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# Effects of Experimentally Induced Visual and Auditory Hallucinations on Cognitive and Emotional Functioning in Schizophrenia Patients and Healthy Individuals: The Modulatory Role of Placebo Intervention

**Noureen Bibi & Muhammad Aqeel**

## Abstract

**Background:** Schizophrenia is a complex neuropsychiatric disorder characterized by profound deficits in cognitive and emotional functioning, including altered perceptual experiences, heightened anxiety, amnesia, and impairments in episodic memory. While extensive research has examined naturalistic hallucinations, primarily through correlational approaches, experimental induction of hallucinations remains limited. The present study aimed to investigate the effects of experimentally induced visual and auditory hallucinations on cognitive and emotional functioning and to evaluate the efficacy of a placebo intervention in mitigating their impact in schizophrenia patients and healthy individuals.

**Method:** A placebo-controlled, double-blind, mixed within- and between-group randomized block design was employed. Sixty participants (schizophrenia patients, n = 30; healthy controls, n = 30), aged 18–65 years, were recruited from multiple centers in Islamabad, Pakistan. Participants completed 10 experimental trials involving positive and negative visual and auditory hallucination induction using advanced PsychoPy software, alongside standardized assessments of cognitive and emotional processes.

**Results:** Results revealed that schizophrenia patients exhibited heightened susceptibility to hallucination perception and increased anxiety during exposure to combined negative visual and auditory hallucinations relative to healthy controls. Negative hallucinations exacerbated amnesia and impaired episodic memory retrieval, whereas positive hallucinations facilitated cognitive performance. Importantly, the placebo intervention significantly attenuated the cognitive and emotional consequences of hallucinations, with more pronounced effects observed in schizophrenia patients.

**Conclusions:** These findings highlight the potential therapeutic benefits of non-pharmacological interventions in schizophrenia and provide novel insights into the interaction between multisensory hallucinations and cognitive-emotional functioning. The study underscores the importance of developing individualized therapeutic strategies to address the complex clinical manifestations of schizophrenia across diverse healthcare settings.

**Keywords:** Hallucination induction, episodic memory, amnesia, anxiety, schizophrenia, healthy controls, placebo intervention

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## Background

Schizophrenia is a complex neuropsychiatric disorder characterized by profound impairments in perception, cognition, and emotional expression (Aleman & Sommer, 2023; Bell et al., 2024; Lincoln et al., 2024; Pérez-Flores et al., 2024). It is frequently associated with severe social and occupational dysfunction and affects over 24 million individuals worldwide, representing approximately 0.32% of the global population (Cheng et al., 2024). In Pakistan, prevalence estimates suggest that 1–2% of the population is affected, resulting in substantial reductions in quality of life (Bogie et al., 2024).

Hallucinations perceptual experiences occurring in the absence of corresponding external stimuli are among the core features of schizophrenia. Visual and auditory hallucinations are most commonly reported in clinical populations, although such phenomena are increasingly recognized in nonclinical individuals (McKay et al., 2024; Sheffield et al., 2024). These hallucinations disrupt episodic memory retrieval, induce symptoms of amnesia, and exacerbate emotional dysregulation, particularly anxiety (Aleman & Sommer, 2023; Bell et al., 2024). Episodic memory, the cognitive ability to recall personal past experiences and construct coherent self-representations, relies on intact cortical and hippocampal networks. Disruptions to these networks during hallucinatory episodes impair memory encoding and retrieval, compromising adaptive functioning (El Haj & Laroi, 2024). Moreover, hallucinations contribute to anxiety symptoms by intensifying uncertainty and reducing the brain's capacity to accurately predict sensory inputs (Park et al., 2024; Milde et al., 2024).

Experimental induction of visual and auditory hallucinations provides a controlled method to examine their cognitive and emotional effects. Hallucinatory experiences are thought to emerge from disturbances in the brain's predictive coding system, in which prior expectations disproportionately influence perception over actual sensory input, producing distorted experiences (Bell et al., 2024; Corlett et al., 2019; Rao & Ballard, 1999). Persistent predictive errors not only distort perception but also impair memory consolidation, leading to amnesia-like symptoms and heightened anxiety (Barron et al., 2020; Ortiz-Tudela et al., 2024; Sheffield et al., 2024). Tulving's (1972) model of memory, which differentiates episodic, semantic, and procedural systems, underscores how such disruptions blur the boundary between imagined and real events, impair memory retrieval, and amplify emotional dysregulation (De Brigard, 2024.; Hoerl & McCormack, 2024; Honcamp et al., 2024).

Placebo interventions represent a promising non-pharmacological approach for mitigating hallucinatory disturbances. By leveraging expectancy-driven mechanisms, placebos enhance top-down cognitive control, recalibrate perceptual interpretation, and improve emotional stability (Colloca & Miller, 2011; Janssen et al., 2024; Shafir et al., 2023; Zunhammer et al., 2021). Expectation theory emphasizes that beliefs and anticipation of therapeutic benefit can positively modulate cognitive and physiological responses, enhancing attention, memory retrieval, and emotional regulation in both clinical and nonclinical populations (Khalighi et al., 2021; Żegleń et al., 2024).

The present study investigates the effects of experimentally induced auditory and visual hallucinations on episodic memory, amnesia, and anxiety, and evaluates the capacity of placebo interventions to attenuate these effects. By examining these phenomena in both schizophrenia patients and healthy individuals, the study aims to elucidate the complex interplay between perceptual distortions, cognitive impairments, and emotional dysregulation, while exploring the therapeutic potential of expectation-driven interventions.

Hallucinations are a hallmark symptom of schizophrenia, contributing to cognitive deficits and emotional disturbances (Aleman & Sommer, 2023). Despite extensive documentation of hallucinations' impacts, the precise mechanisms through which they impair memory and exacerbate anxiety remain insufficiently understood. Existing treatments often fail to address these multidimensional consequences, revealing a critical gap in therapeutic strategies (Fernández et al., 2023; Hohenschurz-Schmidt et al., 2024).

Controlled experimental paradigms, such as the Ganzflicker technique, provide valuable insights into hallucinatory states in both schizophrenia patients and healthy individuals, enabling direct comparisons across populations (Sahu et al., 2020; Shenyan et al., 2024). While prior research has primarily focused on isolated cognitive deficits, such as memory impairment, the combined effects of hallucinations on episodic memory, amnesia, and anxiety remain underexplored.Integrating placebo interventions with predictive coding frameworks offers an innovative approach to mitigating hallucinatory impairments. Placebos may reduce cognitive and emotional disruptions associated with hallucinations by modulating expectation-driven top-down processes, representing a promising avenue for non-pharmacological therapy, particularly in schizophrenia populations (Rajkumar et al., 2024; Zunhammer et al., 2021).

# Method

## Research Design

A placebo-controlled, double-blind, mixed within- and between-group randomized block design was employed. Event-related tasks, widely utilized in advanced cognitive neuroscience experiments, were implemented to assess brain and cognitive responses under specific stimulation conditions (Aguirre, 2007; Ciric et al., 2017; Hamilton & Huth, 2020; Repovš & Baddeley, 2006). Participants underwent multiple experimental conditions, including auditory hallucinations, visual hallucinations, combined auditory and visual hallucinations, followed by a placebo intervention in the final trial. This design allowed for assessment of within-subject variability and placebo effects.

## Objectives

The present study aimed to examine the effects of experimentally induced positive and negative auditory and visual hallucinations on cognitive functioning including hallucination perception, episodic memory retrieval, and amnesia and emotional functioning, specifically anxiety, in individuals with mild schizophrenia and healthy controls. Additionally, the study evaluated the efficacy of an inert placebo intervention in mitigating the cognitive and emotional consequences of induced hallucinations, with a focus on both schizophrenia patients and healthy individuals.

