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Multisensory Stimulation to Improve Functional Performance in Moderate-to-Severe Dementia—Interim Results

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Abstract
Dementia is a growing problem worldwide and interventions to effectively manage and promote function are urgently required. Multisensory environments (MSEs) have been used extensively with people with dementia; however, no studies have been conducted to explore the efficacy of sensory stimulation on functional performance. This study explores to what extent multisensory stimulation influences functional performance in people with moderate-to-severe dementia using an MSE compared with a control activity. Thirty participants with moderate-to-severe dementia were recruited from the South of England. Following baseline assessment and design of a bespoke intervention, each participant attended their allocated intervention (3 × week, for 4 weeks). Assessments were carried out pre and postsession using the Assessment of Motor and Process Skills. Results indicate significant improvement in functional performance in both the MSE and the control activity. Findings support the use of MSEs as a strategy for enhancing functional performance in dementia.

Keywords
multisensory environments, sensory stimulation, dementia, activity

Introduction

Dementia is an important health problem of increasing magnitude.[1] People with these progressive disorders present with discrete deficits in cognition, mood, behavior, and functional ability leading to difficulty with participation in activity.[2,3] Although a number of nonpharmacological interventions, such as Reminiscence Therapy, have been developed to manage some of these deficits, clinicians report difficulties in their use.[4] Failure to provide suitable activity has been associated with individuals enduring long periods of chair sitting, punctuated by pacing and personal care experiences.[5] Conceivably, nonpharamocological interventions fail due to the effort required by the facilitator to enagage the person with dementia in an activity that is suitable.[6] Despite the difficulties in facilitating activity highlighted above, there is a widely held assumption that it is a worthwhile endeavor and important for maintaining well-being for this population.[7-9]

The National Framework for Older People,[10] like other international strategies,[11] outlines a 10-year programme to improve services for older people. This programme takes a positive view of old age, encouraging the development and evaluation of innovative practice. One intervention that could be considered innovative in relation to dementia care is the use of multisensory environments (MSE). Multisensory environments contain a variety of equipment to stimulate the senses providing an activity-based intervention which is argued to address imbalances in sensory stimulation by pacing sensory-stimulating activity with sensory-calming activity. It is this sensory pacing that may assist people with dementia in coping with confusion and behavior changes that are consequences of progressive, debilitating illness.[12-14]

As a treatment strategy, MSEs have been available for people with dementia for the last 20 years, be it in an unstructured format. However, its value for people with dementia has yet to be established[15] and research into its efficacy is limited. This study aimed to address this gap in knowledge by exploring to what extent the sensory components of MSEs influence functional performance in people with moderate-to-severe

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dementia. Multisensory environments were compared with a control intervention, gardening, selected using activity analysis, to provide comparable multisensory stimulation but to differ in the degree to which the activity is structured and the more subtle mode of multisensory stimulation. Both interventions were well-established activities used regularly by the participants.

Method

Research Design

A randomized single-blind design using stratified randomization was used to evaluate the effect of the interventions on functional performance.

This study was approved by Local Research Ethics Committees.

Sample Size

Sample size was calculated using 2 sources of data. First, as the study was to be powered to find an effect of either the MSE or the control group, the baseline mean (M) and standard deviation (SD) of all participants from a completed pilot were used to calculate a sample size sufficient to detect a 0.5 change in the primary outcome. Second, the predicted sample sizes were compared with calculations from other studies using the Assessment of Motor and Process Skills (AMPS).[16-18] A conservative sample size estimation suggested that 25 participants per group (total $n = 50$) would be required for a definitive finding.

