Effects of Time Pressure on Visual Search and The Modulatory Role of Short-Term Guided Meditation on Stress-Related Brain Regions

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ABSTRACT:
This study used a visual search task created in PsychoPy to examine the effects of brief guided meditation on cognitive function under time constraints. The test was done in two phases, before and after a 5-day meditation intervention, by ten individuals with normal or corrected vision, both with and without a time-based stressor. In order to target the brain regions involved in stress regulation and attention—specifically, the hypothalamus, thalamus, and hippocampus—the meditation routine combined Nadi Shodhana (alternate nostril breathing), yogic postures (Vrikshasana, Paschimottanasana, Sarvangasana), Trataka, or mindfulness meditation, and Bhramari (humming breath).
According to pre-test data, during stress, reaction times were slower, which may indicate cognitive strain and attentional overload. Even under pressure, participants' reaction times were faster or more stable, according to post-intervention data, indicating increased attentional control, emotional control, and cognitive flexibility. These modifications are consistent with the INLM concept (Information, Need, Limitations, Mechanisms), which describes how adaptive mechanisms and internal regulation might improve cognitive function in the face of limitations. In order to enhance mental effectiveness and stress resilience in cognitively taxing circumstances, this study advocates the incorporation of holistic, not pharmaceutical in nature practices such as yoga and mindfulness.

KEYWORDS: Visual Search , Reaction time, Psychopy, Hypothalamus, Hippocampus , Thalamus.

PURPOSE OF THE STUDY:
This study sought to determine whether brief guided meditation might enhance performance under stress and how time constraint affects reaction speed during a visual search task. Using the INLM model and the tenets of holistic psychology, the study concentrated on the functions of the hippocampus (working memory and learning), thalamus (attention and sensory relay), and hypothalamus (stress and arousal).

INTRODUCTION
Specialized areas of the human brain cooperate to facilitate emotional and cognitive processes. The hypothalamus, thalamus, auditory cortex, and hippocampus are the four main brain regions that are the

subject of this study. The hypothalamus affects motivation and emotional reactions by controlling internal states like hunger, stress, and arousal. As a sensory relay hub, the thalamus helps people pay attention and stay awake by sending information to the right cerebral regions. In order to help with sound detection and attentional shifts, the auditory cortex processes auditory stimuli. For learning, memory formation, and spatial navigation, the hippocampus is essential. This study links brain activity with cognitive reaction by examining the effects of time pressure (through a timer) on visual search performance. A framework for comprehending this relationship is offered by the INLM model (Information, Need, Limitations, and Mechanisms). Cognitive systems must maintain goal-directed behaviour while juggling limited attentional resources and memory capacity when under time pressure. This stimulates areas of the brain such as the hippocampus (working memory), thalamus (sensory filtering), and hypothalamus (stress/arousal). The significance of reaction time in cognitive processing—a crucial component of learning and decision-making—makes this study significant. Gaining an understanding of these systems is useful in high-stakes situations like emergency response or aviation, as well as in educational settings and user interface design.

HOLISTIC PSYCHOLOGY PERSPECTIVE:

Holistic psychology holds that emotional, bodily, and cognitive conditions all affect mental function. Guided meditation seems to improve mind-body awareness and emotional regulation in this study, allowing participants to react calmly and efficiently even under time constraints. The idea that enhancing one's internal well-being can result in improved performance on cognitive activities is supported by this.

THE INLM MODEL

INLM DOMAIN	DEFINITION IN CONTEXT	STUDY APPLICATION	INTERPRETATION BASED ON SCORES
INFORMATION	The task-relevant input that needs to be processed under pressure. In your study: the letters on screen (L and T).	Participants had to visually scan and identify the target letter “T” among distractors (L), which required attention and visual discrimination.	Pre-test: Participants showed delayed reaction times under time pressure, indicating **difficulty in quickly processing visual information**. Post-test: Improved scores suggest **faster recognition and better information processing**, especially under stress.
NEED	The goal-directed demand or purpose of the task. Here: completing the task accurately and quickly under a timer.	Participants were expected to complete the visual search under a 10-minute constraint in one condition, which added cognitive urgency.	Pre-test: Time constraints increased stress and reduced performance. Post-test: Scores were more stable or improved even under pressure, showing **enhanced goal focus and motivation control**.

LIMITATIONS	Internal cognitive constraints like stress, memory load, divided attention, or emotional interference.	High arousal, stress, and limited working memory under the timer likely interfered with participants' ability to focus.	Pre-test: High variability and slower scores with the stressor indicate **mental fatigue and cognitive overload**. Post-test: Lower variability and faster times show **reduced internal cognitive strain**, possibly due to meditation.
MECHANISMS	The adaptive strategies or cognitive tools used to cope with pressure—such as attention control, emotional regulation, or working memory support.	The 5-day meditation routine activated mechanisms like breath control, emotional stability, and focused attention.	Post-test: Improved reaction times under the stressor indicate **stronger self-regulation and attentional filtering mechanisms**, involving the thalamus, hypothalamus, and hippocampus.

