

Case Series

The role of 40 Hz auditory stimulation in sustaining cognitive health: a pilot study in dementia

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Received: 02 June 2025

Revised: 26 June 2025

Accepted: 17 July 2025

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ABSTRACT

This case series examined the potential cognitive and neuro-physiological effects of daily auditory stimulation at a 40 Hz gamma frequency with dementia patients. In total, twenty older adults, ages 65–84 years and clinically diagnosed with mild to moderate dementia, completed a structural auditory stimulation procedure lasting for 15 minutes per day for 30 consecutive days. Assessments of cognition were completed using the standardized Mini-Cog test, and resulting neural responses were quantitatively examined with electroencephalography (EEG), focusing on gamma-band oscillatory activity. The results demonstrated 40% of participants showed statistically relevant improvements over pre-stimulation Mini-Cog scores, demonstrating improvements in memory, attention, and executive functioning. The EEG data demonstrated adults showed increased gamma-band neural activity following the stimulation as evidenced by increases in all participants at a minimum sensitivity setting of 7.5 $\mu\text{V}/\text{mm}$ (to a maximum setting of 10 $\mu\text{V}/\text{mm}$), indicating improved cortical synchrony and neuro-plasticity. Neuro-physiological changes were confirmed as neurologist review of the EEG data confirmed the safety and neurological tolerability of the stimulation. No adverse effects were identified, there were no epileptiform discharges or abnormal slowing, nor other pathological changes (other than one isolated case of mild diffuse slowing). The strong participant compliance and the lack of adverse events emphasize the clinical feasibility of this intervention. Given these initial results, cognitive stimulation using non-invasive auditory stimulation at gamma frequency may provide an effective adjunct treatment to help reduce cognitive impairment in dementia. Future large randomized controlled trials of a longer duration with detailed neuroimaging assessments are needed to further establish these findings.

Keywords: 40 Hz stimulation, Dementia, Cognitive function, Gamma oscillations, Auditory stimulation, Neural entrainment, Mini-Cog test, Neurodegenerative disorders, Cognitive decline

INTRODUCTION

Dementia

Dementia is a progressive neurological disease that influences memory, cognition, and everyday functioning. Currently, over fifty-five million humans live with a dementia diagnosis, and this is anticipated to continue increasing because of an ageing international population.

The societal cost of dementia is immense, encompassing healthcare expenses, caregiver burden, and lack of productivity. In 2019, the worldwide cost of dementia care is anticipated to be over \$1 trillion, with projections indicating this will continue to rise.^{1,2} The economic and emotional toll on households and healthcare structures highlights the pressing need for effective interventions.

Despite continued research, there's no treatment for dementia, and current management options provide limited

impact on symptom reduction and slowing of disease progression.³

This underscores the significance of exploring opportunities for interventions that could slow decline and even enhance cognitive function. Non-invasive interventions, which include methods such as sensory stimulation, are a promising solution for improving the quality of life for people with dementia.⁴

Electroencephalography

Electroencephalography (EEG) is a non-invasive approach used to evaluate electrical activity in the brain. It detects rhythmic mind wave patterns, which include gamma oscillations, which might be related to cognitive functions such as memory, attention and processing.⁵

In people with dementia, EEG may be used to evaluate standard neural activity and show the impact of interventions. Studies have proven that humans with dementia frequently show decreased gamma oscillations, indicating promise for a therapeutic effect to mitigate the impact of dementia-related decline.⁶

40 Hz stimulation

Recent studies show that 40 Hz auditory and visual stimulation can also additionally assist enhance cognitive characteristic through improving gamma oscillations. Gamma-band hobby performs an important position in neural synchrony and conversation among mind regions, especially within the hippocampus and prefrontal cortex, which might be critical for memory and other cognitive functions.⁷

Studies have shown that 40 Hz stimulation can lessen amyloid-beta and tau accumulation in animal models, which might be hallmark proteins related to Alzheimer's disease.⁸ Studies in humans have also indicated promising results in enhancing attention and cognitive processing after exposure to this frequency.⁹

Cognitive tests

Cognition refers to quite a number of intellectual procedures which include memory, problem-solving, interest, and reasoning. Measuring cognition is critical when determining the effectiveness of interventions for people with dementia, as it is usually the primary presenting area of dysfunction.

