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**INVESTIGATING THE RELATIONSHIP BETWEEN SENSORY-SPECIFIC  
MEMORY FORMATION AND LEARNING STYLE PREFERENCE**

**BY**

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**THIS THESIS IS SUBMITTED TO THE UNIVERSITY OF GHANA LEGON IN  
PARTIAL FULFILMENT OF THE REQUIREMENT FOR THE AWARD OF A  
MASTER OF PHILOSOPHY DEGREE IN PHYSIOLOGY**



**SEPTEMBER 2023**



## DECLARATION

I Valentina Adjei, hereby declare that this research work is the result of my original work and that neither part nor the whole has been presented to the University or elsewhere for another degree.



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## DEDICATION

This thesis is dedicated to my lovely mother Madam Mabel Kommey and my sister Mrs. Josephine Adjei Opoku.

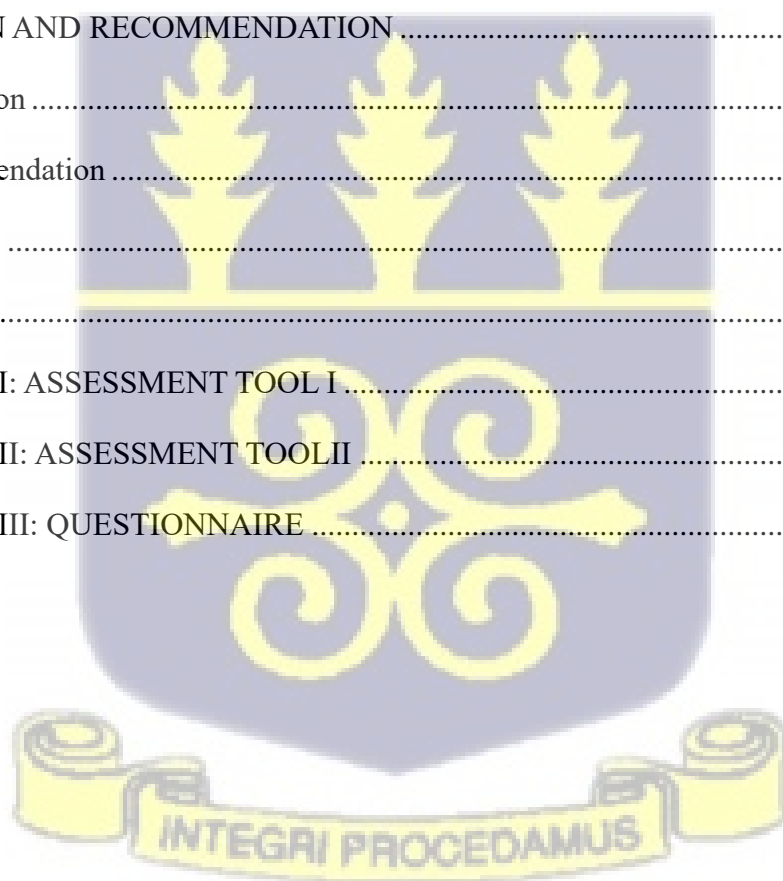


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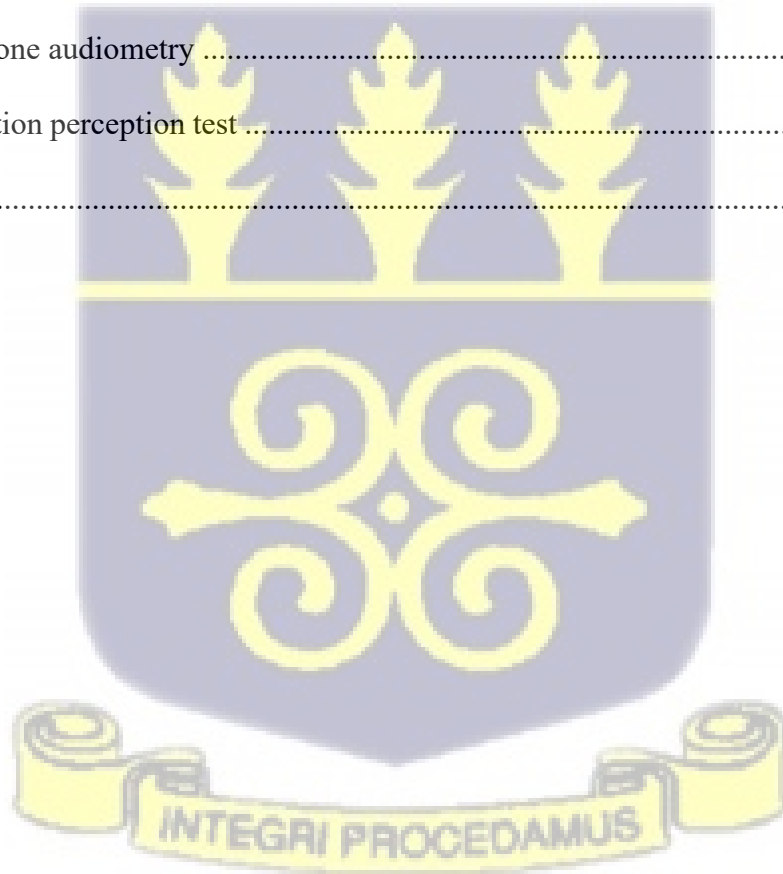
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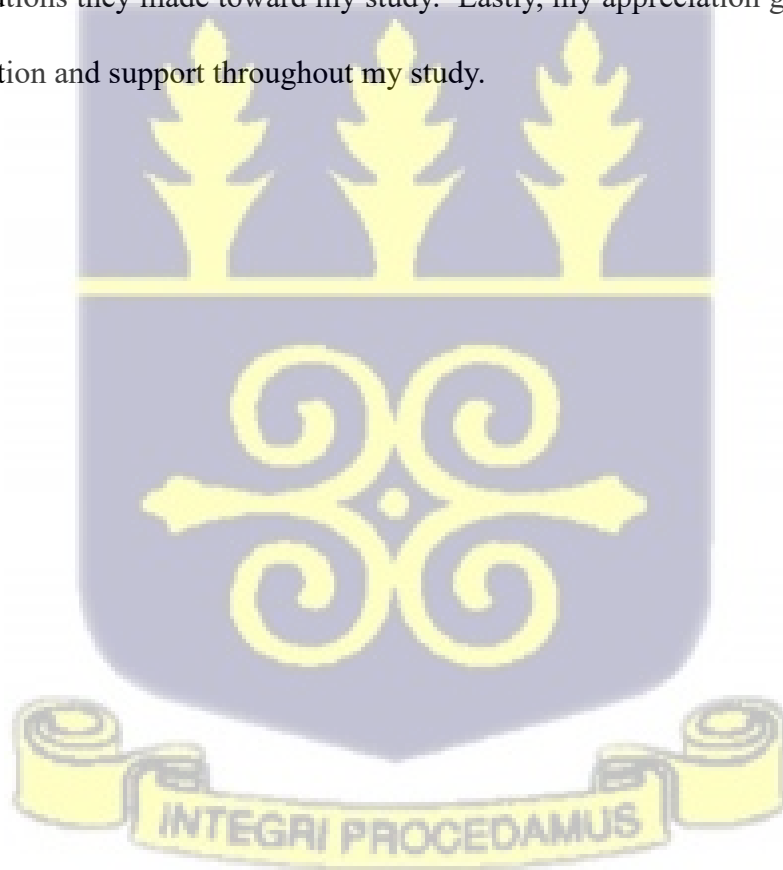
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## ABSTRACT

**Background:** Memory processing and the ability to concentrate on a given activity has been shown to differ depending on the sensory modality which is stimulated. This is key because although learners appear to follow the same basic learning process and stages; some learners appear to find learning easier or are more effective than others.