INTERVENTION:

Participants were given instructions to follow a systematic 5-day holistic intervention that combined physical postures, mindfulness exercises, and yogic breathing in order to alleviate stress and modulate cognitive function under time pressure. Every day, participants took part in:

Three to five minutes of alternating nostril breathing, or Nadi Shodhana, is a pranayama method that is known to balance the autonomic nerve system and lower physiological arousal. This calms the hypothalamus, which controls stress, internal states, and emotional reaction.

Ten to fifteen minutes of yoga poses, such as Sarvangasana (shoulder stand), Paschimottanasana (sitting forward bend), and Vrikshasana (tree pose): By strengthening attentional concentration and sensory integration, these poses stimulate thalamic functioning, increase body awareness, and increase blood flow to the brain. Through the hypothalamus, they also support emotional equilibrium and endocrine activity regulation.

Five minutes of mindfulness or Trataka (focused gaze meditation): By teaching the brain to filter distractions and improve cognitive control over internal impulses, this component targets the hippocampus and improves working memory and sustained attention.

Finally, three minutes of Bhramari (humming bee breath): In addition to stabilising attention through thalamic sensory filtering, this moderate breathing method produces calming vibrations that activate the vagus nerve, encouraging relaxation and improving emotional regulation through the hypothalamus.

RELEVANCE:

Modern cognitive contexts, where people frequently operate under pressure and deadlines, are relevant to this topic. It advances our knowledge of how the brain's attention, memory, and stress-reduction mechanisms react to outside stimuli. It also demonstrates how brief meditation can improve focus and reaction times, which are important abilities for high-stakes work, and emergency decision-making. By combining cognitive neuroscience with comprehensive mental training, this study provides a practical and empirically supported approach to enhance performance under pressure in the real world.

LITERATURE REVIEW

1. How does Hypothalamus respond to stress?

Robert J. Douglas (1967) suggested that the hippocampus does more than only store memories; it also serves as an inhibitory structure, aiding in the suppression of dominant or automatic responses. After lesion investigations revealed no significant alterations in these domains, early notions that connected it to emotion or scent were rejected. Douglas re-examined the Scoville and Milner (1957) case, pointing out that whereas animals exhibit erratic outcomes, humans who suffer hippocampus damage experience memory loss, indicating a working memory involvement. Studies on lesions showed deficiencies in inhibition, including poor perseverance and passive avoidance. Douglas delineated four primary roles, supported by neurophysiological data such as feedback circuits and theta rhythms: working memory, attentional gating, internal inhibition, and stimulus-response suppression.

2. The Hippocampus and behaviour

The hippocampus was reinterpreted by Robert J. Douglas in 1967 as a structure essential for inhibitory regulation, not a repository for emotion or memory. Lesion tests that revealed no consistent abnormalities in scent or emotion disproved early notions that linked it to these senses. Animal studies demonstrated intact or even better learning following hippocampus removal, despite cases like Scoville and Milner (1957) showing catastrophic memory loss in humans. This suggests the hippocampus plays a function in filtering interference and modulating attention, rather than retaining memories. In tests requiring behavioural flexibility, including habituation, reversal learning, and passive avoidance, animals with lesions consistently shown deficiencies. Douglas endorsed the following four major theories of hippocampus function: working memory support, attentional filtering, internal inhibition, and stimulus-response suppression. This involvement was backed by neurophysiological data, such as theta rhythms and feedback circuits. The unique function of the hippocampus in regulating adaptive behaviour was validated by comparisons with lesions in the frontal cortex, cingulate, and amygdala. Douglas's research changed our concept of the hippocampus from a memory archive to a dynamic cognitive regulator, laying the groundwork for contemporary hypotheses of its participation in executive function, attention, and behavioural control.

3. The hippocampus , memory and consciousness

The hypothalamus is essential for controlling mood, appetite, stress, reproduction, and circadian rhythms. It is a major target of neurodevelopmental study because of its early development and participation in a number of illnesses, as highlighted by Swaab (1995). At birth, the brain's circadian clock, known as the suprachiasmatic nucleus (SCN), is partially operational. By the age of ten, sex differences start to show as it matures postnatally. TH expression represents stress reactions to prenatal hypoxia, whereas CRH neurons affect the time of delivery. Although the exact cause is unknown, hypothalamic neurotransmitter abnormalities are seen in SIDS. Swaab comes to the conclusion that understanding both normal and abnormal neurodevelopment requires an understanding of early hypothalamic development, sexual differentiation, and hormone regulation. Because of its intricate structure, the hypothalamus is still little understood despite its significance.