Participants

Participants were selected from people with a clinical diagnosis of dementia with a Standardized Mini-Mental State Examination (SMMSE) score less than 17 who were resident on wards or nursing homes within the South of England.[19]

Standardization of the Interventions

Each intervention was standardized according to protocols identified by the PAL Instrument for Occupational Profiling (PAL)[20] and the Adult Sensory Profile (ASP)[21] in order to describe the presentation of the equipment and the structure and timing of the intervention given the participant's level of functioning. These protocols ensured the interventions were structured to meet individual sensory needs to increase the chance of successful engagement and to ensure that application of the interventions was standardized between participants. The PAL uses a framework with differing levels of activity-based care for people with dementia. The ASP identifies the stable and enduring sensory processing preferences of an individual.

Intervention Delivery

The MSE included bubble tubes, optic fibres, music of choice, scents, citrus fruits, and sherbert. This activity was run in a quiet area or purpose-built MSE.

The control activity (gardening) was run in a quiet room using gardening activities that could be completed indoors. Participants were asked about the type of gardening activity they would like to do. For those who were unable to make a choice, carers were consulted.

Both interventions were implemented as indicated by results of the PAL and the ASP.

Assessment Tools

Baseline assessments were conducted to ascertain key participant characteristics including level of dementia and functional activity. The SMMSE[19] and the Gottfries Bråne Steen scale (GBS)[22] were used to identify degree of physical inactivity, intellectual impairment, emotional and cognitive impairment. The AMPS[23] was used to identify a baseline of functional performance. Furthermore, as the primary outcome measure, the AMPS was used pre and postsession for each of the 12 sessions, in order to monitor changes in functional performance.

Procedure

Assessments were completed by the blinded assessor (LC) and participants were randomized to either the MSE or the control intervention. The participant was taken by their key-worker to their allocated intervention. The key-worker facilitated the activity as directed by the PAL and ASP then returned the participant to the assessor for postsession assessment.

Statistical Analysis

Data were analyzed according to intention-to-treat. Given a number of changes in individual health status and service restructuring, not all participants completed the planned 12 sessions. Analysis, therefore, considered 2 endpoints (a) last treatment session (LTS) and (b) after 6 sessions as 70% of participants made it to this point, after which participant numbers dropped significantly.

Primary analysis compared the descriptive variables (age, gender, sensory profile) and baseline variables (SMMSE and GBS) using χ^2 or Fisher Exact statistic. Baseline dependent variables (AMPS) were explored using Student Independent *t* tests. Analysis of dependent variables from baseline to LTS and baseline to session 6 was conducted using a 2-way analysis of variance (ANOVA), of time (BASELINE/LTS) by group (MSE/control) for each of the AMPS motor and process scores. As individual differences may have been achieved pre and postsession or the effect of the intervention may be short-lived, sessional analysis was carried out using mean δ scores for each session. Finally, a *t*-test was used to explore group differences in the percentage of sessions for which an improvement was made.

Results

Fifty-four participants were identified for inclusion in the study; however, only 30 participants were actually enrolled.

Table 1. Demographic and Clinical Characteristics

M (SD), range	MSE (n = 17)	Control (n = 13)
Age (years)	80.00 (7.2), 60-91	83.08 (6), 70-95
Gender (Male: Female)	7:10	10:3
Recruitment site		
Day hospital	4 (23%)	4 (31%)
Continuing care	6 (35%)	4 (31%)
Nursing home	2 (12%)	1 (8%)
Assessment ward	5 (29%)	4 (31%)
Diagnosis		
Alzheimer's disease	13 (77%)	9 (69%)
Vascular dementia	4 (23%)	3 (23%)
Lewy body disease	0 (0%)	1 (8%)
SMMSE	9.53 (5.08), 1-17	10.54 (4.61), 4-17
Sensory profile		
Low registration	6 (35%)	4 (31%)
Sensation seeking	8 (47%)	3 (23%)
Sensory sensitive	1 (6%)	4 (31%)
Sensation avoiding	2 (12%)	2 (15%)
PAL		
Planned level	3 (18%)	4 (31%)
Exploratory level	5 (29%)	4 (31%)
Sensory level	2 (12%)	4 (31%)
Reflex level	7 (41%)	1 (8%)
GBS		
Intellect	43.88 (12.73), 26-62	33.77 (15.49), 11-63
Emotional	7.12 (4.19), 1-17	5.15 (4.99), 0-17
ADL	18.82 (12.19), 2-40	14.23 (10.86), 0-36

Abbreviations: SMMSE, standardized mini-mental state examination (<14 = moderate to severe dementia); PAL, pool activity levels; GBS, gottfries bråne steen scale; ADL, activities of daily living-higher score, more severe impairment.

