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ORIGINAL ARTICLE

Visual contrast enhances food and liquid intake in advanced Alzheimer's disease

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Summary *Background & aims:* Patients with severe Alzheimer's disease (AD) in long-term care have deficient contrast sensitivity and poor food and liquid intake. The present study examined how contrast manipulations affect these intake levels.

Methods: Participants were nine men with advanced AD. Independent variables were meal type (lunch and supper) and condition (baseline, intervention, and post-intervention). Dependent variables were amount of food (grams) and liquid (ounces). Data were collected for 30 days (10 days per condition) for two meals per day. White tableware was used for the baseline and post-intervention conditions, and high-contrast red tableware for the intervention condition. In a follow-up study 1 year later, other contrast conditions were examined (high-contrast blue, low-contrast red and low-contrast blue).

Results: Mean percent increase was 25% for food and 84% for liquid for the high-contrast intervention (red) versus baseline (white) condition, with 8 of 9 participants exhibiting increased intake. In the follow-up study, the high-contrast intervention (blue) resulted in significant increases in food and liquid intake; the low-contrast red and low-contrast blue interventions were ineffectual.

Conclusions: Simple environmental manipulations, such as contrast enhancement, can significantly increase food and liquid intake in frail demented patients with AD.

Introduction

Alzheimer's disease (AD) is a progressive neurodegenerative disorder characterized by impairments not only in cognition but also in physiological

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status. Significant weight loss[1] affects 40% of AD patients[2] and may arise from depression,[3] inability to attend to more than one food at a time, and the inability to eat independently.[4] One additional explanation that remains uninvestigated is vision impairments, which alone may account for up to 50% of the variance in activities of daily living (ADl) performance in the elderly[5] and cognitive deficits in AD.[5]

Patients with AD have deficient contrast sensitivity.[6,7] Without sufficient contrast, individuals may have difficulty distinguishing a plate from a table setting, food from a plate, or liquid from its container (e.g., milk from a white cup), leading to a reduction in consumption. Recent research suggests that modifications of the visual contrast environment may improve AD patients' ability to perform ADls.[8,9] Given the noted problems with weight loss in AD, we examined how contrast manipulations may affect food and liquid ingestion.

Methods

Participants

Nine men with a diagnosis of probable AD[10] had an average age of 82.7 years (72–89) and an average education of 13.3 years (12–20). Cognitive status was measured by the Mini-Mental State Exam (MMSE).[11] The average score was 2.9 (0–8; modal 0) out of a possible 30, indicating severe global impairment. We attempted to assess acuity, color discrimination, and contrast sensitivity formally but no participant was able to complete the testing. All resided in long-term care units of the Geriatric Research, Education and Clinical Center at the ENRM Veterans Affairs Medical Center (VAMC) in Bedford, Massachusetts.

The inclusion criterion was the ability to eat independently. Exclusion criteria were current diagnosis of serious chronic medical illness; uncontrolled seizures, hypertension or diabetes mellitus; and diagnosis of neurological disease other than AD.

Measures

Data were collected over three consecutive 10-day periods in order to coincide with menu changes. Independent variables were meal type (lunch and supper) and condition (baseline, intervention, and post-intervention). Dependent variables were food intake (grams) and liquid intake (ounces). Absolute weight and volume values for each individual were converted into percentages and compared across conditions.

For the first 10 days of the study (baseline), white plates, white cups (luminance 45.0 fl) and stainless-steel flatware were used as is standard for this facility. For the next 10 days (intervention), high-contrast red plates, red cups and red flatware (7.1 fl) similar in size and shape to VAMC tableware were used. The red tableware provided a maximal visual contrast to the food served at the VAMC (e.g., chicken, mashed potatoes, milk). For the last 10 days (post-intervention), the plates, cups and flatware from the baseline condition were used. There were no variations in staff, room setting, lighting, daily routine, or health status of the AD patients over the 30-day testing period.