4. Development of the Human Hypothalamus

The anatomical differences in the hypothalamus by gender and sexual orientation were investigated by Swaab and Hofman (1994). Some regions of the brain, such as the SCN and INAH-3, are larger in males than in women due to sexual dimorphism. INAH-3 is frequently found to be smaller in gay men, which makes it more akin to the size usually observed in heterosexual women.These variations imply that sexual orientation has a neurodevelopmental basis. These trends are attributed by the authors to prenatal hormone exposure, specifically testosterone and its aromatisation to oestradiol, which affects hypothalamic development during critical times. Early-life programming is indicated by the limited postnatal alterations. They acknowledged the paucity of information on transgender people and made a distinction between gender identity and sexual orientation. Their research, which emphasised that sexual orientation is biologically based, not a pathology, generated important scientific and ethical arguments despite depending on postmortem investigations and tiny sample sizes.

5. Meditation

Meditation's significance in improving cognitive function is well-supported by Michael West's (1979) review, which examines its psychophysiological effects, personality changes, and clinical applications. According to the study, frequent meditation improves emotional stability, raises alpha and theta brainwave activity, and lowers physiological arousal (heart rate, respiration, etc.), all of which promote better attention and stress management. Meditation is a promising therapy for controlling stress-related cognitive limitations since clinical studies have shown that it can help reduce anxiety, sleeplessness, and hypertension. These observations have an immediate impact on the current investigation, in which individuals showed enhanced cognitive control and reaction time under time constraints after a 5-day meditation regimen.

METHODOLOGY:

The impact of time constraints and meditation on visual search performance was examined in this study utilising a within-subjects design using PsychoPy. An initial test and a post-meditation test five days later comprised the two stages of the investigation. In the first stage, 10 individuals with normal or corrected-to-normal vision performed a visual search task in two different ways: with and without a timer. The first condition involved a 10 minute time limit. The objective was to locate and click on the target letter "T" among the distractor letters "L," which were positioned at random. To determine how time constraint affected cognitive function, reaction times were measured. To account for order effects, both conditions were given in a counterbalanced order. Following the initial testing, participants were given instructions to engage in daily guided meditation for five days with the goal of boosting memory and learning (hippocampus), lowering stress (hypothalamus), and increasing focus (thalamus). To assess performance changes, the same visual search task was administered again after this meditation period, with and without a timer. Informed consent, confidentiality, and voluntary participation were all adhered to, and the experiment was carried out in a quiet and closed space free from disturbance , inside an environment free from outside influences.

RESULT and DISCUSSION:

PRE TEST:

PARTICIPANT NAME	WITHOUT STRESSOR	WITH STRESSOR	TIME
Participant 1	8.616792	9.205035	9 min 20 sec
Participant 2	2.652905	3.97591	9 min 55 sec
Participant 3	2.073317	2.820598	6 min 53 sec
Participant 4	1.733644	1.76795	6 min 45 sec
Participant 5	4.867203	4.205571	10 minutes
Participant 6	4.316325	3.480764	Above 10 min
Participant 7	1.826724	2.553322	5 mins 64 sec
Participant 8	1.621052	2.97591	6 min 40 sec
Participant 9	1,651103	2.469182	5 min 10 sec
Participant 10	2.379007	3.498668	8 min 16 sec

According to the pre-test results, most participants had slower reaction times while under time pressure; the average reaction time increased from 3.17 seconds when there was no stressor to 3.69 seconds when there was. This pattern implies that time limitations reduced effectiveness during the visual search task by acting as a cognitive stressor. The longer reaction times suggest that participants were under strain and probably faced with greater mental load, diminished attentional control, and potential emotional interference. This corresponds with the anticipated activation of the hippocampus (working memory strain), thalamus (sensory overload), and hypothalamus (stress response). Individual differences in stress tolerance are evident in the fact that only a small percentage of subjects performed better under stress. Time pressure can have negative effects on cognitive performance, particularly when it comes to activities that demand rapid decision-making and focused visual attention, according to the pre-test data.

POST TEST

PARTICIPANT NAME	WITHOUT STRESSOR	WITH STRESSOR	TIME
Participant 1	2.741057902	1. 839833	6 min 57 sec
Participant 2	3.939406581	1.385818986	4 min 93 sec
Participant 3	2.102941646	1.587967443	5 min 59 sec
Participant 4	1.479571156	3.255212639	10 min

Participant 5	**2.889076**	**2.707462431**	**8 min 94 sec**
Participant 6	**3.821944797**	**2.142894**	**7 min 68 sec**
Participant 7	**1.22098**	**1.4386**	**4 min 85 sec**
Participant 8	**1.99774161**	**2.332845167**	**8 min 6 sec**
Participant 9	**1.603824028**	**1.64392855**	**4 min 58 sec**
Participant 10	**2446732045**	**2.00653**	**8 min 40 sec**