Seventeen participants were randomized to receive the MSE intervention and 13 to receive the control intervention. The number of participants available during the recruitment period was reduced due to changes in service provision and participants' suitability for inclusion. Due to the number of participants recruited, these finding will be considered as interim results.

There were no significant differences between the 2 intervention groups in relation to age, gender, recruitment site, or diagnosis distribution, in SMMSE, PAL, GBS, or in AMPS scores (Table 1).

Analysis was completed for baseline (session 1) to LTS. Analysis for AMPS motor scores revealed a significant main effect of interventions in that both the MSE group and control group improved in motor skills, $F(1, 27) = 8.63$, $P = .007$. Moreover, there was no significant interaction, $F < 1$, such that the intervention groups were not affected differently, as confirmed by absence of a main effect of group, $F < 1$. Analysis for AMPS process scores also revealed a significant main effect of intervention for both groups, $F(1, 27) = 4.56$, $P = .042$, no significant interaction, $F < 1$, and no main effect of group, $F < 1$. Thus, both interventions (MSE and the control, gardening) led to significant improvements in motor and process scores.

The number of participants who improved from baseline (session 1) to session 6 on the AMPS motor assessment revealed a significant effect of intervention across MSE and gardening groups, $F(1, 19) = 9.67$, $P < .006$, but not of group (intervention r control), $F < 1$. However, a significant interaction revealed a different pattern of change in performance for the MSE and control groups, $F(1, 19) = 7.07$, $P = .016$. Post hoc comparisons revealed significant improvement in MSE group from baseline to session 6, $t(11) = -5.8$, $P < .001$, baseline M 0.3, SD 1.2, session 6 M 1.3, SD 1.1, Bonferroni adjusted, but not for the control condition, $t(8) = -0.2$, $P = .816$, baseline M 0.5, SD 0.9, session 6 M 0.9, SD 1.5. Furthermore, there were no differences between groups at baseline, $t(28) = -0.5$, $P = .641$ or at session 6, $t(19) = 0.8$, $P = .443$.

AQ 1

This analysis was repeated for AMPS process scores. There was no significant effect of intervention, $F(1, 19) = 3.76$, $P = .069$. There was a significant interaction, $F(1, 19) = 11.90$, $P < .003$, but there was no main effect of group, $F < 1$. The interaction term was decomposed and revealed a significant effect of intervention in the MSE group, $t(11) = -3.7$, $P = .004$, even adjusting for multiple testing, but not in the control (gardening) group, $t(8) = 1.2$, $P = .254$. There was no difference between groups at baseline, $t(28) = -1.0$, $P = .308$, or at session 6, $t(19) = 0.8$, $P = .439$.

Sessional Analysis

To explore the effect of each session on AMPS motor scores, the mean change (δ) scores across participants was calculated for each session, for each intervention. A positive score indicates an improvement in motor performance. A δ score greater than or equal to $+0.5$ indicates significant and clinically meaningful improvement.[15] Figure 1 shows mean δ scores over the 12 sessions for the 2 interventions.

The majority of MSE participants improved by ≥ 0.5 after each session. Improvements among the control group were more variable and closer to the 0.5 cut-off with only 3 overlapping confidence intervals (CI) between the 2 groups. The results for the AMPS process scores were more variable. Next, the effect of the interventions over a period of sessions was explored by examining the mean percentage sessions in which a participant improved. Figure 2 shows the mean percentage of sessions for which an improvement in motor and process skills (≥ 0.5) was achieved in each group.