## Hypotheses

It was hypothesized that:

1. Induced negative auditory and visual hallucinations would enhance hallucination perception and impair episodic memory more than positive hallucinations in both mild schizophrenia patients and healthy individuals.
2. Negative hallucinations would exacerbate anxiety and amnesia symptoms compared to positive hallucinations across both groups.
3. Combined negative auditory and visual hallucinations would produce greater impairments in hallucination perception, episodic memory, and emotional functioning than combined positive hallucinations.
4. Placebo intervention would attenuate the cognitive and emotional effects of both positive and negative hallucinations, improving hallucination perception, episodic memory retrieval, anxiety, and amnesia symptoms, with stronger effects observed in schizophrenia patients relative to healthy controls.

## Participants

A total of sixty participants were recruited using a simple random sampling technique from multiple centers in Islamabad and Rawalpindi, Pakistan, between June and August 2024. Participants were assigned to either the schizophrenia group (n = 30) or the healthy control group (n = 30).

## Schizophrenia Patients

Thirty adults aged 18–65 years, diagnosed with mild schizophrenia, were recruited from Happy Life Psychological Services, Mind Care Rehab, Irada Clinic, and the Psychology Department at Fauji Foundation Hospital, Islamabad. Diagnoses were confirmed by licensed psychologists using the PNSS, and only literate individuals were included. Exclusion criteria comprised severe psychosis and any history of neurological or other psychological disorders.

## Healthy Individuals

Thirty healthy adults aged 18–65 years were recruited from the Cognitive and Neuroscience Lab, Department of Psychology, Foundation University School of Science & Technology (FUSST). Inclusion required intact cognitive functioning, and individuals with any history of neurological or psychological disorders were excluded.

## PsychoPy Software

All experimental tasks were designed and administered using PsychoPy, an open-source platform widely adopted in clinical and laboratory-based psychological research. Tasks involved verbal and auditory hallucination induction, as well as cognitive and emotional assessments. Stimuli were presented on a black background using 3 cm white Arial font, with randomized trial sequences and variable inter-trial intervals to reduce response biases and ensure experimental rigor. PsychoPy enabled precise control over stimulus timing and response measurement, ensuring high validity of cognitive and emotional outcome assessments (Peirce et al., 2019). This setup allowed for detailed evaluation of episodic memory retrieval, hallucination perception, anxiety, and amnesia across both schizophrenia and healthy participants.

## Trial Design

The study was approved by the Ethical Review Board of Foundation University Islamabad, Pakistan, and adhered to the ethical guidelines of the American Psychological Association. All participants provided written and verbal informed consent at the Department of Psychology, Foundation Hospital Islamabad, and the Cognitive and Neuroscience Centre, Department of Psychology, Foundation University School of Science & Technology (FUSST), between January 1 and August 31, 2024.

Experimental tasks were implemented using PsychoPy software version 2.3, enabling precise stimulus presentation and response recording. A ten-trial protocol was designed to deliver cognitive and emotional stimuli, combining clinical and cognitive assessments under controlled, double-blind, randomized conditions. Trials T-1 through T-9 involved induced visual and auditory hallucinations, while Trial T-10 incorporated a placebo intervention aimed at mitigating hallucination-induced cognitive and emotional effects. Participants completed episodic memory tasks and standardized psychological assessments including the Beck Anxiety Inventory (BAI), Launay-Slade Hallucination Scale (LSHS), Rey Auditory Verbal Learning Test (RAVLT), and the Altra Brief Amnesia Assessment both before and after each trial to evaluate changes in hallucination perception, episodic memory retrieval, amnesia, and anxiety.

Each trial commenced with instructions and a 10-second fixation screen, followed by task-specific stimuli presentation. Baseline measures (T-0) included 16 hallucination items, 30 episodic memory items, 21 anxiety items, and 12 amnesia items, with standardized presentation times and recall intervals to ensure experimental rigor. Subsequent trials involved 25-second hallucination

interventions, either visual, auditory, or combined, with psychological assessments administered after each trial to evaluate cognitive and emotional responses. The placebo trial (T-10) used an inert marshmallow intervention to create expectancy effects, followed by identical cognitive and psychological assessments.

## Stimuli

## Hallucination Induction Techniques

Hallucination induction refers to the controlled elicitation of perceptual experiences in the absence of corresponding external stimuli, encompassing all sensory modalities (Duhamel et al., 2023). In the present study, we focused on visual and auditory hallucinations, classified as positive (perception of nonexistent stimuli) or negative (failure to perceive present stimuli). Positive hallucinations included perceiving sounds, images, or patterns that were not physically present, whereas negative hallucinations involved missing or failing to perceive environmental stimuli, such as objects or individuals in the visual field (Duhamel et al., 2023).

Induction of hallucinations was achieved through established cognitive and sensory manipulation techniques, including flicker stimulation and controlled auditory inputs. Visual hallucinations were induced using rhythmic flicker stimulation, based on Purkinje's early observations (1819) and modern entrainment research. High-frequency flicker, particularly within the alpha frequency band (~10 Hz), reliably elicited geometric and complex visual patterns by synchronizing neuronal oscillations in the early visual cortex, producing vivid perceptual distortions consistent with Klüver's form constants (Allefeld et al., 2011; Shenyan et al., 2024).

Auditory hallucinations were induced using stimuli adapted from Pearson et al. (2016) and further refined from contemporary experimental studies (Smith et al., 2023). These stimuli comprised scientifically validated sounds, verbal cues, and audiovisual materials designed to reliably evoke hallucinatory experiences in both clinical (schizophrenia) and nonclinical populations. The integration of visual and auditory stimuli allowed for systematic examination of multisensory hallucination effects on cognitive and emotional processes.

This approach enabled precise experimental manipulation of perceptual experiences, providing robust insights into the cognitive and emotional mechanisms underlying hallucinations, as well as the modulatory effects of placebo interventions.

## Instruments

## Cognitive Assessments

**Rey Auditory Verbal Learning Test (RAVLT):** The RAVLT, originally developed by Andre Rey (1964) and subsequently adapted by Taylor (1959), Lezak (1983), and Schmidt (1996), is a standardized measure of verbal episodic memory suitable for participants aged 16 years and older. The test evaluates immediate recall, learning, susceptibility to interference, and delayed recall. Participants were presented with a 15-word list (List A) over five learning trials, followed by an interference list (List B). Immediate recall of List A was assessed post-interference, with a delayed recall trial administered 20 minutes later. Total recall and recognition scores were calculated to quantify episodic memory performance and monitor memory changes over time (Fuentes-Claramonte et al., 2021).

**Altra Brief Amnesia Light and Brief Assessment (ALBA):** It was developed by Bartos (2022), ALBA is a rapid cognitive screening tool designed to detect mild impairments in short-term memory, aphasia, and dysgraphia. The task involves repeating a six-word sentence, performing six associated gestures, and recalling the original sentence. Scoring ranges are age- and education-adjusted: normal performance (6–12 points), mild impairment (4–5 points), and severe impairment (0–3 points) for older adults; for individuals with ≥15 years of education, normal performance is 8–12 points, mild impairment 5–7 points, and severe impairment 0–4 points (Bartos & Diondet, 2024).

## Psychological Assessments

**Launay-Slade Hallucination Scale (LSHS):** It was developed by Bentall and Slade (1985), the LSHS assesses hallucinatory experiences, including auditory or visual perceptions absent in the external environment. The scale comprises 12 items rated on a Likert scale from "never" to "almost always," with higher scores indicating greater hallucinatory proneness.