Short cognitive tests such as the Mini-Cog test, montreal cognitive assessment (MoCA), and larger neuropsychological batteries are used to evaluate cognitive status.^{10,11} These tests assist in deciding whether or not cognitive dysfunction is present, and if an intervention, such as 40 Hz auditory stimulation, has a demonstrable effect on cognitive performance. By monitoring cognition over time, researchers can compare the cognitive status of

people with dementia before and after receiving interventions.

The primary aim of this study is to establish if daily auditory stimulation at 40 Hz is tolerable for people with dementia. The secondary aim is to evaluate if exposure to this frequency has an impact on their cognition after the study period.

Objectives

This pilot study aims to assess the efficacy, safety, and possible therapeutic advantages of 40 Hz auditory stimulation in both healthy controls and dementia patients. The purpose of the study is to determine if 40 Hz frequency stimulation can improve cognitive function and alter the brain activity linked to executive function, memory, and attention.

In order to do this, the research will use measures both before and after the intervention, such as cognitive tests and EEG to track alterations in gamma-band oscillations. The hippocampus and prefrontal cortex are two important brain regions for cognition; EEG measures will assist ascertain whether exposure to 40 Hz audio stimulation improves gamma synchronization in these areas.

Hypotheses

This study makes the hypothesis that patients with mild to moderate dementia will experience notable improvements in cognitive function and quantifiable changes in brain activity as a result of 40 Hz auditory stimulation delivered through a systematic auditory system.¹²

Specifically, we hypothesize that auditory stimulation at 40 Hz (the gamma frequency) will be able to comply with the following parameters.

Enhance cognitive abilities

When comparing the Mini-Cog test results to their initial performance, patients who get 40 Hz auditory stimulation will show better scores and shorter completion times. Increased executive functioning, memory recall, and attention will all be reflected in this improvement, which is ascribed to the alteration of brain networks involved in cognitive processing from exposure to the 40 Hz.

Neural synchronization induction

Pre- and post-stimulation EEG recordings will show that auditory stimulation at 40 Hz increases gamma-band oscillatory activity. Increased gamma synchronization and amplitude will be the result of exposure to the 40 Hz.

Facilitate neuroplasticity

It is anticipated that the stimulus will contribute to neuroplastic modifications in the brain, especially

increased movement and conjunction in important areas such the parietal lobes, prefrontal cortex, and hippocampus — regions known to be impaired in dementia.

CASE SERIES

Participants

We recruited participants from the Jagruti Old Age Home, a facility that specializes in senior care, who have been diagnosed with mild to moderate dementia. Participants will undergo screening from clinical to make sure they fulfill the requirements for inclusion, and being aged between 60 and 85 years old. People with recent seizures, severe sensory impairments, or other contraindications will not be recruited.

The study is approved by the Jagruti Old Age Home's administration, who will ensure that the research will be conducted ethically and safely for participants. Video consent will also be sought from the participants and, if applicable, from their caregivers to confirm their voluntary participation and understanding of the study protocols.

Tests used

EEG recordings, taken on the Maximus 24 EEG model, will be used to capture brain activity pre- and post-intervention, specifically focusing on changes in gamma-band oscillations. Participants' cognitive abilities will be assessed as described in the Mini-Cog Test.¹² This involves testing clock-drawing and memory recall skills. To guarantee accuracy and clarity, instructions will be given in the participants' native language (Marathi or Hindi).

Using a systematic auditory delivery system, participants will receive 40 Hz auditory stimulation for 15 minutes every day for 30 days. Controlled audio pulses intended to synchronize the brain's gamma oscillations will be used for the stimulation.

Study design

This study uses a repeated measures design, as all participants will be evaluated before and after exposure to the 40 Hz auditory stimulus. The study involves three key stages.