A follow-up study 1 year later was conducted with five of the original and four new participants matched to the original group for average age (83.1), education (13.9), and MMSE scores (3.2). We followed the procedure of the first study but used high-contrast blue, low-contrast (pastel) red, and low-contrast (pastel) blue tableware (5.3, 35.5, 28.3 fl, respectively) for 10 days each, separated by 10-day periods using the white set, which was also used in the first and final periods (total 70 days).

Results

Calculation of individual and group mean percent food and liquid intake

For each contrast manipulation (high-contrast red, high-contrast blue, low-contrast red, and low-contrast blue), the amount of food and liquid consumed and the amount served were recorded each day for each individual for both lunch and supper for the baseline, intervention, and post-intervention conditions. To calculate the percent food and liquid intake for a participant for a particular condition (e.g., the high-contrast red/lunch/baseline condition), the amount of food and liquid consumed over the 10-day period were added and then divided by the total amount of food and liquid served, respectively. If the participant was served a total of 122.8 g of food over the 10-day period and consumed 87.7 of the 122.8 g, the percent food intake was 71%. Similarly, if the individual was served 80 ounces of liquid over the course of 10 days and consumed 60 of the 80 ounces, the percent liquid intake was 75%. These percentages were calculated for each individual for each condition and then averaged across all nine participants to obtain the group mean percent food and liquid intake for each condition for each contrast manipulation.

Calculation of group mean percent increase in food and liquid intake

For each contrast manipulation, a group mean percent increase in food and liquid intake was calculated by comparing the baseline and intervention conditions. This percentage was used to determine whether participants demonstrated an overall increase in their food and liquid consumption when the plates and cups were changed from white (baseline) to high- or low-contrast red or blue (intervention). Building upon the example above, for the high-contrast red/lunch/baseline condition, a given participant over a 10-day period consumed 87.7 (a) of 122.8 (b) g of food, and for the high-contrast/red/lunch intervention condition consumed 104 (c) of 112.6 (d) g. The increase in the number of grams consumed in the intervention condition was calculated using the following formula $((b \cdot c)/(b \cdot d)] - ((a \cdot d)/(b \cdot d]$. The resulting difference in grams was divided by the number of grams consumed in the baseline condition $(a \cdot d)$ yielding, in this example, a value of 0.29 or 29%. This value represents the percent increase from baseline in food intake that this participant demonstrated at lunch when the white tableware was changed to red. These percentages were calculated for each individual and then averaged across all nine participants to obtain the group mean percent increase in food and liquid intake for each contrast manipulation.

Group findings, main study

Mean percent increase was 24.6% for food and 83.7% for liquid for high-contrast intervention vs. baseline (white). A multivariate analysis of variance (MANOVA) was conducted to determine the within-subject effects of meal type (lunch and supper) and condition (baseline, intervention, and post-intervention) on the two dependent variables, food intake and liquid intake. Participants were included as a factor to account for the fact that multiple observations were obtained from each participant. A significant difference was found for condition (Wilks' $\lambda = 0.33$, $F[4,78] = 39.03$, $P = 0.00$ ($\eta^2 = 0.67$)), but not for meal type (Wilks'