**Positive and Negative Syndrome Scale (PANSS):** The PANSS (Kay et al., 1987) evaluates symptom severity in schizophrenia across three subscales: Positive Symptoms (e.g., delusions, hallucinations), Negative Symptoms (e.g., emotional withdrawal, lack of spontaneity), and General Psychopathology (e.g., anxiety, depression, hostility). Each item is rated on a 7-point Likert scale (1 = absent to 7 = extreme). For this study, PANSS scores were categorized per Leucht et al. (2005) as mildly ill (58–74), moderately ill (75–94), markedly ill (95–115), and severely ill (116–210).

**Beck Anxiety Inventory (BAI):** The BAI (Beck et al., 1961, 1996) is a 21-item self-report instrument assessing cognitive and somatic anxiety over the preceding week. Items are rated on a 4-point Likert scale (0 = not at all to 3 = severely), with total scores ranging from 0–63: minimal anxiety (0–7), mild (8–15), moderate (16–25), and severe (26–63).

## Placebo Intervention

An inert placebo (marshmallow) was administered to participants to control for expectancy effects, which can influence cognitive and emotional responses in experimental settings (Kirsch, 2018; Price et al., 2008; Colloca & Miller, 2011). This approach distinguished between effects driven by experimental manipulation and those mediated by participants' expectations of therapeutic benefit. The placebo was administered prior to the final trial (T-10) and integrated with the same cognitive and psychological assessments to evaluate its modulatory impact.

## Procedure

The study received ethical approval from the Foundation University Islamabad Ethical Review Board and adhered to APA guidelines. Sixty participants (30 mild schizophrenia patients, 30 healthy controls) were recruited from hospitals and universities in Islamabad and Rawalpindi between June 1 and August 31, 2024. All participants provided informed written and verbal consent and were

assured of the right to withdraw without penalty. Debriefing and psychological support were provided to ensure participant safety.

Experimental tasks were administered using PsychoPy software version 2.3, allowing precise control over stimulus presentation, response timing, and randomization. Participants completed a ten-trial protocol consisting of baseline assessment (T-0), nine trials of induced auditory and visual hallucinations (T-1 to T-9), and a final placebo trial (T-10). Cognitive tasks and standardized psychological measures including RAVLT, ALBA, BAI, LSHS, and PANSS were administered before and after each trial to evaluate episodic memory retrieval, hallucination perception, anxiety, and amnesia symptoms.

Data analysis employed multivariate statistical methods, including two-way repeated measures ANOVA, to examine the effects of positive and negative auditory and visual hallucinations on cognitive and emotional outcomes in schizophrenia patients and healthy participants. Reliability analyses using Cronbach's alpha ensured internal consistency of the psychological instruments. This rigorous methodology allowed for detailed assessment of cognitive-emotional interactions under induced hallucinations and placebo intervention conditions.

## Results

This study investigated the impact of experimentally induced auditory and visual hallucinations on hallucination perception, episodic memory retrieval, anxiety, and amnesia in individuals with mild schizophrenia and healthy controls. A mixed design was employed, incorporating between-subject factors (group: schizophrenia patients vs. healthy individuals) and within-subject factors (hallucination trials: T1–T10), allowing for a comprehensive analysis of the dynamics of hallucination perception across repeated exposures (see Figure 2 and Table 1)

### Perception of Hallucination

A two-way repeated-measures ANOVA (Group × Time) on hallucination perception revealed a significant main effect of time [$F(2, 30) = 62.02$, $p < .001$, $\eta p^2 = .51$] and a significant Group × Time interaction [$F(2, 30) = 20.06$, $p < .001$, $\eta p^2 = .25$]. These results indicated that participants with schizophrenia experienced significantly higher levels of both positive and negative auditory and visual hallucinations compared to healthy individuals. The main effect of time demonstrated changes in hallucination intensity across the ten trials, with schizophrenia patients showing a progressive increase in hallucination severity over trials. The significant interaction effect further indicated that the temporal pattern of hallucination perception differed between schizophrenia patients and healthy controls, with patients consistently exhibiting higher negative hallucination intensity across trials.

Bonferroni-corrected post hoc analyses were conducted to examine differences in the perception of positive and negative auditory and visual hallucinations across trials. Positive hallucinations, induced in trials HT2, HT3, HT6, HT8, and HT9, showed lower intensity in schizophrenia patients compared to healthy individuals. Conversely, negative hallucinations, presented in HT4, HT5, and HT7, were more pronounced in schizophrenia patients relative to controls. Notably, the placebo intervention significantly attenuated hallucination severity in both groups, particularly during more severe trial conditions (HT7 and HT8), indicating a robust mitigating effect of the placebo on hallucination experiences (see Figure 2 and Table 1).

### Retrieval of Episodic Memory

A two-way repeated-measures ANOVA (Group × Time) on episodic memory retrieval revealed a significant main effect of time [$F(2, 30) = 33.69$, $p < .001$, $\eta p^2 = .36$] and a significant Group × Time interaction [$F(2, 30) = 6.04$, $p < .001$, $\eta p^2 = .09$]. These findings indicated that individuals with schizophrenia exhibited significantly greater impairment in episodic memory retrieval under conditions of induced positive and negative auditory and visual hallucinations compared to healthy controls. The significant interaction effect further demonstrated that the trajectory of episodic memory retrieval across trials differed between schizophrenia patients and healthy participants, with patients consistently showing greater difficulty, particularly in trials involving negative hallucinations.

Bonferroni-corrected post hoc analyses were performed to examine trial-specific differences in memory retrieval under positive and negative hallucination conditions. Positive auditory and visual hallucinations, presented in HT2, HT3, HT6, HT8, and HT9, were associated with lower memory retrieval impairment in schizophrenia patients relative to healthy controls. In contrast, negative hallucinations, presented in HT4, HT5, and HT7, elicited greater episodic memory deficits in schizophrenia patients compared to controls. Importantly, the placebo intervention significantly improved episodic memory retrieval and attenuated the disruptive effects of induced hallucinations in both groups. This effect was particularly pronounced in more severe trials involving negative hallucinations (e.g., Epi7), suggesting that the placebo effectively mitigated hallucination-related memory impairments (see Figure 3 and Table 2).

### Symptoms of Amnesia

A two-way repeated-measures ANOVA (Group × Time) on amnesia symptoms revealed a significant main effect of time [$F(2, 30) = 39.17$, $p < .001$, $\eta p^2 = .40$] and a significant Group × Time interaction [$F(2, 30) = 3.88$, $p < .001$, $\eta p^2 = .06$]. These results indicated that individuals with schizophrenia exhibited significantly greater amnesia symptoms compared to healthy controls. The main effect of time further demonstrated that the severity of amnesia increased across the ten trials in schizophrenia patients. The significant interaction effect revealed that the temporal pattern of amnesia symptoms differed between schizophrenia patients and healthy participants, with patients consistently showing higher symptom levels across trials.

Bonferroni-corrected post hoc analyses examined trial-specific effects of positive and negative hallucinations on amnesia symptoms. Positive auditory and visual hallucinations, presented in HT2, HT3, HT6, HT8, and HT9, were associated with lower amnesia severity in schizophrenia patients relative to healthy individuals. In contrast, negative hallucinations, presented in HT4, HT5, and HT7, elicited greater increases in amnesia symptoms in schizophrenia patients compared to controls. Overall, these findings indicate that negative hallucinations exert a stronger disruptive effect on memory, while positive hallucinations have a comparatively milder impact on amnesia symptoms in

schizophrenia (see Figure 4 and Table 3).