**Aim:** This study aims to investigate the relationship between sensory-specific memory formation (auditory, visual and tactile), cognitive ability and perceived/objective learning styles.

**Methods:** A cross-sectional study was conducted at the Physiology Department of the University of Ghana Medical School, Korle Bu. A purposive sampling technique was used to select a total of 94 study participants who were assessed using a standard structured questionnaire and a battery of physiological (Visual sensitivity – Pelli Robson Chart; Auditory sensitivity – Audiometry; Tactile Sensitivity – Vibration Perception Threshold) and cognitive assessments (Visual memory – Self ordered pointing task; tactile memory – Tactile Performance measure; Auditory memory – Babcock Test)..

**Results:** A total of 94 medical students were enrolled in this study. Based on self-reported data, 33(35.1%) preferred the visual learning style, 15(16.0%) preferred the auditory learning style, 43(45.7%) had equal learning style preference and only 3(3.2%) students preferred the tactile learning style. Barsch tactile learning style scores of second-year medical students ( $21.2 \pm 4.2$ ) were significantly lower and different ( $p = 0.020$ ) than the tactile learning scores of students in the other year groups (1<sup>st</sup> year  $-24.1 \pm 5.6$ , 3<sup>rd</sup> year  $-24.8 \pm 3.7$  and 4<sup>th</sup> year and above  $-23.3 \pm 3.4$ ). A strong correlation between students' auditory memory processing and the Barsch auditory learning style of medical students was also found in this study.

**Conclusion:** The findings of the study reveal that distinct student learning styles are linked to specific memory performance and processing.

Furthermore, the visual learning style was found to be the most popular, followed by auditory and tactile learning styles.

## CHAPTER ONE

### INTRODUCTION

#### 1.1 Background

Conventionally, some learners are fast learners, although all learners still follow the same basic learning processes and go through the same learning phases (Felder & Brent, 2005). These differences in learning speed could be due to cognitive differences among learners during instruction as well as their uniqueness based on the multiple intelligence theory (Calik & Birgili, 2013; Cook, 2006; Paas *et al.*, 2003). Wilson (2006) reports that students handled by board-certified teachers perform better in terms of understanding than students handled by nonboard-certified teachers, implying that instructional approaches are important in the learning process. Disparities in learning approaches can be detected by analysing students' discourse and activities, resulting in performance disparities. A separate study found that certain learners differ from others during instruction due to five categorical variables (creative thinking, nature of explanations, asking questions, metacognitive activity, and task approach) (Chin & Brown, 2006).

Aside from these factors, several studies have shown that learning style has an impact on concentration and overall student performance. The preferred learning style of a person describes how the individual learns best (Sadler-Smith *et al.*, 2006). Despite inconsistencies in the literature, auditory, visual, and tactile/kinesthetic learning styles are three types of learning styles that are frequently found in students (Gilakjani, 2012; Gilakjani & Ahmadi, 2011). One of the most significant benefits of these learning styles is that they make it simple for teachers to incorporate them into their classes, resulting in increased student comprehension (Hawk & Shah, 2007). While students acquire information using all of their senses, they appear to have learning preferences (Pashler *et al.*, 2008), with visual learning being the most common

(Bidabadi et al., 2010). Learning styles are frequently defined as a set of cognitive, affective, social, and physiological characteristics that serve as generally consistent markers of how students perceive, interact with, and respond to their learning environment (Larkin, 2003; Larkin-Hein, 2000). It is commonly acknowledged that adapting instruction to students' overall learning outcome is improved, motivation and efficiency are increased, and a positive attitude toward the knowledge being taught is fostered through learning styles. (Larkin-Hein, 2000). The goal of using learning styles is to determine the most effective strategies for both students and teachers to learn and teach (Akkoyunlu et al., 2008).

In the learning process, learning style does not function in isolation, but in cohorts with other known measures such as concentration and comprehension. Concentration is the ability to focus one's attention on what one wants, whereas comprehension is the ability to understand and interpret what one has received (Annisa & Suyadi, 2018). Although the cerebrum's prefrontal cortex is linked to learning, other areas involved in sensory processing also play a role. The parietal lobe (Haggard et al., 2003) processes tactile sensory information, the temporal lobe (Jamison et al., 2006) processes auditory stimuli, and the occipital lobe processes visual information (Pins & Ffytche, 2003). The hippocampus, which is involved in memory formation, also plays a role. Therefore, there are connections between sensory processing, focus, and memory function (Paton et al., 2006; Simons & Spiers, 2003).

## 1.2 Problem Statement

Learning styles are significant components of teaching and learning sessions. For instance, it is observed that students' attentiveness and understanding are linked to learning styles (Romanelli et al., 2009; Denig, 2004). While concentration and comprehension have been found to be associated with cortical processing (Budde *et al.*, 2008; Bressler & Kelso, 2001), several studies have also reported on how immediate sensory environment can affect concentration, learning and memory

(Mawardi & Supadi, 2018; Wang & Lieberoth, 2016). This suggests that an individual's perceived learning style and sensitivity to the immediate sensory environment can significantly influence the learning process. However, it is not fully understood the interplay between varying sensitivity in the different sensory modalities and varying preferences in learning styles. This has implications for providing optimal learning environments for teaching and learning, particularly in demanding courses such as medicine. Here the vast amount of course content means that new knowledge that can improve the efficiency of teaching and learning will serve all stakeholders well. While there have been several studies on learning styles and sensory modalities, little is known about the biological role of these learning styles in relation to sensory processing and their association with cognitive processes including memory formation. This serves as a major gap in knowledge regarding the specific individual learning style preference based on sensory processing and cognitive performance.

### 1.3 Justification

Learning and memory take place over time and are made up of many different events, such as attention, encoding (learning), and retrieval (memory). Just like sensory modalities, different aspects of memory are processed by specific cortical and non-cortical areas. Making the sensory modalities that students choose when internalizing information an important part of learning theory. Teachers who understand and integrate their students' preferred sensory modalities are therefore more effective at communicating and educating. Sensory stimulation affects concentration and instructions but also helps identify the preferences of students when it comes to learning styles and academic performance.