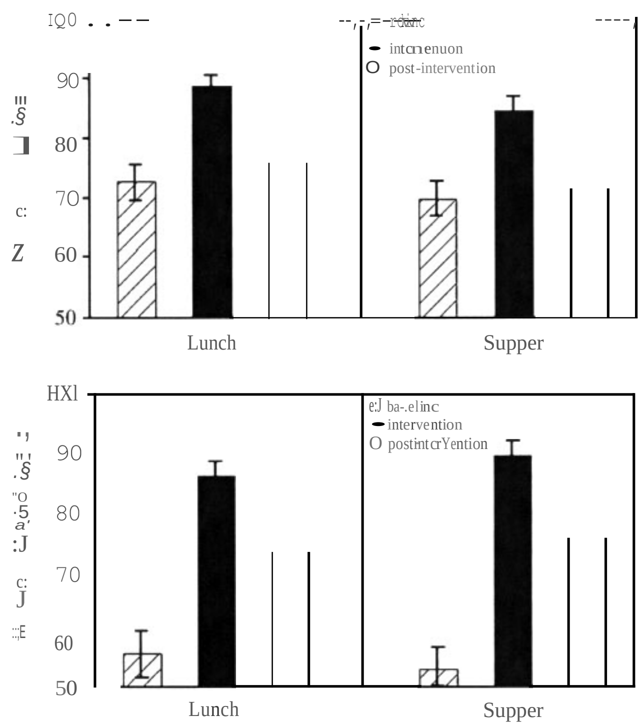

Figure 1 Group results of main study in which food and liquid intake was measured under the baseline and post-intervention condition using white background (luminance 45.0 fl) and under the intervention condition using high-contrast red background (luminance 7.1 fl). (Top) Mean percent food intake for the group is plotted as a function of the baseline, intervention, and post-intervention conditions for lunch (left) and supper (right). Error bars represent the standard error of the mean for each condition. (Bottom) Mean percent liquid intake for the group is plotted as a function of the baseline, intervention, and post-intervention conditions for lunch (left) and supper (right). Error bars represent the standard error of the mean for each condition.

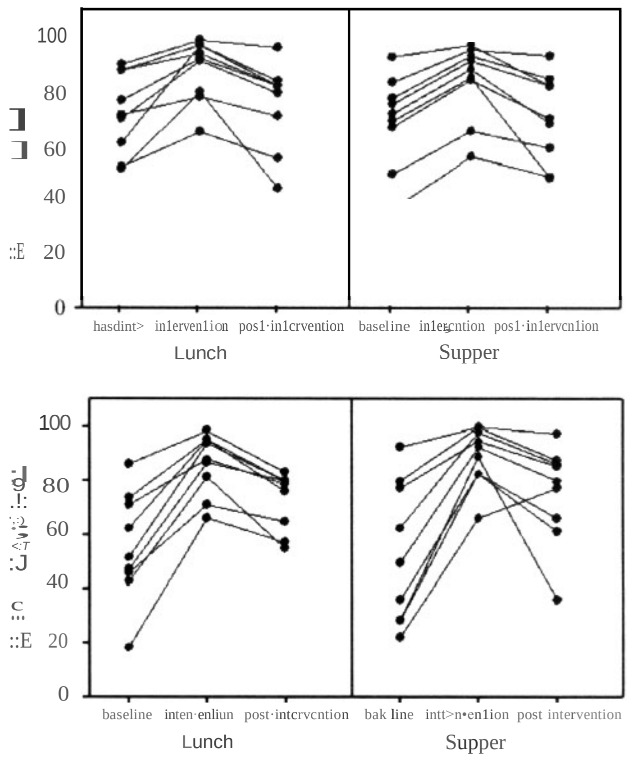

Figure 2 Individual results of the main study. (Top) Individual food intake (in grams) is shown, averaged across days for each condition. For each participant, mean percent food intake is plotted as a function of the baseline, intervention, and post-intervention conditions for lunch (left) and supper (right). (Bottom) Individual liquid intake (in ounces) is shown, averaged across days for each condition. For each participant, mean percent liquid intake is plotted as a function of the baseline, intervention, and post-intervention conditions for lunch (left) and supper (right).

$A = 0.94$, $F[2, 80] = 2.63$, $P = 0.08$) or the interaction (Wilks' $A = 0.98$, $F[4, 78] = 0.40$, $P = 0.81$).