## Symptoms of Anxiety

A two-way repeated-measures ANOVA (Group × Time) on anxiety symptoms revealed a significant main effect of time [$F(2, 30) = 46.26$, $p < .001$, $\eta p^2 = .89$] and a significant Group × Time interaction [$F(2, 30) = 5.56$, $p < .001$, $\eta p^2 = .50$]. These findings indicated that individuals with schizophrenia exhibited significantly higher levels of anxiety compared to healthy controls. The main effect of time further demonstrated a progressive increase in anxiety across the ten trials in schizophrenia patients. The significant interaction effect showed that the trajectory of anxiety symptoms across trials differed between schizophrenia patients and healthy individuals, with patients consistently experiencing higher symptom levels.

Bonferroni-corrected post hoc analyses examined trial-specific effects of positive and negative hallucinations on anxiety. Positive auditory and visual hallucinations, presented in HT2, HT3, HT6, HT8, and HT9, were associated with lower anxiety severity in schizophrenia patients relative to healthy controls. In contrast, negative hallucinations, presented in HT4, HT5, and HT7, elicited stronger increases in anxiety symptoms in schizophrenia patients compared to controls. Importantly, the placebo intervention significantly reduced anxiety in both groups, with the effect most pronounced during more severe trials involving negative hallucinations (e.g., AnxT7), indicating that placebo effectively mitigated hallucination-induced anxiety (see Figure 5 and Table 4).

# Discussion

Schizophrenia is a complex neuropsychiatric disorder characterized by profound impairments in cognitive and emotional functioning, with deficits in attention, processing speed, and both short- and long-term memory considered core features of the pathology (Aleman & Sommer, 2023; Bell et al., 2024; Lincoln et al., 2024; Pérez-Flores et al., 2024). The relationship between psychotic symptoms particularly auditory and visual hallucinations and cognitive dysfunction is well-established (Wykes et al., 2011; Goff et al., 2017). Recent research suggests, however, that the severity and intensity of hallucinatory experiences modulate the extent of cognitive and emotional impairment (Davis & White, 2023).

The present study investigated the effects of experimentally induced positive and negative auditory and visual hallucinations on cognitive functioning—including perception of hallucinations, episodic memory retrieval, and amnesia and emotional functioning, particularly anxiety, in individuals with mild schizophrenia and healthy controls. Results demonstrated that both positive and negative hallucinations disrupted episodic memory, heightened anxiety, and exacerbated amnesia symptoms, with negative hallucinations producing more pronounced impairments across both cognitive and emotional domains. These findings indicate that individuals with mild schizophrenia are particularly susceptible to the deleterious effects of hallucinatory experiences compared to healthy controls, highlighting the need for targeted cognitive and emotional interventions within clinical practice.

The study further explored the efficacy of a placebo intervention in mitigating hallucination-induced cognitive and emotional disturbances. The results revealed that placebo administration significantly reduced hallucination intensity and alleviated associated emotional disturbances, including anxiety and depressive-like symptoms, in both schizophrenia patients and healthy participants. Notably, the placebo effect was observed even in healthy controls, suggesting broad applicability. These findings align with prior research demonstrating that negative hallucinations can trigger cognitive distortions and emotional dysregulation, particularly impairing episodic memory and amplifying anxiety and amnesia (Hohenschurz-Schmidt et al., 2024; Liampas et al., 2024; Shi et al., 2021).

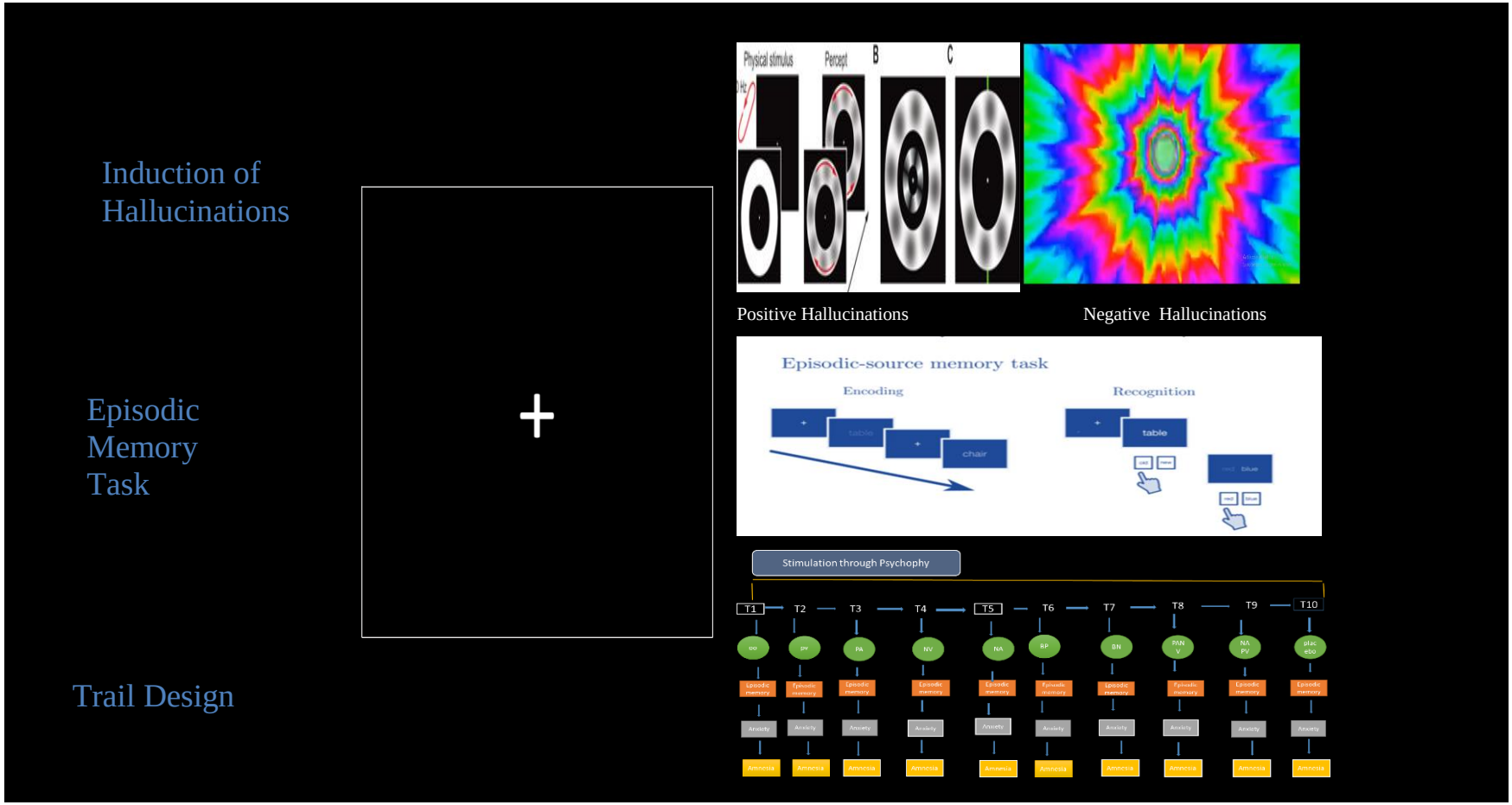
Placebo interventions in schizophrenia care have gained increasing attention in recent years. They are thought to modulate cognitive and emotional outcomes by influencing expectations, thereby reducing symptom severity (Schumann et al., 2024; Price et al., 2017). In the present study, placebo administration not only attenuated hallucination-related cognitive distortions and emotional disturbances but also facilitated mechanisms of emotional regulation and stress reduction. This highlights the potential utility of placebo-based interventions in clinical care, particularly in scenarios where pharmacological treatments are limited by side effects or disease progression.

