to measure contrast deficits across a range of different spatial frequencies. Results show that AD patients exhibit contrast deficits across all levels of spatial frequency. This would potentially make it difficult for patients to distinguish between people, places, and things in a real-world environment. Although research has demonstrated that deficits measured in a laboratory setting using vision charts relate to deficits in the real-world, we have no direct measure of contrast sensitivity in real-world tasks. For example, although we may know that patients will do better in a high-contrast task (pouring milk into a black mug) than a low-contrast task (pouring milk into a white mug), we do not know what the contrast between the two items (milk and cup) needs to be in order for the patient to succeed at this task.

Present Project. The present project aimed to measure contrast sensitivity in a real-world task by having AD patients find pills of various shades of gray on a tiled background (simulating a white-tiled floor). This method allowed us to find the exact contrast the pill needs to be to the background in order for patients to be able to successfully find the pill. These findings were then compared to a questionnaire that measured general activities of daily living. This enabled us to compare laboratory based tests to everyday functioning. The results from this study aim to increase the functional independence of AD patients, both in the home environment and nursing home facilities. This increase in independence can result in reducing health care costs and increase the overall well-being of patients.

Methodology
Participants. This study consisted of 15 patients with AD, 13 healthy elderly control participants (EC) and 25 young participants (YC). EC participants were community volunteers and AD patients were recruited from Community Family Incorporated (AD day programs) located in Lowell and Medford, Massachusetts. Participants were matched on education, age, and near acuity.

Materials and Procedures. Materials consisted of a questionnaire that measured activities of daily living, and four conditions that measured the ability of participants to identify a pill of varying contrast levels on a tiled surface. Each measure is described in detail below.

Questionnaire. The Activities of Daily Living Scale (ADL) was given to each participant and his/her caregiver or informant. The ADL scale consists of 28 items that cover areas of self-care, household care, employment/recreation, shopping/money, and travel/communication.

Pill Study. The pill study consisted of four different conditions. Two of these conditions were naturalistic and two were computerized. When conducting research with patient populations it is often the case that researchers use computerized stimuli to measure abilities and then generalize these findings to the real-world. It is unclear, however, whether one can make direct statements about real-world abilities based on these artificial measurements. One goal of this study was to compare performance on computerized assessments to performance on comparable naturalistic assessments. As such, two naturalistic conditions were developed. The first used a real pill on a real background (N1: completely naturalistic), while the second used a printed pill on a real background (N2: partially naturalistic). The contrast of the pill to the background was identical in both conditions. The first computerized condition (C1) was perceptually identical to condition N2 (contrast values are identical, luminance values are different), except it was presented on a computer, whereas the second computerized condition (C2) was physically similar to condition N2 (both contrast and luminance values were similar) but was perceptually different than N2. The rationale for including these four conditions was to aid in differentiating the factors that contribute to the ability of an Alzheimer’s patient to detect an object of varying shades of contrast on an identified surface and to determine whether performance differed between computerized and naturalistic assessments. Each of the four conditions used seven pills of varying shades measured using a Minolta CS-100 photometer. Shade one was the lightest and the hardest to see and shade seven was the darkest and the easiest to see. The luminance of each of the seven pills was measured against the luminance of the tiled background to result in seven different contrast levels per condition. For all conditions, the contrast of the pill relative to the background ranged from 1.2% to 6.6%.

Naturalistic Version 1 (real pill; N1). In this version, pills were created to emulate a 10 mg donepezil HCL tablet. This drug is commonly prescribed to individuals with AD. Pills were presented on an 8.5” x 11” piece of paper printed with a six by six grid comprised of 36 squares meant to represent a tiled electrical outlet need to be before a patient could detect it against a white wall? Research shows that deficits in contrast sensitivity directly affect everyday activities such as food and liquid intake (Dunne, Neargarder, Cipolloni, & Cronin-Golomb, 2004) object detection (Neargarder & Cronin-Golomb, 2005), and face discrimination (Cronin-Golomb, Cronin Golomb, Dunne, Brown, & Jain, 2000).
background. Each of the seven pills was presented randomly four times per quadrant for a total of 112 trials. A white screen was used to conceal the placement of the pill from the participant before each trial. Participants were instructed to locate and touch the pill as quickly as possible. Reaction times were recorded.

Naturalistic Version 2 (printed pill: N2). In this version, pills were printed onto a tiled background; real pills were not used. The background from N1 remained the same. A photometer was used to verify the contrast values. Trials were bound using 3 binders and were presented to participants by flipping the pages like a book. Like in N1, 112 trials were presented and reaction times were recorded.

Computerized Version 1 (high luminance: C1). Using Adobe Photoshop, trials perceptually similar to both N1 and N2 were created. The same counterbalancing and randomization from conditions N1 and N2 were used and presented on a calibrated touch screen monitor using Superlab 4.0. This program recorded the area touched by the participant and reaction times.

Computerized Version 2 (low luminance: C2). A different computerized version was created with the luminance and contrast values similar to the naturalistic versions. Again contrast values of the pills were consistent with those used in C1. Randomization, counterbalancing and presentation were also consistent with C1. Reaction time was measured using Superlab 4.0.