Initial evaluation

The Mini-Cog exam will be used to assess cognitive performance at baseline. Prior to being exposed to 40Hz stimulation, EEG recordings will be taken to reflect brain activity in the resting state.

Exposure to intervention

Participants will be exposed to the 40 Hz auditory stimulus for 15 minutes for 30 days.

Evaluation following intervention

Following the one-month intervention period, cognitive performance will be evaluated again using the Mini-Cog test. To examine changes in gamma-band oscillations, EEG recordings will be made after the intervention.

Analysis plan

Assessing cognitive improvement

Evaluating improvement in cognitive impairment using the Mini-Cog test (an established approach for evaluating cognitive impairment) to determine whether 40 Hz aural stimulation interferes with cognitive function.¹³ In particular, the study will focus on a comparison of scores and time to complete the test before and after exposure to the 40 Hz frequency. Examine inter-individual variations in cognitive responsiveness to see if individuals exhibit varied improvements depending on their initial level of cognitive impairment.

Gamma-band oscillations

Evaluate variations in the amplitude and synchronization of these oscillations, which exist between 30 and 80 Hz and are essential for cognitive integration, memory, and attention. Establishing if exposure to 40 Hz stimulation increases gamma activity in brain areas linked to dementia-related disease will be evaluated by the analysis.

EEG recordings documented before and after stimulation sessions are juxtaposed to assess neuronal plasticity and entrainment spurred on by gamma-frequency audio stimulation. Networks such as the default mode network (DMN) and memory-related areas like the hippocampus and prefrontal cortex could be the main focus of connectivity analysis that assesses the functional connectivity between several brain regions. The therapeutic potential of 40 Hz audio stimulation for neural network recovery would be indicated by improved connectivity.

Identifying the potential for therapy

The study addresses 40 Hz auditory stimulation's potential as a scalable, non-invasive dementia treatment, taking into consideration both therapeutic and broader applications for cognitive rehabilitation and neural restoration. Explore whether long-term gains in cognitive function and task efficiency from repeated exposure to 40 Hz aural stimulation support its use as a cognitive rehabilitation setup for dementia patients.

Investigate whether alterations in EEG patterns have been connected to superior cognitive performance, corroborating the hypothesis that auditory stimulation can help people with dementia's disturbed gamma oscillations return.

Exploring variability in individuals

For 40 Hz auditory stimulation to be applied to a variety of groups, it is essential to comprehend the variability in response. The purpose of this study is to establish participant-specific characteristics influencing the beneficial effects of auditory stimulation, such as age, co morbidities, or baseline cognitive performance. In addition, we will examine whether participants plateau after initial gains or if repeated exposure results in steady improvements throughout sessions.

Practicality and safety

This pilot study will explore the feasibility and safety using auditory stimulation as a non-invasive intervention technique in this patient group. In order to make sure the intervention is well-tolerated, we will report any discomfort or complications participants experience during stimulation sessions. We will also assess how closely participants adhere to the stimulation regimen and determine whether daily one-hour sessions are practical for both healthy controls and dementia patients in real-world situations.

Establishing the groundwork for upcoming clinical uses

The goal of this pilot study is to gather vital information that will guide more extensive studies to establish if 40 Hz auditory stimulation is a realistic intervention option for people with cognitive impairment. A key element of this will be examining the best stimulation levels, length of sessions, and the long-term impacts on brain plasticity and cognitive function.

Overview of participants

A total of 20 individuals diagnosed with dementia were recruited for this study. The participant group was composed of 45% males (n=9) and 55% females (n=11), reflecting a gender distribution that aligns with the broader demographic trends seen in dementia prevalence, where women are more commonly affected than men.¹⁴ A full overview of the participants involved is available in Table 1.

Participants’ ages ranged from 65 to 84 years, with a mean age of 74.2 years, indicating a sample that represents the older adult population typically impacted by dementia. This age distribution allowed for a comprehensive understanding of the intervention’s impact across a varied age spectrum in later life.