The findings also support theoretical and empirical evidence that hallucinations disrupt reality monitoring and episodic memory retrieval while contributing to emotional dysregulation, including heightened anxiety (Cangas et al., 2011; Swyer et al., 2024). The study demonstrates that non-pharmacological strategies, such as placebo-based interventions, can effectively improve cognitive and emotional outcomes, offering a promising adjunctive approach to schizophrenia management.

The hypotheses tested in this study were largely supported. Negative hallucinations produced greater impairment in perception, episodic memory, anxiety, and amnesia than positive hallucinations, particularly among schizophrenia patients. Placebo interventions effectively mitigated these negative effects, improving both cognitive and emotional outcomes across groups. These findings are consistent with neuroimaging and experimental evidence indicating that negative hallucinatory experiences reduce activation in brain regions involved in attention, memory, and emotional regulation (Yates et al., 2021; Van Ommen et al., 2023; Powers et al., 2017). The results underscore the role of expectation-driven cognitive-affective mechanisms in modulating hallucination perception and associated cognitive-emotional disturbances.

**Figure 1**

*Stimulation presentation of positive and negative hallucination induction and episodic memory task.*




*Note.* The figure illustrates the stimulation presentation, showing both the positive and negative hallucination induction technique images (Top), the semantic task, accompanied by instructions and trail design (Bottom)**.** TO = Initial trial, T1 = trial one, T2 = trial two, T3 = trial three, T4 = trial four, T5 = trial five, T6 = trial six, T7 = trial seven, T8 = trial eight, T9 = trial nine, T10 = trial ten. Additionally, 00 = initial screening, PV = positive video, PA = positive audio, NV = negative video, NA = negative audio, BP = both positive audio and video, BN = both negative video and audio, PANV = positive audio and negative video, NAPV = negative audio and positive video.

**Table 1**

*Mean differences and Post Hoc analysis in perception of hallucination after exposure to positive and negative induced hallucinations in healthy individuals (N=30) and mild schizophrenia patients (N* = 30).

| | | Healthy individuals *(n=30)* | | Schizophrenia Patients *(n=30)* | | Time | | | Group*time | | | | | | Mean difference *(95% CI)* | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trails | Hallucinations | *M* | *SD* | *M* | *SD* | *F* | *p* | $\eta_p^2$ | *F* | *P* | $\eta_p^2$ | *i-j* | *Mean (i-j)* | *p* | *LL* | *UL* |
| Ht1 | Initial screening | 9.66 | 3.62 | 43.70 | 4.43 | 62.02 | .00 | .51 | 20.06 | 00 | .25 | | | | | |
| Ht2 | Positive visual hallucination | 16.43 | 5.32 | 32.46 | 8.21 | | | | | | | | | | | |
| Ht3 | Positive auditory hallucination | 23.60 | 10.74 | 35.60 | 10.79 | | | | | | | 5.15* | 3>2 | .00 | 1.34 | 8.95 |
| Ht4 | Negative visual hallucination | 29.03 | 7.99 | 40.90 | 7.70 | | | | | | | 8.28* | 4 >1 | .00 | 4.63 | 11.93 |
| | | | | | | | | | | | | 10.51* | 4 >2 | .00 | 7.63 | 13.40 |
| | | | | | | | | | | | | 5.36* | 4 >3 | .00 | 2.23 | 8.49 |
| | | | | | | | | | | | | 7.57* | 4 >9 | .00 | 1.53 | 13.61 |
| | | | | | | | | | | | | 9.01* | 4 >10 | .00 | 4.49 | 13.53 |
| Ht5 | Negative auditory hallucination | 31.06 | 11.12 | 40.40 | 9.85 | | | | | | | 9.05* | 5 >1 | .00 | 4.32 | 13.73 |
| | | | | | | | | | | | | 11.28* | 5 > 2 | .00 | 7.39 | 15.16 |
| | | | | | | | | | | | | 6.13* | 5 >3 | .00 | 2.16 | 10.10 |
| | | | | | | | | | | | | 8.34* | 5 >9 | .00 | 1.62 | 15.06 |
| | | | | | | | | | | | | 9.78* | 5 >10 | .00 | 3.89 | 15.67 |
| Ht6 | Positive auditory and visual hallucination | 30.50 | 9.37 | 38.26 | 6.74 | | | | | | | 7.70* | 6 >1 | .00 | 3.89 | 11.50 |
| | | | | | | | | | | | | 9.93* | 6 >2 | .00 | 6.82 | 13.04 |
| | | | | | | | | | | | | 4.78* | 6 >3 | .00 | 1.17 | 8.38 |
| | | | | | | | | | | | | 6.99* | 6 >9 | .00 | 1.33 | 12.65 |
| | | | | | | | | | | | | 8.43* | 6 >10 | .00 | 3.59 | 13.26 |
| Ht7 | Negative visual and auditory hallucination | 46.73 | 10.74 | 48.63 | 5.45 | | | | | | | 21.00* | 7 >1 | .00 | 16.98 | 25.01 |
| | | | | | | | | | | | | 23.23* | 7 >2 | .00 | 19.54 | 26.91 |
| | | | | | | | | | | | | 18.08* | 7 > 3 | .00 | 13.36 | 22.80 |
| | | | | | | | | | | | | 12.71* | 7 >4 | .00 | 9.63 | 15.79 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | 11.95* | 7 >5 | .00 | 7.71 | 16.18 |
| | | | | | | 13.30* | 7 > 6 | .00 | 10.17 | 16.43 |
| | | | | | | 6.16* | 7 >8 | .00 | 2.99 | 9.34 |
| | | | | | | 20.29* | 7 >9 | .00 | 13.70 | 26.88 |
| | | | | | | 21.73* | 7 >10 | .00 | 16.84 | 26.62 |
| Ht8 | Positive auditory and Negative visual hallucination | 35.86 | 7.20 | 47.16 | 5.62 | | | | | |
| | | | | | | 14.83* | 8 >1 | .00 | 11.56 | 18.10 |
| | | | | | | 17.06* | 8 >2 | .00 | 14.14 | 19.99 |
| | | | | | | 11.91* | 8 >3 | .00 | 7.26 | 16.56 |
| | | | | | | 6.55* | 8 > 4 | .00 | 3.44 | 9.65 |
| | | | | | | 5.78* | 8 >5 | .00 | 1.94 | 9.62 |
| | | | | | | 7.13* | 8 >6 | .00 | 3.47 | 10.78 |
| | | | | | | 14.12* | 8 >9 | .00 | 7.85 | 20.40 |
| | | | | | | 15.56* | 8 >10 | .00 | 10.51 | 20.61 |
| Ht9 | Positive visual and Negative auditory hallucination | 21.87 | 10.58 | 32.90 | 12.18 | | | | | |
| Ht10 | Placebo intervention | 22.50 | 11.03 | 29.40 | 7.62 | | | | | |

*Note.* HT = hallucination trials; M = mean; SD = standard deviation; LL = lower limit; UL = upper limit; Time = exposure to induced positive and negative visual and auditory hallucinations across different trials; Group × Time = interaction between group (schizophrenia patients vs. healthy individuals) and time. *p < .01. **p < .001. ***p < .000