Analyses of variances (ANOVAs) on each dependent variable were conducted as follow-up tests to the MANOVA, with alpha set at 0.025 (Bonferroni method). The Huynh-Feldt correction was applied when violations of the sphericity assumption occurred. For food intake, a significant difference was noted for condition ($F[2, 153] = 29.27$, $P = 0.001$ ($\eta^2 = 0.27$]), but not for meal type ($F[1, 81] = 4.41$, $P = 0.04$) or the interaction ($F[2, 162] = 0.10$, $P = 0.90$). To further examine the main effect of condition, post hoc analyses were conducted with alpha set at 0.008 (0.025/3). Results revealed significant differences between baseline (mean 71.2%, SD 26.8%) and intervention (mean 86.7%, SD 19.3%; $P = 0.001$) and between intervention and post-intervention (mean 73.5%, SD 24.1%; $P = 0.001$; Fig. 1, top). There was a 24.7% increase in food intake at lunch (comparing intervention to baseline) and a 24.5% increase at supper (mean 24.6% across meal types).

For liquid intake, there was a significant effect of condition ($F[2, 162] = 59.22$, $P = 0.001$ ($\eta^2 = 0.42$]) but not meal type ($F[1, 81] = 0.22$, $P = 0.64$) or the interaction ($F[2, 161] = 0.72$, $P = 49$). Post hoc analyses revealed significant differences between baseline (mean 54.4%, SD 36.6%) and intervention (mean 87.7%, SD 22.1%; $P = 0.001$), between intervention and post-intervention (mean 74.1%, SD 31.2%; $P = 0.001$), and between baseline and post-intervention ($P = 0.001$; Fig. 1, bottom). There was a 61.5% increase in liquid intake at lunch and a 105.8% increase at supper (mean 83.7% across meal types).

Individual findings

Eight of nine participants exhibited at least a 10% increase in food and liquid intake at intervention relative to baseline and to post-intervention at both lunch and supper (Fig. 2). The poorer ingestors appeared to benefit the most, possibly because the better ingestors had less room for improvement.

Follow-up study

As in the main study, we found a significant increase in food and liquid intake during high-contrast intervention and reversion to baseline level at post-intervention. Neither of the low-contrast

