# CHAPTER 1
# INTRODUCTION

## 1.1 Background of Study

The influence of fragrances on human psychology and well-being has gained increasing interest in scientific research. Aromatherapeutic compounds are known to evoke various emotional and physiological responses, with certain fragrances promoting relaxation and a sense of calmness (Chandra *et al*., 2025; Sowndhararajan & Kim, 2016). However, the underlying neurophysiological mechanisms behind these effects remain largely unexplored. Electroencephalography (EEG) is a widely utilized, non-invasive technique for recording brain activity. It offers important insights into underlying neural mechanisms by examining brainwave patterns, particularly alpha and theta waves, which are widely recognized as indicators of relaxation and cognitive processing. Alpha activity is associated with a calm, wakeful state and reduced cortical arousal, while theta activity reflects internal attention, memory processing, and emotional regulation (Deshmukh, 2023; Hima *et al*., 2020).

Studies imply that fragrances can modulate the autonomic nervous system, influencing heart rate variability, blood pressure, and cortisol levels. Lavender, for instance, has been found to enhance parasympathetic nervous system activity, leading to reduced stress and anxiety (Kim *et al*., 2021). Additionally, EEG-based studies indicate that exposure to calming fragrances is correlated with increased alpha wave activity, which is

associated with states of relaxation and decreased mental stress (Moon *et al*., 2020; Deshmukh, 2023; Hima *et al*., 2020). Despite this, a lack of comprehensive studies remains that links specific fragrance compounds to their neurophysiological effects.

In addition to its potential impact on calmness, fragrance exposure may also modulate cognitive functions, specifically working memory, including non-verbal memory and visual short-term memory. These cognitive functions play a crucial role in everyday tasks, such as recognizing patterns, remembering spatial information, and processing visual stimuli (Baddeley, 2021; Chai *et al*., 2018). Working memory plays a crucial role in the short-term storage and processing of information, with non-verbal memory focusing on pattern recognition and spatial awareness, while visual short-term memory enables the retention and processing of visual information (Begum, 2025).

This study provides insights into the effects of fragrance exposure on brain activity and working memory, contributing to a better understanding of olfactory perception, emotional states, and cognitive performance. Using EEG and gas chromatography–mass spectrometry (GC-MS) in male subjects, this research systematically examined neurophysiological responses and identified the chemical compounds associated with the observed effects.

## 1.2 Problem Statement & Study Rationale

Despite the widespread use of fragrances for relaxation and focus enhancement, there is limited empirical evidence regarding their neurophysiological effects. Although the existing body of research has established the psychological benefits of aromatherapy, the

specific brainwave patterns and chemical components that mediate these effects remain underexplored (Ahmad & Pratap, 2024). Furthermore, the connection between fragrance-induced calmness and working memory performance has yet to be fully understood. Identifying these mechanisms is essential for developing evidence-based applications of fragrance in cognitive and emotional well-being.

Previous findings have shown that fragrances do influence mood, emotions, and a sense of calm (De Luca & Botelho, 2021). However, most of these findings are primarily based on user opinions and consumer-based studies. This data lacks strong scientific backing, particularly in terms of neurological evidence involving brain responses to the effects of fragrances. Furthermore, there is limited neurological data research on fragrance effects, focusing specifically on male subjects, creating a knowledge gap regarding sex-specific responses to fragrance exposure. This represents a significant gap in the field of perfumery, where scientific studies, especially those involving brain-based measurements, could provide more robust support for consumer perceptions.

While other scientific research has shown that fragrance exposure can affect neural oscillations (Deepa *et al*., 2023), the extent to which these effects influence cognitive performance is unclear. Furthermore, there is a lack of studies investigating the comparative effects of different fragrance compositions on brain activity, specifically in males. By identifying specific chemical compounds within fragrances and correlating them with EEG findings, this study seeks to provide a more objective approach to understanding fragrance-induced relaxation and cognitive enhancement of working memory.

## 1.3 Research Questions

1. How does exposure to different types of fragrance impact alpha and theta power in EEG signals, compared to baseline measurements within the same group?
2. What are the associations between the chemical components identified in fragrance samples (using GC-MS) and the observed changes in EEG alpha and theta power?
3. How does fragrance exposure influence working memory performance, specifically non-verbal memory, and visual short-term memory as assessed using the CogniFit App?