**Table 2**

*Mean Differences and Post Hoc Analysis of Episodic Memory Retrieval Following Positive and Negative Induced Hallucinations in Healthy Individuals (N=30) and Patients with Mild Schizophrenia (N=30)*

| | | Healthy individuals *(n=30)* | | Schizophrenia Patients *(n=30)* | | Time | | | Group*time | | | | | Mean difference *(95% CI)* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trails | Hallucinations | *M* | *SD* | *M* | *SD* | *F* | *p* | $\eta_p^2$ | *F* | *p* | $\eta_p^2$ | *i-j* | *Mean(i-j)* | *p* | *LL* | *UL* |
| Epit1 | Initial screening | 9.10 | 2.38 | 6.40 | 1.06 | 33.624 | 0.000 | 0.366 | 6.044 | 0.000 | 0.094 | 1.10* | 1 >3 | .00 | .25 | 1.94 |
| | | | | | | | | | | | | 1.58* | 1 >4 | .00 | .69 | 2.47 |
| | | | | | | | | | | | | 1.88* | 1 >5 | .00 | 1.00 | 2.75 |
| | | | | | | | | | | | | 1.65* | 1 >6 | .00 | .75 | 2.54 |
| | | | | | | | | | | | | 2.91* | 1 >7 | .00 | 1.99 | 3.84 |
| | | | | | | | | | | | | 1.96* | 1 >8 | .00 | 1.22 | 2.71 |
| | | | | | | | | | | | | 2.15* | 1 >9 | .00 | 1.11 | 3.18 |
| Epit2 | Positive video | 8.13 | 1.77 | 5.80 | 0.71 | | | | | | | .80* | 2 > 4 | .05 | .00 | 1.60 |
| | | | | | | | | | | | | 1.10* | 2 >5 | .00 | .39 | 1.80 |
| | | | | | | | | | | | | .86* | 2 >6 | .00 | .11 | 1.61 |
| | | | | | | | | | | | | 2.13* | 2 >7 | .00 | 1.36 | 2.89 |
| | | | | | | | | | | | | 1.18* | 2 > 8 | .00 | .45 | 1.91 |
| | | | | | | | | | | | | 1.36* | 2 >9 | .00 | .51 | 2.22 |
| Epit3 | Positive audio | 8.06 | 1.76 | 5.23 | 0.62 | | | | | | | .78* | 3 >5 | .00 | .12 | 1.43 |
| | | | | | | | | | | | | .55* | 3 > 6 | .01 | .05 | 1.04 |
| | | | | | | | | | | | | 1.81* | 3 > 7 | .00 | 1.10 | 2.53 |
| | | | | | | | | | | | | .86* | 3 > 8 | .00 | .18 | 1.54 |
| | | | | | | | | | | | | 1.05* | 3 > 9 | .00 | .31 | 1.78 |
| Epit4 | Negative video | 7.00 | 1.48 | 5.33 | 0.84 | | | | | | | 1.33* | 4 > 7 | .00 | .73 | 1.93 |
| Epit5 | Negative audio | 6.53 | 1.40 | 5.20 | 0.80 | | | | | | | 1.03* | 5 > 7 | .00 | .39 | 1.66 |
| Epit6 | Positive audio and video | 7.36 | 1.58 | 4.83 | 0.79 | | | | | | | 1.26* | 6 > 7 | .00 | .62 | 1.90 |
| Epit7 | Negative video and audio | 4.96 | 0.96 | 4.70 | 0.70 | | | | | | | | | | | |
| Epit8 | Positive audio Negative video | 6.40 | 1.03 | 5.16 | 0.69 | | | | | | | .95* | 8 > 7 | .00 | .38 | 1.51 |
| Epit9 | Positive video Negative audio | 6.30 | 2.45 | 4.90 | 0.88 | | | | | | | | | | | |
| Epit10 | Placebo | 8.60 | 2.09 | 7.03 | 1.09 | | | | | | | 1.16* | 10 >3 | .00 | .33 | 1.99 |
| | | | | | | | | | | | | 1.65* | 10 >4 | .00 | .77 | 2.52 |
| | | | | | | | | | | | | 1.95* | 10 >5 | .00 | 1.01 | 2.88 |
| | | | | | | | | | | | | 1.71* | 10 >6 | .00 | .82 | 2.60 |
| | | | | | | | | | | | | 2.98* | 10 >7 | .00 | 2.20 | 3.76 |
| | | | | | | | | | | | | 2.03* | 10 >8 | .00 | 1.20 | 2.86 |
| | | | | | | | | | | | | 2.21* | 10 >9 | .00 | 1.23 | 3.20 |

*Note*. *Epit* = episodic memory trial; *M* = mean; *SD* = standard deviation; *LL* = lower limit; *UL* = upper limit; Time = exposure to induced hallucinations; Group × Time = interaction between group (schizophrenia patients vs. healthy individuals), $p < .01$. $p < .001$. $\boldsymbol{p} < .0001$.

**Table 3**

*Mean Differences in Amnesia Symptoms Following Exposure to Induced Positive and Negative Visual and Auditory Hallucinations in Healthy Individuals (N = 30) and Mild Schizophrenia Patients (N = 30).*

| | | Healthy individuals (n=30) | | Schizophrenia Patients (n=30) | | Time | | | Group*time | | | | | Mean difference (95% CI) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trails | Hallucinations | *M* | *SD* | *M* | *SD* | *F* | *P* | $\eta_p^2$ | *F* | *P* | $\eta_p^2$ | *i-j* | *Mean( i-j)* | *P* | *UL* | *LL* |
| Alabt1 | Initial screening | 8.36 | 1.29 | 8.00 | 0.69 | 39.17 | .00 | .40 | 3.88 | .00 | .06 | .85* | 1>3 | .00 | .15 | 1.54 |
| | | | | | | | | | | | | .91* | 1 >4 | .03 | .03 | 1.79 |
| | | | | | | | | | | | | .85* | 1>5 | .02 | .05 | 1.64 |
| | | | | | | | | | | | | 1.30* | 1 >6 | .00 | .64 | 1.95 |
| | | | | | | | | | | | | 3.26* | 1 >7 | .00 | 2.51 | 4.01 |
| | | | | | | | | | | | | 1.60* | 1 >8 | .00 | .95 | 2.24 |
| | | | | | | | | | | | | 2.48* | 1 > 9 | .00 | 1.64 | 3.32 |
| Alabt2 | Positive visual hallucination | 7.60 | 1.49 | 7.36 | 1.21 | | | | | | | .60* | 2>6 | .01 | .07 | 1.12 |
| | | | | | | | | | | | | 2.56* | 2 >7 | .00 | 1.71 | 3.41 |
| | | | | | | | | | | | | .90* | 2>8 | .00 | .24 | 1.55 |
| | | | | | | | | | | | | 1.78* | 2>9 | .00 | .85 | 2.71 |
| Alabt3 | Positive auditory hallucination | 7.66 | 1.21 | 7.00 | 1.17 | | | | | | | 2.41* | 3>7 | .00 | 1.48 | 3.34 |
| | | | | | | | | | | | | .75* | 3>8 | .00 | .22 | 1.28 |
| | | | | | | | | | | | | 1.63* | 3>9 | .00 | .82 | 2.44 |
| Alabt4 | Negative visual hallucination | 7.33 | 1.47 | 7.20 | 1.78 | | | | | | | 2.35* | 4>7 | .00 | 1.20 | 3.49 |
| | | | | | | | | | | | | 1.56* | 4>9 | .00 | .67 | 2.46 |
| Alabt5 | Negative auditory hallucination | 7.66 | 1.68 | 7.00 | 1.55 | | | | | | | 2.41* | 5 >7 | .00 | 1.41 | 3.42 |
| | | | | | | | | | | | | .75* | 5 >8 | .02 | .04 | 1.45 |
| | | | | | | | | | | | | 1.63* | 5 >9 | .00 | .76 | 2.50 |
| Alabt6 | Positive auditory and visual hallucinations | 6.83 | 1.39 | 6.93 | 0.94 | | | | | | | 1.96* | 6 >7 | .000 | 1.18 | 2.74 |
| Alabt7 | Negative visual and auditory hallucinations | 5.20 | 0.96 | 4.63 | 1.79 | | | | | | | | | | | |
| Alabt8 | Positive auditory Negative visual hallucinations | 5.86 | 0.86 | 7.30 | 1.05 | | | | | | | 1.66* | 8 >7 | .00 | .80 | 2.52 |
| Alabt9 | Positive visual Negative auditory hallucinations | 5.43 | 1.30 | 5.96 | 1.60 | | | | | | | .88* | 8 >9 | .00 | .17 | 1.59 |
| Alabt10 | Placebo interventions | 8.33 | 1.26 | 8.03 | 1.58 | | | | | | | .85* | 10 >3 | .01 | .08 | 1.61 |
| | | | | | | | | | | | | .91* | 10 > 4 | .05 | .00 | 1.83 |
| | | | | | | | | | | | | 1.30* | 10 > 6 | .00 | .48 | 2.11 |
| | | | | | | | | | | | | 3.26* | 10 >7 | .00 | 2.26 | 4.26 |
| | | | | | | | | | | | | 1.60* | 10 >8 | .00 | 1.00 | 2.19 |
| | | | | | | | | | | | | 2.48* | 10 > 9 | .00 | 1.51 | 3.45 |