The present study seeks to investigate the relationship between sensitivity to a given sensory modality and the corresponding effect on memory, concentration, and comprehension. By investigating the basic modalities by which the nervous system receives information, we may be

able to identify variations that potentially influence information processing. This will aid in the goal of identifying the most effective ways for students to learn and teachers to teach in a personalized manner. Additionally, these insights can also be applied to our understanding of learning disorders related to sensory processing deficits such as those observed in Attention Deficit Hyperactivity Disorder (ADHD) and Autism Spectrum Disorders. Finally, As sensory perception decreases with age, the study will be able to lay the foundations to later explore how this contributes to the age-related decline in cognitive processing. These findings will ultimately influence institutional policy in relation to the design of teaching and learning environments as well as identifying alternative aetiologies for learning deficits.

#### **1.4 Main Objective**

This study aims to investigate the relationship between sensory-specific memory formation (auditory, visual and tactile), cognitive ability and perceived learning styles.

#### **1.5 Specific Objectives**

1. To determine the subjective (Self-reported) and objective (Barsch assessment) learning style preferences of students.
2. To assess students' sensory-specific (visual, auditory and tactile) memory performance.
3. To find the association between learning style and memory processing.

#### **1.6 Research Questions/Hypothesis**

1. What are the learning style preferences and sensory-specific memory performance of medical students?
2. What is the relationship between Barsch's learning styles and self-reported learning styles and their correlation with perceived memory processing?

## CHAPTER TWO

### LITERATURE REVIEW

#### 2.1 Memory Formation

Memory, according to Thompson, is based on specific groups of connected neurons that sustain the 'memory trace' (Thompson, 2005). Only a subset of neurons is engaged in a given memory, according to electrophysiological and cellular imaging studies (Rumpel et al., 2005). Memory traces are often physiologically stored within the brain through changes in the strength of synaptic networks, which result in the formation of new patterns of neural activity. In short-term memory, functional changes appear to occur in synapses, whereas, in long-term memory consolidation, protein synthesis and structural changes are detected in synaptic connections (Ota et al., 2013). One of the primary roles of the developing neurological system is the long-term retention of information in the form of memory. The ability to use this data offers evolutionary benefits in terms of adapting and responding to new situations (Thompson, 2005). Memory formation and functional plasticity in the brain throughout development have been linked to long-term potentiation between neurons which is one example of structural and functional plasticity (Ota et al., 2013). The processes of the nervous system, including the brain's most important cognitive functions, are carried out at the level of neural networks (Arshavsky, 2014).

According to Nadel et al. (2012), memory is not only produced but also reformed or modified after initial encoding, according to experience. Memory transformation entails alterations to the strength (and weakness) of memory traces, as well as the updating of old traces by incorporating new data (Sekeres et al., 2012). Specific memory engrams, which are groupings of neurons responsible for the storage and retrieval of diverse memory types, have been

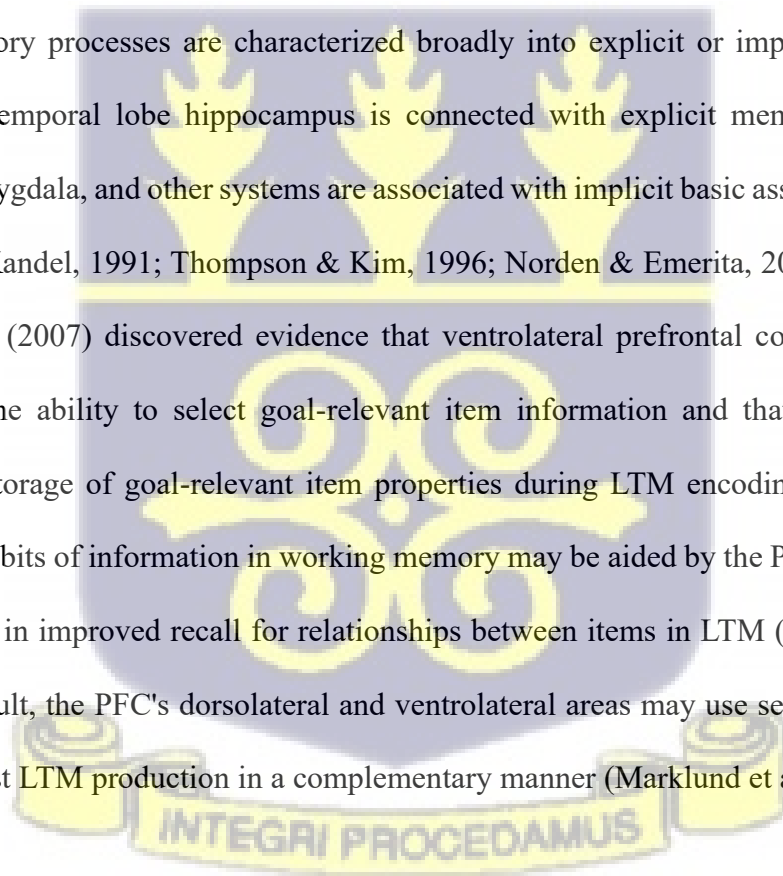
discovered in recent research (Bostancklolu, 2020). When information that will be stored as a memory arrives in the hippocampus via afferent neurons, engram neuron excitability states help it find its neuron (Tonegawa et al., 2015).

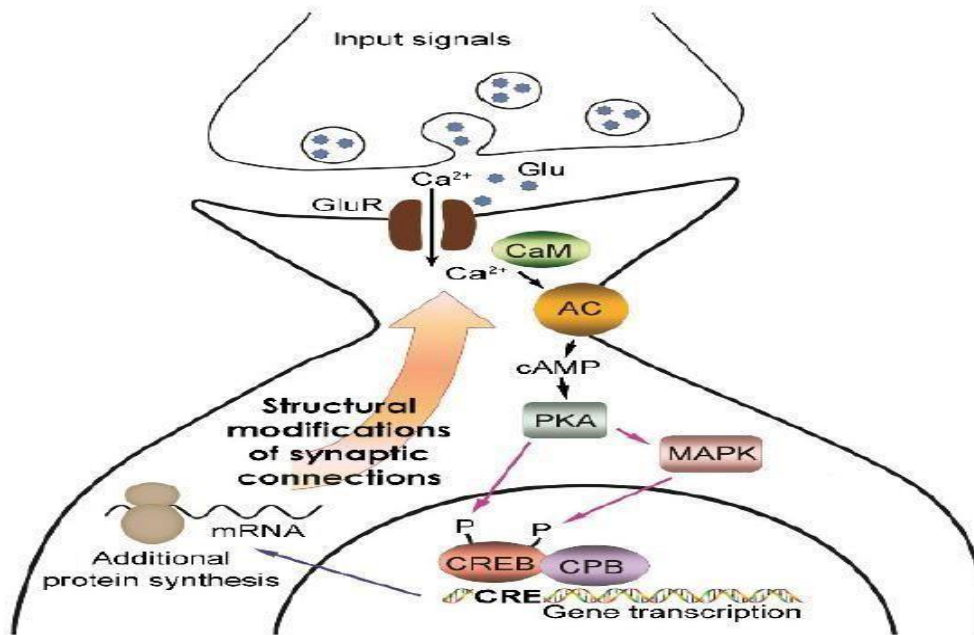
According to Ota et al. (2013), astrocytes play a vital role in memory formation and physiological synaptic plasticity via regulating synaptic transmission. Astroglia's synthesis of macromolecules such as glutamate, ATP, and cytokines, for example, is likely to alter the survival and function of newly formed connections (Ota et al., 2013). Many studies have revealed that memories are formed after learning via modifications in glutamate-dependent excitatory synaptic transmission of input fibres on the dendrites of hippocampus pyramidal cells (Potier et al., 2010; Antion et al., 2008; Lamprecht & LeDoux, 2004). According to recent animal studies, memory engrams can be produced in the neocortex at the same time as hippocampal engrams during encoding, and these neocortical engrams can aid in the recovery of long-term (weeks old) memories (Hebscher et al., 2019; Kitamura et al., 2017; Lesburguères et al., 2011). Optogenetic activation of neocortical engram cells, for example, can result in the restoration of recently learnt memories within minutes to hours of encoding (Hebscher et al., 2019).