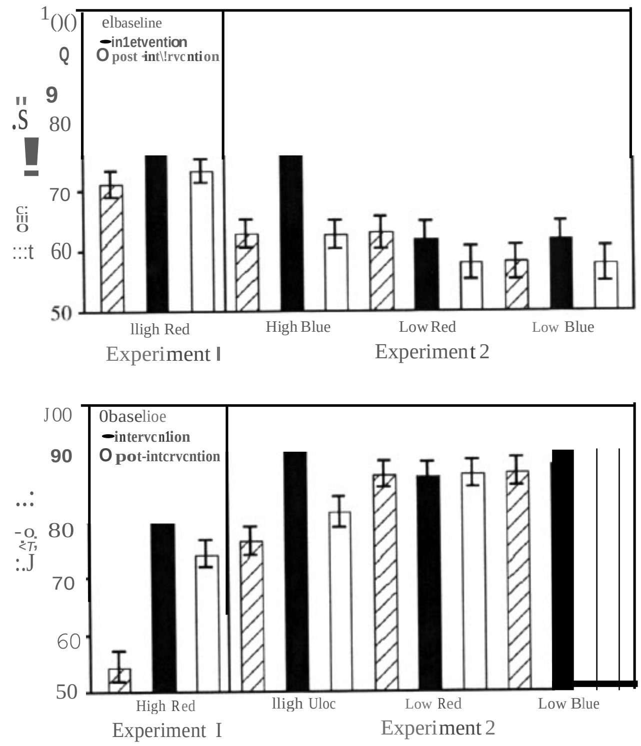

Figure 3 Results of follow-up study in which intake was measured under the baseline and post-intervention conditions using a white setting and under the intervention conditions using high-contrast blue (n = 9), low-contrast red (n = 7), and low-contrast blue settings (n = 6). Numbers reflect attrition over the 70-day study (death of three participants). A single white run served as the baseline for one intervention and as the post-intervention condition for another intervention (baseline/post-intervention differences reflect different sample sizes in the various contrast conditions). Data from lunch and supper are combined. For comparison purposes, the results of the main study for food intake are depicted at the far left of the figure. High red: high-contrast red condition; high blue: high-contrast blue; low red: low-contrast red; low blue: low-contrast blue. (Top) Greater food ingestion at intervention than at baseline or post-intervention (10% or more) was seen in 8/9 participants for the high red condition, 6/9 for high blue, 2/7 for low red, and 3/6 for low blue. (Bottom) Greater liquid ingestion at intervention than at baseline or post-intervention (10% or more) was seen in 8/9 participants for the high red condition, 5/9 for high blue, 1/7 for low red, and 0/6 for low blue.

interventions resulted in significant change in intake levels of food or liquid (Fig. 3).

The mean percent increase in food intake was 25.1% for high-contrast blue, 0% for low-contrast red (−3.1%), and 5.2% for low-contrast blue interventions (all interventions relative to baseline). Mean percent food intake for the high-contrast blue condition was 63% baseline (SD 29%); 78% intervention (SD 25%); 63% post-intervention (SD 29%); for the low-contrast red condition, 63% baseline (SD 29%); 62% intervention (SD 29%); 58% post-intervention (SD 29%); for the low-contrast blue condition, 58% baseline (SD 28%); 62% intervention (SD 30%); 58% post-intervention (SD 29%). For all conditions, there was significantly greater food intake at lunch than at supper. This result was the same as in the main study (Fig. 1).

Greater food ingestion at intervention than at baseline or post-intervention (10% or more) was seen in 6 of 9 participants for the high-contrast blue condition, 2 of 7 for the low-contrast red condition, and 3 of 6 for the low-contrast blue condition.

The mean percent increase in liquid intake was 29.8% for high-contrast blue, 0.4% for low-contrast red, and 0.3% for low-contrast blue interventions (all interventions relative to baseline, which rose across conditions). Mean percent liquid intake for the high-contrast blue condition was 77% baseline (SD 34%); 92% intervention (SD 21%); 81% post-intervention (SD 33%); for the low-contrast red condition, 88% baseline (SD 25%); 88% intervention (SD 25%); 88% post-intervention (SD 26%); for the low-contrast blue condition, 88% baseline (SD 25%); 90% intervention (SD 22%); 92% post-intervention (SD 20%). For all conditions except low-contrast blue, for which liquid intake was the same for lunch and supper, there was significantly greater liquid intake at lunch than at supper. This result was the same as in the main study (Fig. 1).

Greater liquid ingestion at intervention than at baseline or post-intervention (10% or more) was seen in 5 of 9 participants for the high-contrast blue condition, 1 of 7 for the low-contrast red condition, and 0 of 6 for the low-contrast blue condition.

Discussion

Significant increases in food and liquid intake were observed with high-contrast intervention compared to baseline in our AD participants. Arguing against a general effect of novelty is the return to baseline at post-intervention during the high-contrast runs and the lack of effect of intervention during low-contrast runs. Intake levels changed as a function of contrast levels of the tableware and hence as a function of perceptual salience. Hue itself was relatively unimportant.

Although our participants' severe dementia precluded formal contrast sensitivity assessment, many AD patients of all levels of dementia severity exhibit deficits in contrast sensitivity beyond normal age-related loss.[6,7,11,12] Contrast sensitivity loss at some spatial frequencies is significantly correlated with dementia severity.[12] In light of the advanced age and AD diagnosis of our participants, it is likely that they had deficient contrast sensitivity.

The results of this study are encouraging. They indicate that simple environmental manipulations, such as contrast enhancement, can significantly increase food and liquid consumption in severely demented AD patients in long-term care facilities. Although the number of participants was small, this robust effect that was reliable at 1-year study replication suggests that clinicians and caregivers should consider implementing such interventions to increase food and liquid intake in this population.

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