*Note.* Alabt= Amnesia trail; M=Mean; SD=Standard deviation; LL= lower limit; UL=Upper limit; Time = Exposure to induce hallucinations; Group × Time = Interaction between group (schizophrenia patients vs. healthy individuals), $p < .01$. $p < .001$. $\boldsymbol{p} < .0001$.

**Table 4**

*Mean Differences and Post Hoc Analysis of Anxiety Symptoms Following Visual and Auditory Induced Hallucinations in Healthy Individuals (N = 30) and Mild Schizophrenia Patients (N = 30).*

| | | Healthy individuals *(n=30)* | | Schizophrenia Patients *(n=30)* | | Time | | | Group*time | | | | | Mean difference *(95% CI)* | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Trails | Hallucinations | *M* | *SD* | *M* | *SD* | *F* | *P* | $\eta_p^2$ | *F* | *P* | $\eta_p^2$ | *i-j* | *Mean(i-j)* | *p* | *LL* | *UL* |
| Anxt1 | Initial screening | 8.76 | 4.50 | 29.00 | 11.59 | 104.99 | .00 | .64 | 9.27 | .00 | .138 | | | | | |
| Anxt2 | Positive visual hallucination | 17.20 | 9.81 | 36.80 | 5.73 | | | | | | | 8.11* | 2>1 | .00 | 3.20 | 13.02 |
| Anxt3 | Positive auditory hallucination | 25.70 | 12.99 | 37.80 | 5.68 | | | | | | | 12.86* | 3>1 | .00 | 7.49 | 18.24 |
| Anxt4 | Negative visual hallucination | 32.93 | 12.63 | 41.80 | 9.60 | | | | | | | 18.48* | 4 > 1 | .00 | 12.77 | 24.19 |
| | | | | | | | | | | | | 10.36* | 4 > 2 | .00 | 5.35 | 15.38 |
| | | | | | | | | | | | | 5.61* | 4 > 3 | .00 | 2.04 | 9.19 |
| | | | | | | | | | | | | 8.13* | 4 > 10 | .00 | 2.78 | 13.47 |
| Anxt5 | Negative auditory hallucination | 35.40 | 12.10 | 45.16 | 7.91 | | | | | | | 21.40* | 5 > 1 | .00 | 15.84 | 26.95 |
| | | | | | | | | | | | | 13.28* | 5 > 2 | .00 | 8.91 | 17.65 |
| | | | | | | | | | | | | 8.53* | 5 >3 | .00 | 4.48 | 12.58 |
| | | | | | | | | | | | | 11.05* | 5 > 10 | .00 | 5.20 | 16.89 |
| Anxt6 | Positive auditory and visual hallucinations | 36.53 | 10.70 | 45.93 | 4.84 | | | | | | | 22.35* | 6 >1 | .00 | 17.29 | 27.40 |
| | | | | | | | | | | | | 14.23* | 6 >2 | .00 | 10.43 | 18.03 |
| | | | | | | | | | | | | 9.483* | 6 > 3 | .00 | 5.64 | 13.32 |
| | | | | | | | | | | | | 12.00* | 6 > 10 | .00 | 7.28 | 16.71 |
| Anxt7 | Negative visual and auditory hallucinations | 45.13 | 13.50 | 50.56 | 7.35 | | | | | | | 28.96* | 7 >1 | .00 | 22.81 | 35.12 |
| | | | | | | | | | | | | 20.85* | 7 >2 | .00 | 15.84 | 25.85 |
| | | | | | | | | | | | | 16.10* | 7 >3 | .00 | 11.60 | 20.60 |
| | | | | | | | | | | | | 10.48* | 7 >4 | .00 | 5.60 | 15.36 |
| | | | | | | | | | | | | 7.56* | 7 > 5 | .00 | 3.26 | 11.87 |
| | | | | | | | | | | | | 6.61* | 7 > 6 | .00 | 3.34 | 9.89 |
| | | | | | | | | | | | | 18.61* | 7 >10 | .00 | 13.12 | 24.10 |
| Anxt8 | Positive auditory and Negative visual hallucinations | 42.60 | 9.24 | 46.33 | 6.16 | | | | | | | 25.58* | 8 >1 | .00 | 19.66 | 31.50 |
| | | | | | | | | | | | | 17.46* | 8 >t2 | .00 | 13.54 | 21.38 |
| | | | | | | | | | | | | 12.71* | 8 >3 | .00 | 8.32 | 17.11 |
| | | | | | | | | | | | | 7.10* | 8 >4 | .00 | 1.72 | 12.48 |
| | | | | | | | | | | | | 15.23* | 8 >10 | .00 | 9.56 | 20.90 |
| Anxt9 | Positive visual and Negative auditory hallucinations | 47.70 | 10.45 | 53.80 | 4.38 | | | | | | | 31.86* | 9 >1 | .00 | 26.27 | 37.45 |
| | | | | | | | | | | | | 23.75* | 9 >2 | .00 | 18.90 | 28.59 |
| | | | | | | | | | | | | 19.00* | 9 >3 | .00 | 14.21 | 23.78 |
| | | | | | | | | | | | | 13.38* | 9 >4 | .00 | 8.31 | 18.45 |
| | | | | | | | | | | | | 10.46* | 9 >5 | .00 | 5.84 | 15.09 |
| | | | | | | | | | | | | 9.51* | 9 >6 | .00 | 6.16 | 12.86 |
| | | | | | | | | | | | | 6.28* | 9 >8 | .00 | 2.90 | 9.66 |
| | | | | | | | | | | | | 21.51* | 9 >10 | .00 | 15.86 | 27.16 |
| Anxt10 | Placebo intervention | 20.40 | 10.72 | 38.06 | 11.89 | | | | | | | 10.35* | 10 >1 | .00 | 4.95 | 15.74 |

*Note.* Anxt= Anxiety trail; M=Mean; SD=Standard deviation; LL= lower limit; UL=Upper limit; Time = Exposure to induce hallucinations; Group × Time = Interaction between group (schizophrenia patients vs. healthy individuals), $p < .01$. $p < .001$. ***p*** < *.0001*.