The underlying mechanisms require glutamate produced by input fibre endings of astrocytes to activate glutamate receptors, particularly AMPA receptors, resulting in the influx of  $\text{Ca}^{2+}$  into the cell. Increased intracellular  $\text{Ca}^{2+}$  activates various protein kinases, including cAMPdependent protein kinase (PKA) mitogen-activated protein kinases and GTPases (Arshavsky, 2014; Ota et al., 2013). Elevated intracellular calcium and subsequent activation of second messenger signalling pathways in the postsynaptic neuron cause alterations in synaptic transmission (Leenders & Sheng 2005). Translocation of activated protein kinases into the nucleus causes phosphorylation of the transcription factor CREB. CREB binding to the

cAMP-dependent element (CRE) on DNA causes the transcription of "early regulatory genes" to be activated. This procedure necessitates the involvement of the transcriptional coactivator CREB-binding protein. Early regulatory gene products operate as transcription factors, controlling the expression of downstream genes (Arshavsky, 2014; Tolias et al., 2011). After learning, immediate cytoskeletal and adhesion molecule changes contribute to short-term plasticity and memory, whereas later changes, which rely on both de novo protein synthesis and the early modifications, appear to be necessary for long-term memory persistence (Bukalo & Dityatev 2012).

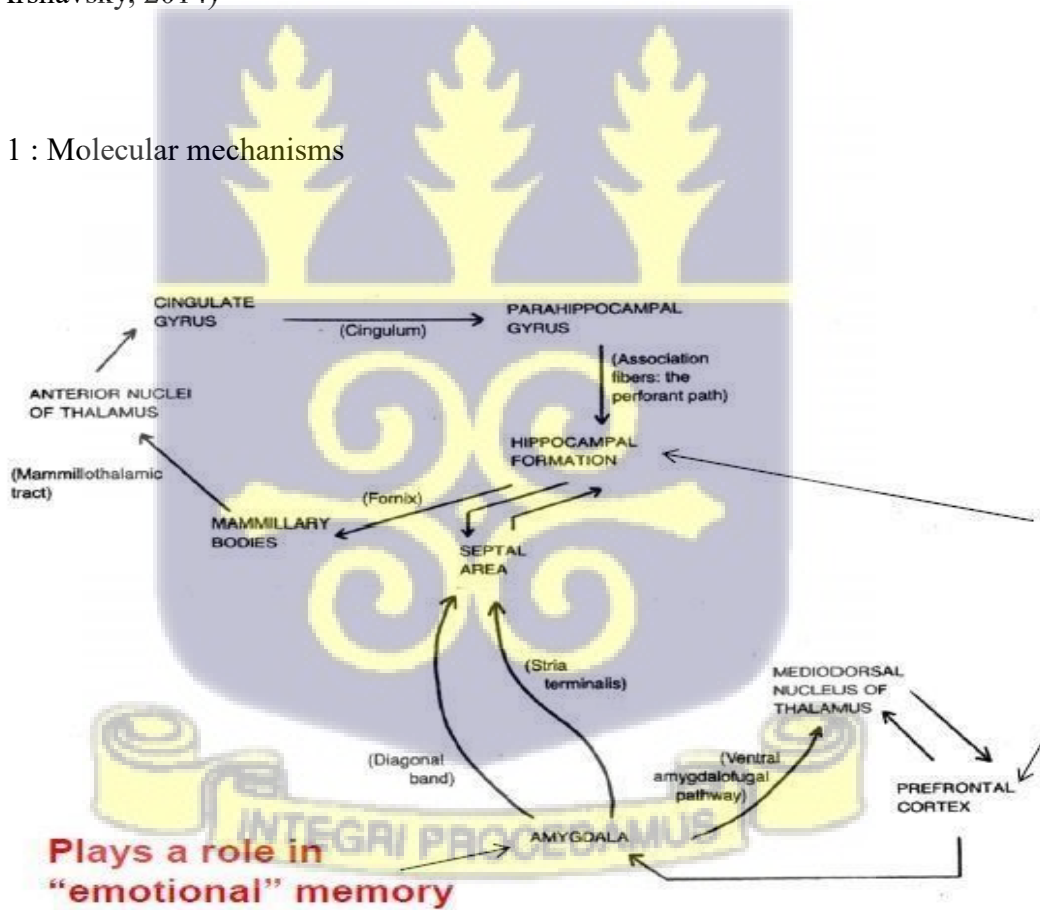
There are several types of components of learning and memory activities that affect brain function. Memory processes are characterized broadly into explicit or implicit. The medial aspect of the temporal lobe hippocampus is connected with explicit memories, while the cerebellum, amygdala, and other systems are associated with implicit basic associative learning and memory (Kandel, 1991; Thompson & Kim, 1996; Norden & Emerita, 2012). Blumenfeld and Ranganath (2007) discovered evidence that ventrolateral prefrontal cortex (PFC) areas contribute to the ability to select goal-relevant item information and that this processing promotes the storage of goal-relevant item properties during LTM encoding. The ability to arrange several bits of information in working memory may be aided by the PFC's dorsolateral areas, resulting in improved recall for relationships between items in LTM (Bledowski et al., 2010). As a result, the PFC's dorsolateral and ventrolateral areas may use separate regulatory systems to assist LTM production in a complementary manner (Marklund et al., 2007).





Source: (Arshavsky, 2014)

Figure 2. 1 : Molecular mechanisms



Source: (Kandel, 1991)

Figure 2. 2 : Brian areas involved in memory formation

## 2.2 Different Types of Memory

The ability to take in, store, and retrieve information and past experiences in the human brain is referred to as memory (Mcdermott & Roediger, 2018). Memory is made up of a series of encoded neuronal connections in the brain. The synchronized firing of neurons involved in the original event recreates or reconstructs past experiences. Memory is the total sum of our memories, and it helps us to learn from and adapt to previous events, as well as build bonds with others (Zhang, 2019). Our memories determine who we are as people, but how they work has received little consideration. For several decades, researchers and professionals have debated how to classify memories, although it is a phenomenon that incorporates a variety of processes and can be divided into numerous categories. Memory can be broken down into phases and processes as well. According to those who define memory into only two separate forms, implicit and explicit memory, other sorts of memories, such as sensory, short-term, and long-term memories, are not types of memory, but stages of memory (Stangor & Walinga, 2014). Each type of memory has its mode of action, but they all work together to generate a permanent memory and can be thought of as three steps in the process (Zhang, 2019).