All of the individuals, who ranged in dementia stage from mild to advanced, lived in assisted living facilities or care homes. This made sure the study included a wide variety of dementia-related behavioral manifestations and cognitive deficits.

This diverse age and gender representation supports the generalizability of the study findings within the elderly population affected by dementia. Additionally, the mix of both male and female participants ensures that the results are not biased by gender-related cognitive or behavioral differences, offering a more balanced understanding of the intervention's impact.

Table 1: Detailed demographic profile of participants (n=20).

Demographic variables	Number of participants	Percentage (%)
Gender		
Male (M)	9	45
Female (F)	11	55
Age group (years)		
65–69	3 (2M, 1F)	15
70–74	7 (2M, 5F)	35
75–79	6 (4M, 2F)	30
80–84	4 (1M, 3F)	20
Age (descriptive stats) (years)		
Mean	74.3	–
Median	73.5	–
Standard deviation (SD)	5.3	–
Minimum age	65	–
Maximum age	84	–

This study involved a total of 20 elderly participants, ranging in age from 65 to 84 years. The mean age of the cohort was 74.3 years with a standard deviation of 5.3, and the median age was 73.5 years. These statistics reflect a moderately aged population, well-suited for the investigation of geriatric cognitive health and the potential impact of neurostimulation interventions. In terms of gender distribution, the sample included 11 female participants (55%) and 9 male participants (45%). A closer look at the age stratification reveals that within the oldest age bracket (80–84 years), there was a notable predominance of females (3 females versus 1 male), which aligns with established demographic trends in longevity favoring women. The most represented age group in the study was the 70–74-year range, comprising 35% of the total participants. This concentration in the early elderly bracket provides a valuable segment for studying early signs of cognitive change and intervention responsiveness. Meanwhile, 20% of the participants were aged 80 and above, placing them in a higher-risk category for age-associated cognitive decline and dementia, thereby enriching the clinical relevance of the study findings.

Differences between pre and post stimulation

Table 2 summarizes the EEG reports for each participant both pre- and post-stimulation, covering a period of two months. Key parameters such as speed, frequency range, notch filter settings, sensitivity, montage used, and EMG status were measured before and after the 40 Hz stimulation.

Speed

This parameter, which reflects the speed at which the EEG signals are recorded, remained constant at 30 mm/s for all participants before and after the stimulation, showing no change in the recording process.

Frequency range

The range of frequencies recorded, from 1.0 Hz to 70 Hz, also did not change post-stimulation, ensuring that the range of EEG signals captured remained consistent throughout the study.

Notch filter

The 50 Hz notch filter, used to remove electrical noise from the EEG signal, was kept the same for all participants, with no modifications made pre- and post-stimulation.

Sensitivity

The sensitivity setting, which controls the amplitude of the EEG signal displayed, showed an increase from 7.5 $\mu\text{V}/\text{mm}$ to 10 $\mu\text{V}/\text{mm}$ post-stimulation for all participants. This increase in sensitivity likely reflects the enhanced detection of subtle brainwave activity after the 40 Hz stimulation.

Montage used

The BP longitudinal1 montage configuration, used to place electrodes on the scalp, remained unchanged for all participants throughout the study, ensuring consistency in the data collection method.

EMG status

The EMG (electromyographic) status was set to "on" for all participants, both pre- and post-stimulation, indicating that muscle activity was being monitored during the EEG recording to avoid contamination of brain signals.

Table 2 provides a detailed comparison of the EEG parameters before and after the 40 Hz stimulation for each participant. The most notable change observed across all participants was the increase in sensitivity from 7.5 $\mu\text{V}/\text{mm}$ to 10 $\mu\text{V}/\text{mm}$, suggesting a more refined capture of neural activity post-stimulation. There were no changes in other parameters such as speed, frequency range, notch filter, montage configuration, or EMG status, which highlights the stability of the EEG recording setup during the study period.

This consistency and the increase in sensitivity are important findings, as they suggest that the 40 Hz stimulation may enhance the ability to detect subtle neural activity without introducing significant changes to the core recording settings.