Results

Reaction time data were analyzed by using mixed design analyses of variance followed by a priori comparisons using an adjusted alpha level for each condition. Correlational analyses were also performed between the pill reaction time data and the ADL scale. Any and all violations regarding the use of parametric statistics were properly addressed. For ease of presentation, results are displayed graphically using symbols to indicate significant differences between groups. Results of all of the individual analyses are not listed.

Naturalistic Version 1 (real pill: N1). For normal aging (YCs versus ECs), there were no significant differences in reaction time across the seven contrast levels. However, AD patients differed from EC participants at all contrast levels (see Figure 1).

Naturalistic Version 2 (printed pill: N2). For normal aging (YCs versus ECs), there were significant differences in slower latency times in contrast levels two through six. However, AD participants compared to ECs showed significant differences for levels two through five, no differences were noted at levels six or seven (see Figure 2).

Computerized Version 1 (high luminance: C1). For normal aging (YCs versus ECs), there were significant differences in reaction time across contrast levels two through seven. AD patients when compared to ECs did not show significant differences across any of the seven contrast levels (see Figure 3).

Computerized Version 2 (low luminance: C2). For normal aging (YCs versus ECs), there were differences in reaction time across contrast levels three through seven. When AD patients were compared to ECs there were differences across contrast levels three through seven. (see Figure 4).

Everyday Functioning Questionnaire. For both AD and EC groups, significant positive correlations were noted between RT performance and the ADLs of household care and travel.

Discussion

In regards to normal aging, results indicated that EC performance when compared to YC performance was significantly slower for the printed pill (N2), computerized high (C1), and computerized low (C2) conditions. Most likely, the additive effect of decreased contrast across conditions and low-luminance stimuli resulted in poorer performance; the EC had more difficulty seeing the pills. Both YC and EC performance was similar on the Real Pill (N1) condition; this suggests that the cue of depth and the naturalism of the stimuli enhanced the detection of the object despite low luminance. An implication of the Naturalistic 3-D Pill appears to be that for a nearby and non-cultured real world assessment, depth is a strong indicator of performance and that in some cases, if depth is present, contrast deficits may be minimized. These findings were also related to the ADLs of household care and travel. Taken together, these results support the findings that EC individuals demonstrate impairments in contrast sensitivity and that these impairments directly relate to real-world functioning.

When compared to the EC group, individuals with AD exhibited slower latency times on all pill conditions except for the Computer High-Luminance condition (C1). The lack of a significant difference between EC and AD individuals for this condition was most likely due to the added benefit of increased luminance provided by the computer monitor. Though they did not make any errors on the Naturalistic 3-Dimensional Pill (N1), they were slower than the EC group at all contrast levels. Differences in performance were also observed for the Computer Low-Luminance Condition (C2). In general, the AD group exhibited slower reaction times than the EC group.
across contrast levels most likely due to the low luminance and contrast levels of the stimuli.

An interesting pattern emerged for the Naturalistic Printed-Pill condition (N2). Here, differences between the AD and EC participants were observed at the lower contrast levels but not the higher ones (contrast levels 6 and 7). At these levels, the AD and EC participants exhibited similar reaction times. These results suggest that in certain conditions, if the contrast of the stimuli is high enough, performance differences between groups disappear. Overall, findings suggest that by increasing the luminance and contrast of stimuli, one can potentially compensate for contrast sensitivity losses noted in the AD population. Similarly to the EC group, findings were related to the ADLs of household care and travel thereby suggesting that losses in contrast sensitivity relate to everyday functioning.

These results suggest that individuals with AD exhibit contrast deficits beyond those that occur with normal aging. These deficits most likely impair their ability to function independently. In addition, results tend to differ depending on a variety of factors including the overall luminance of the stimuli used, the contrast of the stimuli when compared to a background, and whether the stimuli are presented in a naturalistic or computerized form. All of these things should be taken into account when generalizing laboratory results to real-world conditions. Finally, by examining the results of the four conditions, one can pinpoint where performance falls off for AD patients. This information can be used to create environments that help to minimize the visual deficits experienced by these patients.

Interventions to improve visual function, specifically contrast enhancement and increased luminance, may be of practical use in improving the everyday functioning of older adults. For example, it may be of use for individuals when managing their medications. If the right level of contrast is used in the environment wherein individuals with AD reside, they will be better able to detect pills on a surface which will increase medication adherence. Increasing contrast in environmental settings can aid AD patients in living a more independent lifestyle.

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Figures
For each of the figures that follow, reaction time (in log units) is plotted as a function of Michelson contrast values (also in log units). Each of the seven data points represent the mean reaction time for that contrast level. From left to right, the contrast levels are given in order ranging from contrast level 1 (the most difficult to see) to contrast level 7 (the easiest to see). Vertical bars represent the standard error of the mean for each condition. Results are plotted for the YC, EC, and AD groups. The symbol ‘†’ represents a significant difference between the YC and EC groups and the symbol ‘*’ represents a significant difference between the EC and AD groups.
References