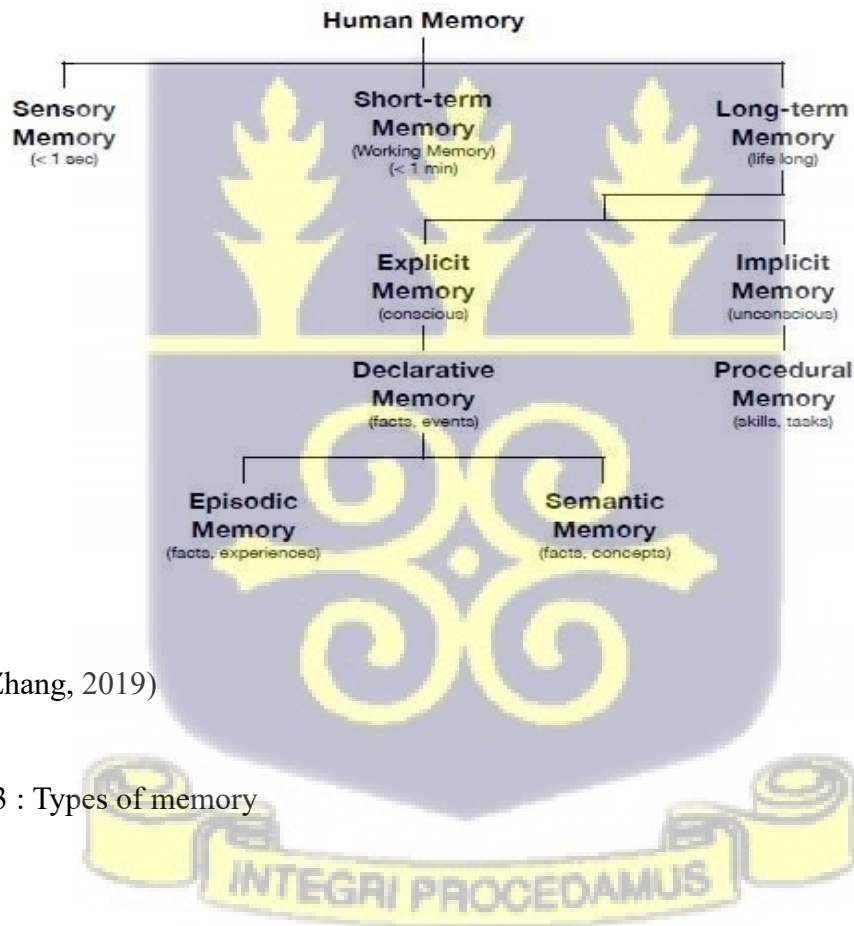
Sensory memory is the shortest-term component of memory, according to Zhang (2019). It refers to the ability to recall sensory information after the initial experience has faded. It functions as a cushion for impulses obtained by the five senses of sight, hearing, smell, taste, and touch, which are accurately stored but only for a brief period. Sensory memory is the ability to look at something and recall how it seemed after only a fraction of a second of viewing it. All other memories, according to academics who describe memory as phases rather than kinds, begin with the establishment of sensory memories. Normally, sensory memory only stores information for a short period. The ability to recall the sensation of someone's touch or a passing sound is referred to as sensory memory (Camina & Güell, 2017). When you have a

sensory experience multiple times and begin to correlate it with other memories, the sensory memory fades. It could be kept in your short-term or long-term memory (Zhang, 2019). There are three types of sensory memory: iconic (visual memory), echoic (auditory memory), and haptic (tactile memory) (Camina & Güell, 2017; Zhang, 2019).

Short-term memory allows you to recall precise knowledge about anything for a short amount of time. Short-term memory is not as fleeting as sensory memory, but it is also not as durable as long-term memory. Primary memory and active memory are other terms for short-term memory. Short-term memories, according to a study, last roughly 30 seconds (Casella & Khalili, 2021; Zhang, 2019). Rehearsing aids in the retention of information in your short-term memory. If you need to remember a series of digits, keep repeating them to yourself until you have them memorized. While some scientists believe working memory to be a fourth form of memory, it can also be categorized as short-term memory, and the two categories are usually used interchangeably (Zhang, 2019).

Moreover, the majority of our memories are kept in our long-term memory. Any memory that we can recall after 30 seconds is considered long-term memory. The importance of these memories ranges, from remembering the name of a pleasant face at your favourite coffee shop to essential data such as a close friend's birthday or your present residence. Our long-term memory has no upper limit on how much and for how long it can store information. Long-term memory can be further divided into two types: explicit and implicit. Explicit long-term memories are those that we form and recall consciously and purposefully. Explicit memory stores information such as your phone number or your best friend's birthday. Significant life milestones, such as childhood memories, graduation dates, or schoolwork finished, are typically included. Explicit memories might be episodic or semantic in nature. Episodic memories are generated as a result of unique events in one's life (for instance, the first time you

rode a bike or your first day at school). Semantic memories are general facts and information snippets that you've gathered over time. When you solve a crossword puzzle, for example, you use your semantic memory to recall random information. Alzheimer's disease, for example, has a significant impact on explicit memories (Zhang, 2019). We don't put in the same amount of effort to form implicit memories as we do explicit memories. Implicit memories form unconsciously and can influence how a person thinks and acts. Implicit memory is frequently used when learning motor skills such as walking or riding a bike. If you learned to ride a bike when you were ten and didn't pick it up again until you were twenty, implicit memory will help you remember how to ride it (Zhang, 2019).



Source: (Zhang, 2019)

Figure 2. 3 : Types of memory

### 2.3 Role of Plasticity in memory formation

The hippocampus, which is located in the inferior temporal lobe, is well known for memory formation and storage (Kroes & Fernández, 2012; Ota et al., 2013). The CA1, CA3, and dentate

gyrus are three functional areas of the hippocampal structure that have been linked to memory formation. Long-term potentiation (LTP), a form of synaptic plasticity can be found in various parts of the brain, but the hippocampus is one of the structures that has gotten a lot of attention because of its overall functional importance (Ota et al., 2013).

Synaptic plasticity refers to the structural and functional changes in the connections between neurons caused by experience, which leads to changes in neural circuits (Fu & Zuo, 2011; Lee, 2006). One form this can take is synaptogenesis, the process of developing and strengthening neural circuits by reinforcing some connections while removing other synapses, which can happen in response to environmental stimuli. Plasticity can occur during early development via a wide range of dendritic and axonal conformational changes, and while these processes are observed in the adult mammalian brain, their scale and the efficacy of the regulatory processes involved are inhibited (Lehmann et al., 2012). While adults' brains change less overall, both early developmental plasticity in children and memory formation and learning in adults are likely dependent on structural changes and synapse function (Harms & Dunaevsky, 2007; Chen & Nedivi, 2010). Because the brain has a high density of synapses, tuning activity could be accomplished by regulating synaptic function with relatively little conformational change, which is important in learning and storing large amounts of information without interfering with other signalling pathways (Ota et al., 2013).