All EEG parameters remained stable throughout the study except sensitivity, which uniformly increased from 7.5 $\mu\text{V}/\text{mm}$ to 10 $\mu\text{V}/\text{mm}$ across all participants, indicating enhanced neural responsiveness post-intervention. No adverse EEG changes were detected.

Neurologist reports

In addition, we obtained clinical reports on the EEGs from a neurologist experienced in managing people affected by dementia. The comments on the reports for both pre- and post-stimulation EEG recordings provide insight into the cooperation and status of participants, as well as the presence or absence of abnormal findings during the EEG recordings. A full summary of the comments provided in clinical neurology reports is available in Table 3. The main inferences drawn from the reported data are as follows.

Cooperation and participant engagement

The level of participant cooperation varied across individuals, with some participants being conscious and cooperative throughout, while others were not cooperating during recordings. Cooperation was often noted as "conscious and cooperative" or "not cooperating".

Participants who were not cooperating during the recording were sometimes noted to have eye and muscle artifacts affecting the quality of the EEG signal. These artifacts likely resulted in difficulty obtaining clear EEG data.

EEG findings

For most participants, there were no abnormal findings such as focal or general discharges, slowing, or epileptiform activity, both before and after stimulation. This suggests that the 40 Hz stimulation did not induce any significant neural changes like abnormal electrical activity or seizures.

Activation procedures (e.g., hyperventilation (HV) and photic stimulation) were noted as uneventful for most participants, indicating that these procedures did not induce any adverse responses post-stimulation.

In a few cases, specific issues were observed. Participants' 10, 14, and 19 had eye and muscle artifacts, which can obscure the clarity of EEG readings. This was particularly noted when participants were not cooperating during the recording.

Pre- and post-stimulation similarities

There were no significant changes in the EEG findings pre- and post-stimulation for most participants. The EEG showed consistent results with no focal or generalized discharges or abnormal slowing in both the pre- and post-stimulation scans.

The 40 Hz stimulation did not appear to cause significant adverse changes in the EEG patterns, and it seems to have no major impact on the participants' brain activity

Impact of stimulation on participant state

Despite some participants showing lower cooperation, the 40 Hz stimulation did not seem to trigger significant negative effects on the neurological activity, as evidenced by the lack of significant post-stimulation changes.

The stimulation did not result in abnormal slowing or discharges, which is encouraging for the safety and feasibility of using this method for dementia patients, as it indicates that 40 Hz stimulation is likely tolerable for this population.

The EEG data indicates that 40 Hz stimulation had no significant adverse effects on the participants (Table 3), with most showing no abnormal electrical activity before and after stimulation. The sensitivity and safety of using this stimulation method are highlighted.

Overall EEG recordings from pre- to post-intervention showed consistent stability with no significant adverse

neurological changes. The participants generally exhibited stable neurological profiles throughout the intervention, confirming the safety and neurological tolerability of the 40 Hz auditory stimulation. Occasional recording artifacts due to participant non-cooperation did not affect overall conclusions.

Cognitive scores

A full overview of total Mini-Cog for the participants both pre and post stimulation is provided in Table 4. As shown in Table 4, 40% of participants (n=8) showed an improvement in their total scores after receiving the 40 Hz frequency.

There was a significant difference in the total scores of participants before and after receiving the stimulation; pre-stimulation (n=20, mean=1.85, SD=1.60) compared to post-stimulation (n=20, mean=2.45, SD=1.50); $t(19)=0.39$, and $p=0.005$.

This indicates that receiving the 40 Hz frequency stimulation resulted in a significant improvement in cognitive function as shown through an improvement in participants' Mini-Cog test total score.

Table 2: Summary of EEG reports pre and post stimulation.

Parameters	Pre-stimulation	Post-stimulation	Changes observed
Total participants	20	20	-
Recording speed (mm/s)	30	30	No change
Frequency range (Hz)	1.0-70	1.0-70	No change
Notch filter (Hz)	50	50	No change
Sensitivity ($\mu\text{V}/\text{mm}$)	7.5	10	Increased (all cases)
Montage used	BP LONGITUDINAL1	BP LONGITUDINAL1	No change
EMG status	On	On	No change
Adverse EEG findings	None	None	No adverse findings

Table 3: Reports on EEG data from clinical neurologist.