## 1.4 Research Objectives

The objectives of this study are:

1. To quantify changes in alpha and theta power density in EEG signals associated with calmness following exposure to different fragrance types.
2. To explore the potential association between the chemical composition of commercial fragrances and their effects on EEG alpha and theta power density.
3. To assess the impact of fragrance exposure on working memory performance, specifically non-verbal memory and visual short-term memory.

## 1.5 Hypothesis

There are several hypotheses in this study, which are:

1. Exposure to different fragrance types results in significant changes in EEG alpha and theta power associated with calmness, with differences observed between fragrance conditions.
2. Fragrances with different chemical compositions will produce distinct changes in EEG alpha and theta power density. These neurophysiological responses will vary according to the dominant compounds present in each fragrance.
3. There will be a significant improvement in accuracy and a significant reduction in reaction time after fragrance exposure during a memory task. The change in working memory performance from pre- to post-fragrance exposure will differ across fragrance groups.

## 1.6 Scope of Study

This research was centred on investigating the neurophysiological effects of fragrance exposure on calmness and working memory using EEG analysis in male subjects. Participants were exposed to selected fragrances known for their calming properties, and EEG data were collected before and after exposure. The study also analysed the chemical composition of fragrances using GC-MS to establish potential links between chemical compounds and observed EEG changes. The research was conducted at the Imaging and Neuroscience facility, Faculty of Science and Technology, Universiti Sains Islam Malaysia (USIM), using the Unicorn Hybrid 8-channel EEG system.

Furthermore, this research employed an experimental design within a controlled environment to eliminate external factors that may influence EEG readings. Counterbalancing measures were implemented to minimize order effects and enhance data

reliability. Instead of the 2-back test, the CogniFit app was used to assess non-verbal memory and visual short-term memory, providing a validated and standardized cognitive assessment tool. The CogniFit application was selected due to its scientific validation in measuring cognitive abilities and its ability to provide objective, reproducible, and real-time feedback on memory performance. By integrating objective EEG measurements with GC-MS chemical profiling, this research provided a robust framework for analysing the effects of fragrance exposure.

## 1.7 Significance of Study

This research contributes to the growing field of olfactory neuroscience by providing empirical evidence on the neurophysiological effects of fragrances, specifically in male subjects. The findings can enhance our understanding of how fragrances influence brain activity, particularly in inducing calmness and improving cognitive function. The study may have practical applications in aromatherapy, cognitive enhancement, and stress management (Spence, 2020). Additionally, the identification of specific chemical compounds responsible for these effects can guide the formulation of effective fragrance-based interventions for mental well-being.

In clinical and therapeutic settings, the potential benefits of fragrance exposure extend to stress reduction techniques and cognitive therapy interventions. If specific fragrance components are found to enhance working memory, specifically non-verbal memory and visual short-term memory, this could lead to innovations in workspace and educational environments, where cognitive performance is crucial. In educational settings, enhancing visual short-term memory could improve students' ability to process and retain

information, thereby benefiting learning outcomes. In professional environments, fragrances that support cognitive performance could be integrated into workspaces to boost productivity and mental focus. Additionally, industries involved in wellness, cosmetics, and aromatherapy may benefit from data-driven fragrance formulations that are designed to optimize relaxation and mental clarity.

## 1.8 Thesis Organization

This thesis was structured into five sections. Chapter One provides an overview of the research by outlining the background, problem statement, research questions, objectives, scope, and the study's overall significance. Next, Chapter Two presents an in-depth review of relevant literature related to the effects of fragrance, EEG research, working memory, and GC-MS analysis. It also examines previous studies on cognitive and neurophysiological responses triggered by olfactory stimuli. The literature cited in this chapter was drawn from a wide range of peer-reviewed articles and journals to support the research objectives and establish a strong theoretical foundation for the study.

Moreover, Chapter Three describes the research methodology, including criteria for participant selection, experimental procedures, data collection methods, and analysis strategies. It details the experimental design, counterbalancing techniques, and statistical approaches to ensure methodological soundness. On the other hand, Chapter Four reports the study's findings and interprets them in the context of existing research. Results from EEG analysis, GC-MS data, and CogniFit memory performance will be examined to explore possible relationships and causal links.

Finally, Chapter Five wraps up the study by summarizing the main findings, discussing their implications, and proposing avenues for future research. The chapter emphasizes the relevance of the results to neuroscience, psychology, and potential practical applications in fragrance-based interventions.