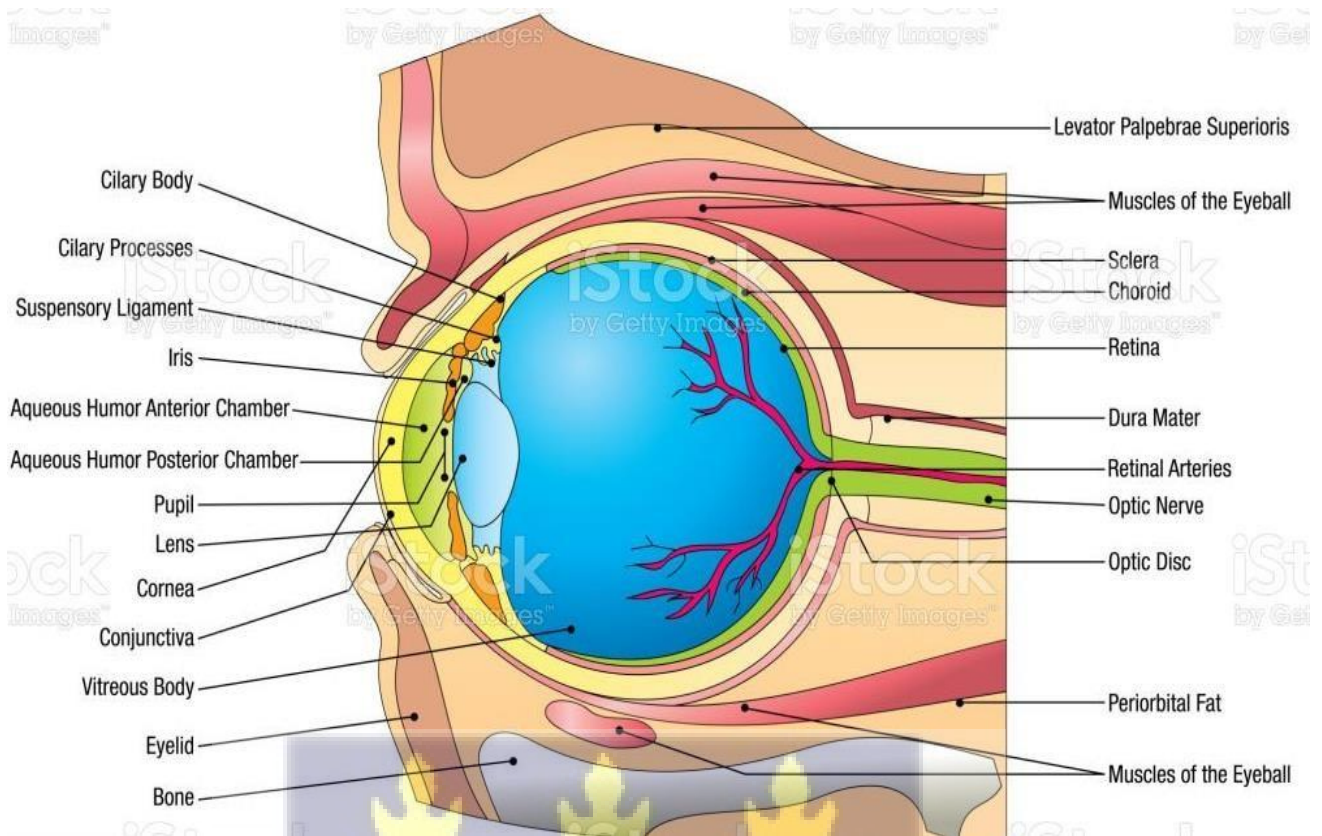
Evidence suggests that repeated activation of a neuron induces metabolic changes that cause the cell's processes to move closer together, producing an associative link. These connections form the physical basis of memory (Lamprecht & LeDoux, 2004). According to Lamprecht and LeDoux, this concept was adopted by notable neuroscience pioneers Cajal and Sherrington, and as a result of their influence, the idea that learning modifies neural connections became a common explanation for how memories are kept. Throughout learning, further structural

changes occur that are analogous to brain growth processes that occur during embryological development (Lamprecht & LeDoux, 2004).

According to research, exposing young animals to an enriched environment produces quantitative and qualitative alterations in the way LTP is produced over long periods and even across generations (Li et al., 2006; Arai et al., 2009; Arai & Feig, 2011). This recent finding suggests that the environment in which one's parents grew up affects the quality of one's memory development processes (Arai & Feig, 2011). Enriched environments have been shown to improve learning and memory, reverse learning defects caused by genetic changes in mice, and postpone the onset of symptoms in animal models of a variety of neurological disorders such as Huntington's, Alzheimer's, epilepsy, Fragile X syndrome, and Parkinson's disease (Nithianantharajah & Hannan, 2006). Fischer proposed that EE can even restore memories that have been lost due to neuronal damage (Fischer et al., 2007). EE has also been shown to cause milder stress responses (MorleyFletcher et al., 2003) and, in some cases, to prevent depression-like behaviours (Sifonios et al., 2009). EE has also been shown to reverse the negative effects of poor maternal parenting on stress response (Champagne & Meaney, 2007). Indeed, all these reports suggest a strong link between sensory stimulation and the state of cognitive processes.

#### **2.4 Visual System**

The retina, the optic nerve (CN II), the optic chiasm, the optic tract, the lateral geniculate nuclei in the thalamus, and the geniculocalcarine tract that extends to the occipital cortex are all involved in visual perception (Hans & Cruysberg, 2020; Hans, 2011).