Following a 5-day meditation session, the post-test scores reveal a reversal of the pre-test trend. Participants' mean reaction times improved from 2.26 seconds (without stressor) to 2.06 seconds (with stressor), indicating that they generally replied more quickly when under time pressure. This modest but significant improvement (average gain of -0.20 seconds) raises the possibility that meditation improved individuals' capacity to stay composed, concentrated, and cognitively adaptable under pressure. A number of participants now displayed decreased or neutral reaction times, which suggests greater working memory (hippocampus), more effective sensory processing (thalamus), and better emotional control (hypothalamus), in contrast to the pre-test when stress typically resulted in worse performance. The INLM model, which argues that when given tools like mindfulness, the brain can modify its systems to handle cognitive load, is supported by this. The findings support meditation as a useful strategy for increasing mental capacity and stress tolerance during time-sensitive tasks.

LIMITATIONS:

1. **Small Sample Size:** The study only included ten people, which restricts how broadly the results may be applied. It is challenging to reach firm, population-level conclusions when the sample size is limited because it decreases statistical power and enhances the influence of individual variability.
2. **Lack of Objective Monitoring:** Participants were instructed to meditate daily, but their actual compliance with the intervention was not tracked through logs, apps, or biometric tools. Without objective tracking, it's uncertain whether the effects observed can be fully attributed to consistent meditation practice.
3. **Short Intervention Period:** The guided meditation was conducted over just five days. Although short term benefits were observed, this duration may not be long enough to produce lasting neuroplastic or emotional regulation changes. Longer-term interventions might show more robust cognitive gains.
4. **Individual Variability:** Participants' baseline cognitive abilities, stress tolerance, and past mindfulness or meditation experience probably varied. These individual differences might have affected how successful the intervention was for each person, but they were never measured nor controlled for.
5. **Uncontrolled Environmental Factors:** The results of the experiment may have been uncontrollably unpredictable due to factors including participant exhaustion, the time of day, personal distractions, or emotional state during testing sessions, even though the experiment was carried out in a quiet indoor environment.

RECOMMENDATION:

This study demonstrates how beneficial short-term guided meditation is as a useful strategy to enhance cognitive function under pressure. It is advised that clinical therapy programs, educational settings, and performance-intensive occupations including emergency services, aviation, and competitive learning environments all include systematic mindfulness activities, even if they are only for five days. According to these findings, these techniques are appropriate for students, workers, and those who are subjected to time-based cognitive problems since they promote improved attention management, working memory, and stress reduction. Future programs should focus on participant motivation and adherence while incorporating regular meditation practices accompanied by visual or auditory instruction.

CONCLUSION:

The study's findings offer compelling proof that brief guided meditation can improve cognitive function, especially when it comes to tasks requiring sustained attention and fast decision-making under time constraints. When given a stressor (such as a timer) during the pre-test phase, participants often showed shorter reaction times, suggesting that cognitive load, emotional arousal, and attentional fragmentation had a detrimental effect on their performance. This pattern is consistent with the functions of the thalamus, which controls attention gating and sensory relay; the hippocampus, which promotes working memory and inhibition; and the hypothalamus, which reacts to stress and controls arousal.Participants' performance showed a significant change after the 5-day mindfulness-based intervention. With the same time limits, many people showed faster or more consistent reaction speeds on the post-test, indicating a discernible increase in executive control and stress resilience. Better top-down control of emotional reactions, more cognitive flexibility, and greater attentional stability—all of which indicate stronger functional involvement of the brain's attentional and emotional systems—are probably the causes of these improvements.This change is well explained by the INLM model (Information–Need–Limitations–Mechanisms), which states that in order to maintain performance under cognitive stress, people must filter pertinent information, identify internal limitations (such as memory and focus capacity), and use adaptive mechanisms. By strengthening these adaptive mechanisms, such as self-regulation, attentional switching, and suppression of intrusive thoughts, the meditation intervention seemed to help participants maintain goal-directed behaviour more successfully.Furthermore, these results are consistent with holistic psychology's tenets, which place an emphasis on self-awareness, emotional equilibrium, and the mind-body link. increased sensory and attentional control (by the thalamus), decreased autonomic arousal (via the hypothalamus), and increased memory and distraction inhibition (via the hippocampus) were all likely effects of the meditation. When taken as a whole, these neurocognitive and psychological benefits demonstrate how mindfulness exercises can be used as inexpensive, non-invasive methods to enhance mental function in both ordinary and therapeutic contexts.

Overall, this research backs the inclusion of short mindfulness interventions in corporate training, academic curriculum, and therapy programs that aim to improve cognitive functioning under pressure, emotional regulation, and attention.

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