There were significantly more sessions for which participants improved on motor performance in the MSE group (M = 67.4, SD = 24.6) compared with the control group (M = 44.8, SD = 29.7), $t(28) = 2.28$, $P = .030$. There was no statistical difference between the MSE (M = 46.6, SD = 24.6) and control group (M = 29.8, SD = 30.6) for process scores, $t(28) = 1.66$, $P = .108$.

Discussion

The analysis of AMPS scores from baseline to LTS revealed a significant improvement in motor and process scores for both the MSE and control groups. However, analysis of AMPS scores from baseline to sessions 6 revealed a significant

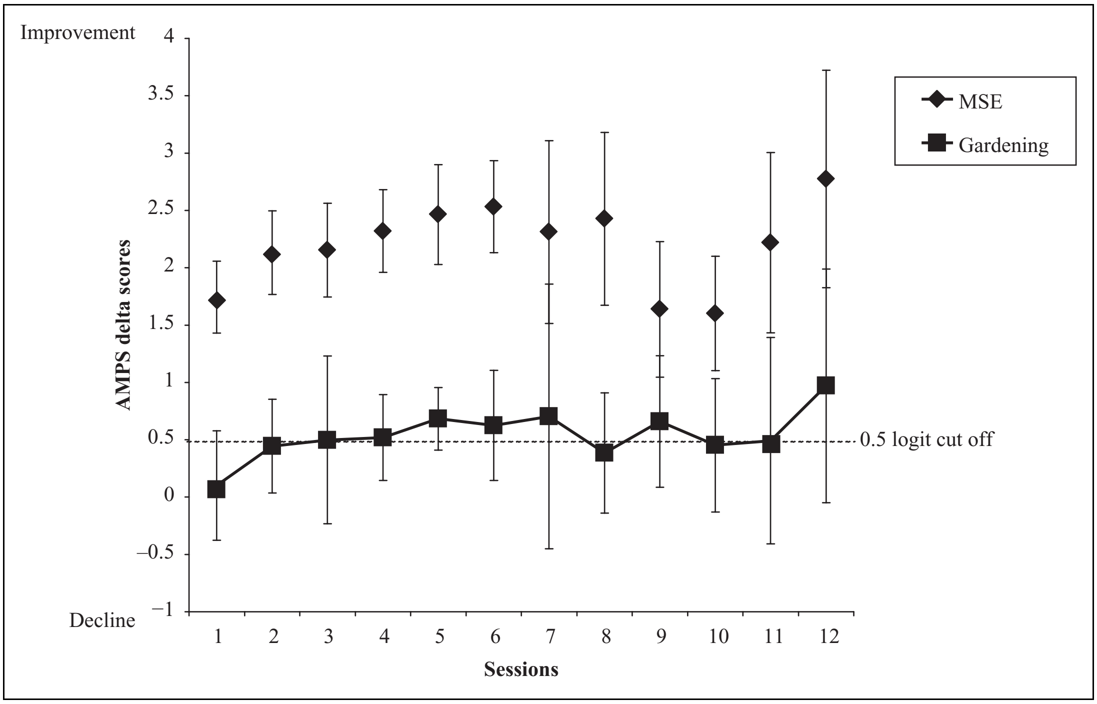

Figure 1. Mean δ Assessment of Motor and Process Skills (AMPS) motor scores over 12 sessions for treatment groups. Note. Error bars, 95% confidence intervals. Different numbers of participants are entered into the mean score recorded for each session.

improvement in motor and process scores for the MSE group only. This anomaly is probably due to the number of participants who achieved 6 sessions (73% of participants) compared with those who were included to the LTS point. Further, analysis of AMPS δ scores for individual sessions revealed that all participants in the MSE group significantly improved in motor skills whereas just over half of the participants in the control group significantly improved. Additionally, participants in the MSE group improved in motor skills for significantly more sessions than in the control group. The interaction between groups for process skills was more limited which is perhaps unsurprising. Process skills, which include cognition, are less likely to show improvement given the normal rate of decline in this population,[24] the focus of the intervention itself, and indeed the nature of the disease. However, motor skills improved in both groups. As motor skills are essential for participation in daily life, the benefits of such improved outcome could, arguably, contribute to improved performance in other activities of daily living such as self-care as suggested by the AMPS.[23] Although the causal association between physical ability and activity remains unclear, these results are also consistent with the findings of a number of other correlation studies,[25,26] all of which have shown a relationship between motor performance and participation.