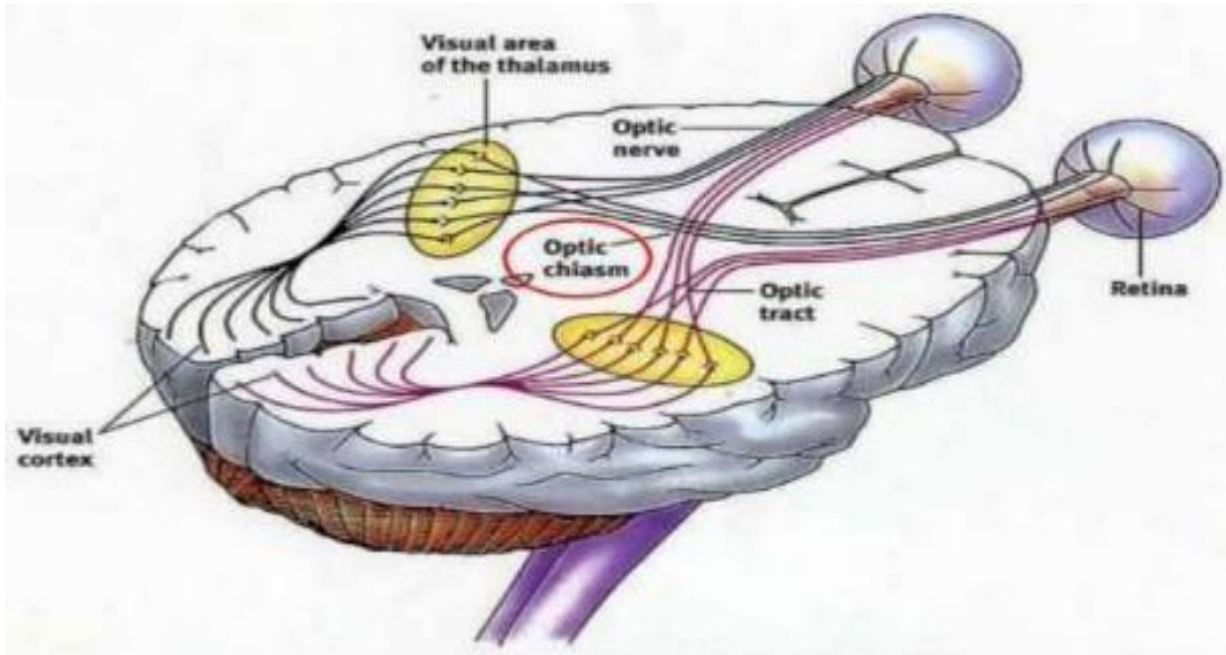


Source: (Hans, 2011)

Figure 2. 4 : A lateral view of the Human Eye

### 2.4.1 Mechanism of Vision

Light is detected by photoreceptors in the retina. The action potential created by photons at the retina travels through the optic nerves to the visual cortex through intermediary nuclei (Haines, 2010). Data is received from the eyes, the temporal ipsilateral part of the visual field, and the nasal contralateral part of the visual field by every optic tract downstream of the optic chiasm. The lateral geniculate nucleus of the thalamus processes this visual information before sending it to the visual cortex (Sillito et al., 2006). Visual information can travel to other structures in the brainstem before reaching the thalamus, such as the pretectal nuclei and superior colliculus (to generate visual reflexes to focus on certain objects) or the hypothalamic suprachiasmatic nuclei (to control circadian cycles) (Stoerig, 2006).



Source: (Stoerig, 2006).

Figure 2. 5 : A transverse section of the brain showing the Optic pathway

#### 2.4.2 Vision and Memory Formation

Jiang et al. (2000) investigated the organization and role of attention on visual short-term memory in their study (VSTM). They discovered that VSTM maintains relational information between individual objects using a change-detection task. The arrangement of things into spatial configurations mediates this relational processing. They also discovered that both topdown and bottom-up attention elements influence the creation of a structure. This is consistent with the findings of Sligte et al. (2008), who hypothesized that people can access information from iconic memory even after a stimulus has vanished from view because they can see an after-image of the presentation.

Although it is required for a wide range of perceptual and cognitive tasks, it is supported by a vast network of brain regions with limited VSTM storage capacity. Using functional magnetic resonance imaging, Todd and Marois, (2004) discovered that this capacity limit is neurally

mirrored in one node of this network, and that activity in the posterior parietal cortex is tightly connected with the limited amount of scene information that can be stored in VSTM.

## 2.5 The Auditory System

The conversion of environmental vibrations into nerve impulses that are transmitted to the brain and interpreted as sound by the ear is referred to as hearing. By detecting and analysing different physical properties of the waves, the ear may perceive many subjective features of a sound, such as its loudness (Moller, 2000). Pitch is the number of wavelengths that move through a specific area in a given amount of time, and it determines how sound waves are perceived. Hertz (cycles per second) is a standard unit of frequency measurement (Toole et al., 2018). The human ear is most sensitive to and hears frequencies between 1,000 and 4,000 hertz, while the whole range of sound hearing, at least for average juvenile ears, is between 20 and 20,000 hertz (Schnupp et al., 2011). The decibel (dB) is a unit for measuring and reporting sound intensity that indicates the relative amplitude of a sound on a logarithmic scale. Human hearing varies from nearly inaudible at 0 decibels to over 130 decibels, which is uncomfortable and possibly hazardous (Riecke et al., 2008).

Pure-tone audiometry (PTA) is a method of assessing hearing sensitivity that involves both the peripheral and central auditory systems. It is a significant indicator for evaluating an individual's auditory performance. It distinguishes between conductive (outer- and middle-ear) and sensorineural (cochlear) hearing loss and describes the configuration of the hearing thresholds in terms of severity and frequency affected (Davies, 2016; Walker et al., 2013). PTA evaluates the central auditory nervous system's (CANS) integrity as well as CANS dysfunction (i.e., inability to concentrate in noisy environments). Due to cochlear or retro-cochlear impairment, lesions in the CANS may result in decreased hearing sensitivity and impaired auditory learning abilities (Musiek & Chermak, 2015). Walker et al reported that PTA of 25 to

30 dB represents normal adult hearing sensitivity and 15 to 20 dB for children.

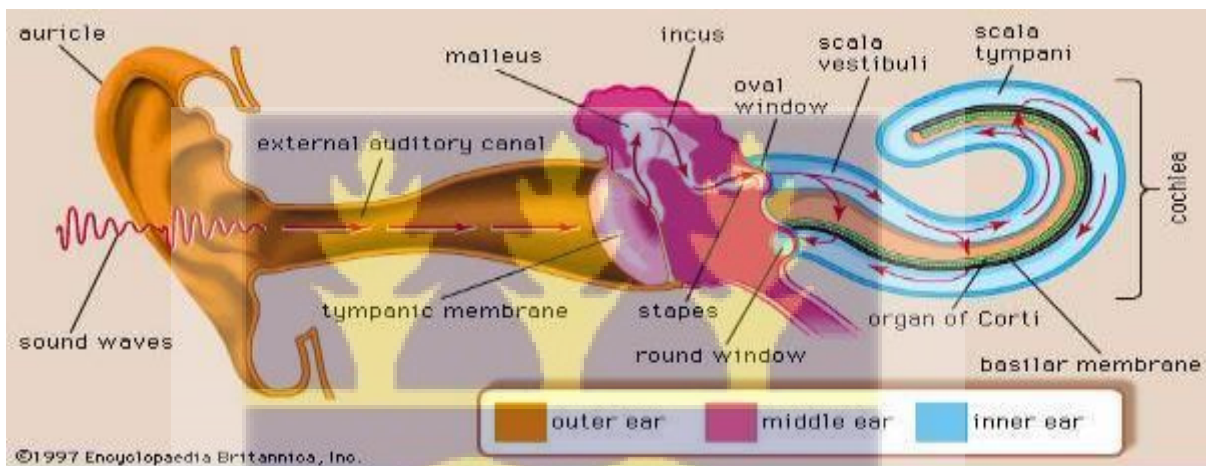
### 2.5.1 Mechanism of Hearing

Sound waves from the outside environment are directed to the tympanic membrane by the outer ear. The auricle, or visible portion of the outer ear, catches sound waves and, together with the concha, the hollow at the entrance to the external auditory canal, contributes to funnelling sound into the canal (Flynn, 2013). Sounds that reach the tympanic membrane are reflected in part and absorbed in part. The only sound that is absorbed causes the membrane to move. Acoustic impedance is the tendency of the ear to resist sound transmission (Wever & Lawrence, 2015).