**Figure 2**

*Mean Differences in Perceptions of Induced Positive and Negative Auditory and Visual Hallucinations in Healthy Individuals and schizophrenia Patients.*

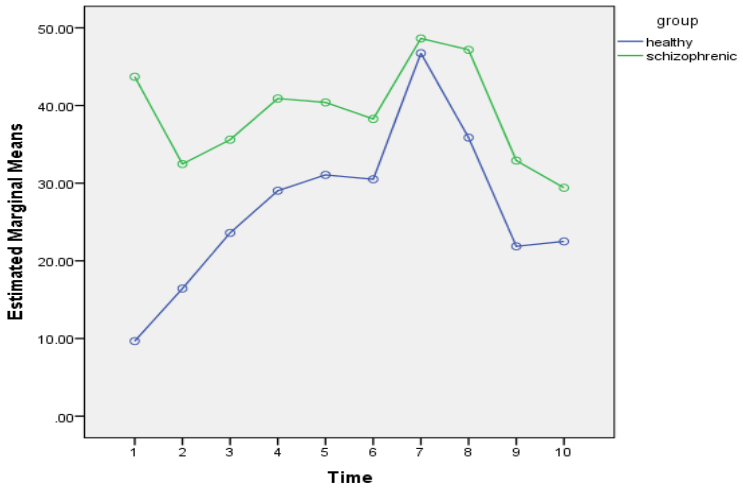



**Figure 3**

*Mean Differences in episodic memory Retrieval after Induced Negative and Positive Auditory and Visual Hallucinations in Healthy Individuals and schizophrenia Patients.*

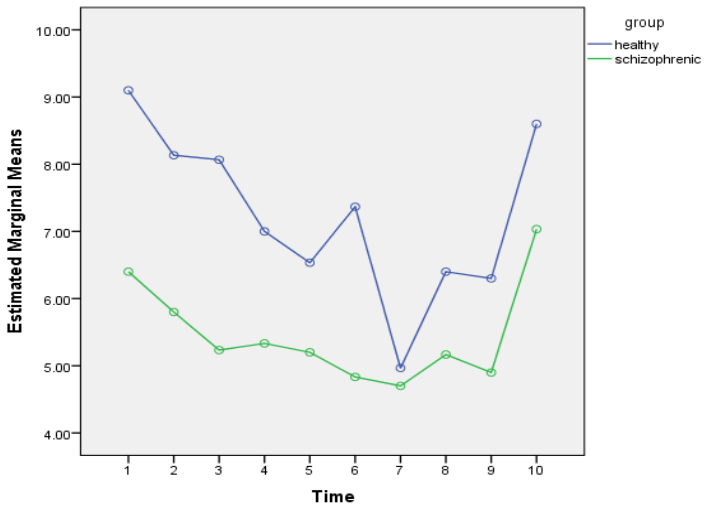


**Figure 4**

*Mean Differences in Symptoms of Amnesia after Induced Negative and Positive Auditory and Visual Hallucinations in Healthy Individuals and Schizophrenia Patients.*

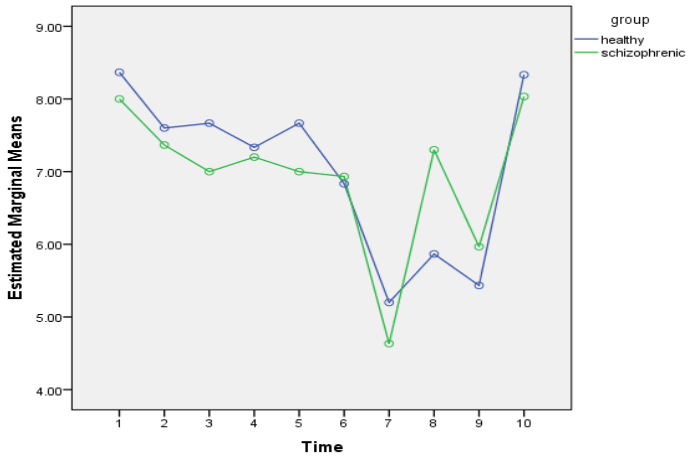
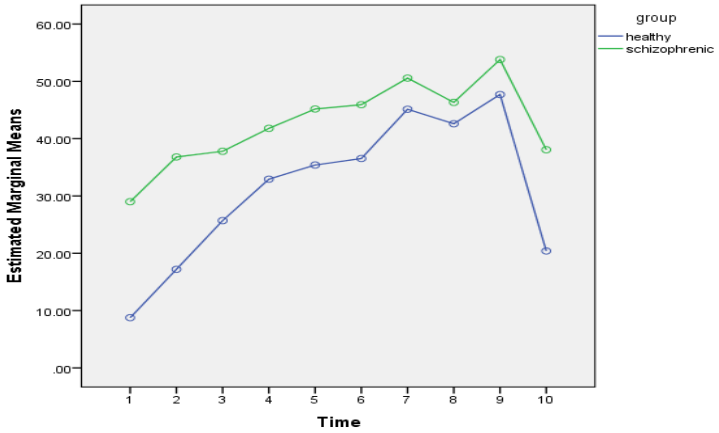



**Figure 5**

*Mean Differences in Symptoms of Anxiety after Induced Negative and Positive Auditory and Visual Hallucinations in Healthy Individuals and Schizophrenia Patients.*



## Novel Contributions

This study makes several important contributions to schizophrenia research. It employed a rigorous double-blind, placebo-controlled, mixed design, allowing precise examination of the differential effects of positive and negative hallucinations on cognitive and emotional functioning. Using a PsychoPy-based controlled hallucination induction paradigm, the study provided a novel, systematic approach to assess hallucination-related changes in perception, episodic memory, amnesia, and anxiety. Importantly, it demonstrated the potential of placebo-based, non-pharmacological interventions to mitigate these disturbances in both schizophrenia patients and healthy individuals. By integrating cognitive and emotional measures within a culturally sensitive Pakistani sample, the study offers contextually relevant insights and multidisciplinary implications for clinical practice, theory, and future research on emotion regulation, neuroplasticity, and cognitive decline.

## Limitations and Future Directions

Despite its contributions, this study has some limitations. The relatively small and demographically homogeneous sample limits the generalizability of the findings, highlighting the need for future research with larger, more diverse populations to examine cultural, demographic, and clinical moderators of hallucination and placebo effects. Additionally, the study focused on short-term outcomes, and longitudinal research is needed to assess the durability of placebo interventions on cognitive and emotional functioning over time. Future studies should also employ advanced neuroimaging techniques (e.g., fMRI, PET) to clarify the neural mechanisms underlying hallucination perception, placebo responses, and related cognitive-emotional changes. Moreover, integrating placebo-based approaches with standard treatments, such as cognitive-behavioral therapy or pharmacological management, may enhance therapeutic outcomes. Finally, investigating individual differences such as expectancy, personality traits, and neurocognitive profiles could refine and personalize the application of non-pharmacological interventions in schizophrenia.

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## Conclusion

This study demonstrates that experimentally induced auditory and visual hallucinations significantly impair episodic memory and exacerbate amnesia and anxiety, particularly among individuals with mild schizophrenia. Negative hallucinations produced more pronounced cognitive and emotional disturbances than positive hallucinations. Importantly, placebo interventions effectively mitigated these effects, improving memory retrieval, reducing anxiety and amnesia, and supporting emotional regulation in both schizophrenia patients and healthy controls.

The findings underscore the importance of comprehensive hallucination management, integrating non-pharmacological strategies alongside conventional care to enhance cognitive and emotional outcomes. Future research should further investigate the mechanisms, long-term efficacy, and clinical integration of placebo and expectation-based interventions, offering alternative avenues for managing hallucinations and related cognitive-emotional deficits in schizophrenia.

## Ethical Consideration

The study was approved by Department of Psychology, Cognitive and Neuroscience Laboratory, Foundation University Islamabad, Pakistan. Consent Form was taken before taking data and participants were asked to take voluntary participation.

## Acknowledgement

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## Availability of data and materials

The data sets used and analyzed during the current study are available from the corresponding author on reasonable request.

## Authors' contributions/Author details

Noureen Bibi conducted this study under the supervision of Dr.Muhammad Aqeel

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