As people age, they show a decline in sensory acuity which is exacerbated by a decline in perception, attention, and information processing.[27] Despite this decline, motor learning remains intact in people with Alzheimer's disease, suggesting preservation of neural structures that integrate sensory and kinaesthetic information.[27] Therefore, loss of motor performance seen in moderate and severe dementia may not be due to neural damage, but rather to the cognitive deficits that create "noise" within the central nervous system. This "noise" is thought to impede sensory processing and motor response.[28]

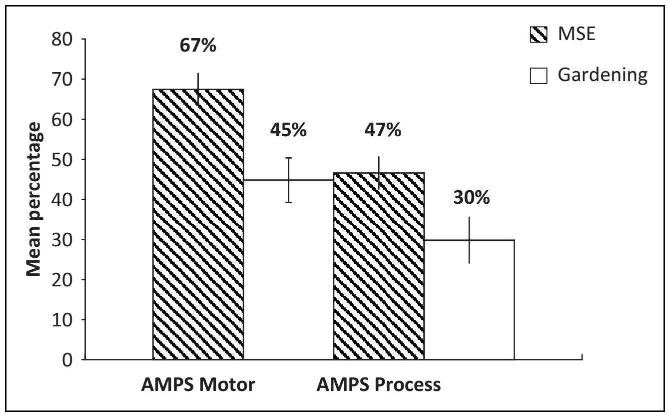

Figure 2. Percentage of sessions for which a participant improved ≥0.5 in Assessment of Motor and Process Skills (AMPS) motor and process scores. Note. Error bars, standard errors of mean percentages.

Stimulus enhancement may also assist in sensory processing. An environment offering weakened or nonspecific stimuli may contribute to the confusion experienced by the person with dementia, thereby leading to an increase in cognitive and behavioral impairments.[29] By enhancing the sensory signal, the demand on the CNS is reduced and performance may be enhanced. Multisensory environments may be modified to control the number of competing stimuli and the intensity of stimulation by matching sensory preferences and individual need. This suggestion is consistent with findings that demonstrated an increase in performance by enhancing the stimulus presentation to match the information-processing ability of the individual.[30]

Therefore, by modifying the level of sensory stimulation presented in the MSE as guided by the ASP, and facilitating participation using the PAL, it may be possible to reduce cognitive "noise." This could assist in accommodating problems in perception, attention, and information processing and improve sensory processing abilities by reducing sensory overload. The control activity (gardening) may also be modified to take into account perceptual and cognitive limitations. However, it is harder to modify the level of sensory stimulation in gardening in the same way as the MSE. These limitations may reflect the lower performance scores achieved by the control group.

Although sample size calculations were undertaken at the start of the study based on 80% power, there were many challenges both in achieving the numbers anticipated and in accessing appropriate data from which to make the calculation. Studentship funding was limited to 3 years. Consequently, at the point these findings were explored, only 30 participants had been recruited, thereby only achieving 60% of the proposed number (n = 50). However, these interim findings are very positive and in order to ensure the final results are sufficiently powered, post hoc analysis has been undertaken. This has revealed that a further 38 additional participants will be needed to power the study to 80%. Further funding is being sought to pursue this study to a satisfactory conclusion.

Results so far support the use of MSE for people with moderate and severe dementia who have difficulty participating in conventional activity and, secondly, recommend the use of the ASP and the PAL to plan and facilitate activity in the MSE in order to meet individual sensory needs.

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