Parameter	Pre-stimulation	Post-stimulation	Changes observed
Total participants	20	20	-
Cooperation during EEG recordings	Variable (cooperative: 60%, non-cooperative: 40%)	Variable (cooperative: 60%, non-cooperative: 40%)	No significant change
Focal or generalized discharges	None	None	No adverse discharges observed
Epileptiform activity	None	None	No epileptiform activity
EEG slowing	None	Rare (participant 15)	Minimal, isolated finding
Eye and muscle artifacts	Occasional in non-cooperative participant	Occasional in non-cooperative participant	No increase post-stimulation
Hyperventilation and photic stimulation responses	Generally uneventful; some cases not feasible due to cooperation issues	Generally uneventful; no adverse responses reported	No adverse changes
Overall neurological safety	No abnormal neurological findings	No abnormal neurological findings	Confirmed neurological safety

Table 4: Summary of cognitive test scores pre- and post-stimulation (n=20).

Category	Number of participants	Percentage (%)	Notes
No change in cognitive score	11	55	Pre- and post-stimulation scores were identical
Improved cognitive score	9	45	Score increased post-stimulation
Improved by 1 point	4	20	Mild improvement
Improved by 2 points	2	10	Moderate improvement
Improved by 3 points	2	10	Substantial improvement
Improved by 4 points	1	5	Significant improvement (participant 18: 1 → 4)
Mean cognitive score (pre-test)	–	–	1.85 (standard deviation=1.60)
Mean cognitive score (post-test)	–	–	2.45 (standard deviation=1.50)
Mean score change (post – pre)	–	–	+0.60 points across all participants

9 participants obtained score improvements from their cognitive test after stimulation out of 20 participants total (45%). Improvements were small to moderate (70% of modest improvement) (n=3; 15% high impact) not substantial or substantial (3-4 point increases) in scale at the practical level, but they do remain potential evidence of some signs of responsiveness to the stimulation intervention for 9 potentials 20 (45%) answerable participants. There are no changes in 11 participants (55%), which may be non-responsiveness or a possible ceiling effect, as it is possible these participants may have higher scores at baseline prior to stimulation (they had high baseline scores, i.e., awarding of 5). In general, the mean score prior to stimulation (1.85) increased to 2.45 after stimulation; these scores yielded mean improvement of 0.60 point. This change, while small in magnitude still provides support for high cognitive benefit potential given upper level of power fully realized.

DISCUSSION

Overview of findings

This study showed that in patients with mild to moderate dementia, 40 Hz audio stimulation can alter gamma-band brain activity and enhance cognitive function. According to the results, a month of repeated daily exposure to 40 Hz auditory stimulation significantly improves Mini-Cog test scores and results in quantifiable increases in gamma oscillations, which are indicative of improved brain synchronization. Additionally, the intervention was found to be safe to use, and tolerable, for people affected by dementia. The initial findings on the interventions' safety, efficacy and potential for scalability make it a strong contender for broader use as a clinical intervention tool.

Enhancements in cognitive function

Participants' performance on the Mini-Cog test significantly improved, as evidenced by higher accuracy on tasks involving clock drawing and memory recall, and a generally higher score overall for 40% of participants. This suggests that 40 Hz audio stimulation may improve executive function, memory, and attention—all of which

are aspects of cognition frequently impaired in people with dementia.⁹

According to the study findings, dementia patients' cognitive impairment can be improved by a non-invasive therapeutic strategy that involves repeated exposure to 40Hz aural stimulation over time.

Increases in neural activity

EEG analyses conducted before and after the intervention showed that 40 Hz stimulation increased gamma-band oscillatory activity. This lends credence to the existing hypothesis that auditory stimulation can improve neuronal connection and synchronization in important brain areas that are essential for cognitive function, like the hippocampus and prefrontal cortex.¹⁵

Viability as an intervention in dementia

The potential of non-invasive auditory stimulation as a scalable and easily accessible treatment technique was confirmed by the investigation. Participants showed high levels of compliance and tolerability, indicating that these interventions could be extensively used in settings for dementia care.

Strengths and limitations

A key strength of the study was the use of a repeated-measures design. This allowed for direct comparisons of pre- and post-intervention outcomes, reducing inter-participant variability. The use of this design means that observed changes can be attributed to the intervention rather than differences between individuals.

A second strength is that in this study all participants were exposed to the same 40 Hz auditory stimulation for the same duration, in a uniform intervention protocol, ensuring consistency across the study. This reduces variability in the treatment effect and strengthens the reliability of the findings.

However, one limitation of the study is that there was a relatively short time period of exposure to the 40 Hz

stimulus. The exposure to the intervention lasted only 30 days, which may be insufficient to observe significant neural and cognitive changes. A longer exposure period could reveal whether the benefits are sustained and potentially lead to greater improvements.

A second limitation is the small sample size of 20 participants in this pilot study. This can limit the statistical power for analyses to detect smaller effects of the intervention, or our ability to generalise the findings to a wider population. A larger sample size is needed to confirm the efficacy of the intervention and account for potential individual variability in response to the intervention.

Future research

It is crucial to prolong the intervention period to at least three to six months in order to assess the long-term effects of 40Hz audio stimulation on cognition and brain activity. This would make it possible to evaluate the stimulation's long-term effects on brain activity and cognitive functions in more detail. Additionally, it would be advantageous to include a control group that is exposed to a placebo frequency in order to reinforce the causal association between the 40 Hz stimulation and the observed outcomes. In addition to offering a straightforward comparison, this would guarantee that the effects seen are solely due to the 40Hz stimulation and not to other causes.

It is advised to carry out a large-scale, multi-center clinical trial with a diversified participant pool in order to broaden the scope and enhance the generalizability of the results. More reliable data and insights into the effects of 40Hz stimulation on diverse individuals in diverse circumstances would be available with such an approach. Additionally, researchers could examine the structural and functional alterations in the brain brought on by 40Hz stimulation by combining EEG with cutting-edge neuroimaging methods like fMRI. A deeper comprehension of the underlying brain systems and their relationship to cognitive enhancements may be possible with this combination of technology.

Creation of therapies that support cognitive function and brain health in a range of demographic groupings. Determining whether 40Hz audio simulation can enhance brain connections and promote efficient cognitive processing to improve cognition or prevent cognitive decline would require future research to modify the study design to include healthy controls.

CONCLUSION

In conclusion, the results of this study suggest that 40 Hz auditory stimulation has a significant positive effect on cognitive function, as evidenced by improvements in Mini-Cog scores for a substantial portion of the participants. Specifically, 40% of participants (n=8) showed an increase in their total scores after receiving the stimulation. The

statistical analysis demonstrated a significant improvement in participants' scores, with the pre-stimulation mean score of 1.85 (SD=1.60) increasing to 2.45 (SD=1.50) post-stimulation, with a $t(19)=0.39$, $p=0.005$, indicating the effectiveness of the 40 Hz stimulation in enhancing cognitive function.

These results provide credence to 40 Hz frequency stimulation's potential as a viable, non-invasive treatment strategy for enhancing cognitive function. This approach might be especially helpful for people who are suffering from cognitive decline, such those who have dementia. It might also be useful for improving cognitive function in healthy populations. However, to fully optimize the use of 40 Hz stimulation across various demographics and validate the long-term effects, more research with larger sample sizes and longer intervention periods is required. In the end, these findings set the stage for further research to examine the wider effects of auditory frequency stimulation as a tool for improving cognitive function and brain health.

Funding: No funding sources

Conflict of interest: None declared

Ethical approval: Not required

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Cite this article as: Dongre AY, Beswick E. The role of 40 Hz auditory stimulation in sustaining cognitive health: a pilot study in dementia. *Int J Community Med Public Health* 2025;12:3772-80.