The core piece, the umbo, vibrates like a rigid cone as sound waves are absorbed by the tympanic membrane, bending inward and outward (Muyschondt & Dirckx 2020). The greater the force of the sound waves, the greater the membrane deflection and the stronger the sound. The greater the frequency of the sound, the higher the pitch of the sound and the faster the membrane vibrates (Chadwick et al., 2009).

The motion of the membrane is communicated to the malleus handle, which is linked to the umbo at its tip. The malleus and incus are finely balanced, with their masses uniformly distributed above and below their common axis of rotation, and are suspended by thin elastic ligaments. The malleus head and the incus body are securely connected, allowing them to move as one unit in tandem with the tympanic membrane (Rogers, 2011). The vibrations are carried on to the stapes at modest sound pressures, and the entire ossicular chain moves as a single mass. The stapes deliver sound waves to the vestibule's perilymph and scala vestibule by their activity (Willi, 2003). The vibrations in the air must be converted to vibrations in the cochlear fluids before sound can be delivered to the inner ear (Stenfelt, 2011). The disparity in impedances, or mismatch, inhibits sound propagation.

The middle ear serves as a transformer or impedance-matching device because the tympanic membrane and ossicles work together to adjust for the impedance mismatch between air and cochlear fluids (Willi, 2003). Finally, fluid vibrations propagate across the basilar membrane as travelling waves, triggering the hair cells of the Corti organ (Nam, 2014). The cochlear nerve fibres convert sound vibrations into nerve impulses, which are then transmitted to the brainstem, where they are processed before being sent to the primary auditory area of the cerebral cortex, the final centre of the brain for hearing. The listener becomes aware of the sound only when the nerve impulses reach this location (Munkong & Juang 2008).



Source: (Encyclopaedia Britannica, 1997)

Figure 2. 6 : Anatomical structure of the External, middle and inner ear

### 2.5.2 Physiology of Muscles of the middle ear and noise regulation

The tensor tympani and stapedius muscles in the middle ear can alter sound transmission via the ossicular chain (Gan, 2004). The tensor tympani pull the malleus handle inward and tenses the tympanic membrane when it contracts. The stapedius contracting pulls the stapes footplate outward from the oval window, reducing the amount of sound reaching the cochlea (Gentil et al., 2013). The stapedius contracts reflexively in response to high-intensity noises, whether administered to the same or opposite ear. The reflex has been compared to an eye blink or the

contraction of the pupil in response to light, and it is regarded to have defensive utility (Hiipakka, 2008). Unfortunately, because middle-ear muscle contractions are not instantaneous, they do not protect the cochlea against damage caused by abrupt extreme noise, such as an explosion or gunshots. They also become fatigued fast, providing little protection against harm caused by high-level noise (Maltby, 2019).

### **2.5.3 Hearing Sensitivity Using Pure Tone Audiometry Test**

To measure hearing sensitivity, pure-tone audiometry, a behavioural test, is employed. This examination examines both the peripheral and central auditory systems. PTTs (pure-tone thresholds) represent the weakest sound that a person can hear at least 50% of the time (Musiek et al., 2017). An audiogram, which is a graph that shows intensity as a function of frequency, is used to measure hearing sensitivity. Tones from the speech spectrum (500 to 4,000 Hz) are provided at the upper limits of normal hearing (25 to 30 dB for adults, 15 to 20 dB for children) during screening audiometry (Walker et al., 2013). Pure-tone audiometry can be used to spotcheck specific frequencies for hearing loss or to assess deficiencies more extensively when hearing loss is suspected. It is carried out with the use of an audiometer (Yadav et al., 2015).

### **2.6 The Somatosensory System**

The somatosensory structures use touch (bodily touch with skin) to tell us approximately objects in our surroundings, in addition to muscle and joint stimulation to tell us approximately the location and motion of our frame parts (proprioception). Somatosensory structures additionally display frame temperature, outside objects, and the environment, and offer comments on painful, irritating, and tickling stimuli. The sensory facts are processed via the way of means of the somatosensory structures travel via awesome anatomical routes relying on the sensory facts carried. The posterior column-medial lemniscal course transmits facts from

the frame, while the principal sensory trigeminal pathway transmits facts from the face. The face promises these facts to the trigeminal nerve within the spine, even as the frame sends rudimentary touch, pain, and temperature alerts to the spinothalamic pathways.

Tactile stimuli are outside forces that come into bodily touch with the pores and skin and reason touch, strain, flutter, or vibration sensations. Touch includes a small quantity of pressure carried out to or via way of means of an item, resulting in little or no pores and skin distortion, while strain includes a bigger quantity of pressure that displaces the pores and skin and underlying tissue. Different receptors mediate those numerous sensations, which range now no longer simply in traits but additionally in their placement under the pores and skin. Encapsulated receptors are a kind of somatosensory receptor determined within the pores and skin. Meissner corpuscles, Pacinian corpuscles, and Ruffini corpuscles are the various encapsulated cutaneous receptors. The Merkel complex (the 1° afferent terminates at the bottom of a specialised receptor molecular known as the Merkel molecular) and the hair follicle receptor (the 1° afferent ends on hair follicles) are unencapsulated cutaneous receptors. Nerve ends that come across touch, pain, and temperature are bare or unattached sensory receptors. They're unencapsulated, do not cease on or close to specialised tissue, and may be mechanoreceptors, nociceptors, or thermoreceptors.

The sensitivity of the 1° afferent terminal is decided through the region of the somatosensory receptor and the composition of the non-neural tissue around it (modality specificity). The Meissner corpuscle is found in glabrous (hairless) pores and the skin's dermal papillae (Figure 2.11). It includes an enclosed stack of flattened epithelial (laminar) cells interdigitated through 1° afferent terminal fibres. Meissner corpuscles are hypothesized to symbolize the flutter and motion-detecting receptors of the discriminative contact gadget in non-furry pores and skin. Pacinian corpuscles may be located in bone, frame wall, and frame hollow space connective tissues, in addition to subcutaneous tissue underneath the dermis. As a result, depending on

their position, they are probably cutaneous, proprioceptive, or visceral sensors. The vibration touchy sensors of the discriminative contact gadget are ideal to be Pacinian corpuscles withinside the pores and skin. The Ruffini corpuscles are located deep beneath the pores and skin, in addition to in joint ligaments and joint capsules, and relying on their position, they can perform as cutaneous or proprioceptive receptors. Ruffini corpuscles withinside the pores and skin are ideal to be pores and skin stretch touchy receptors that hit upon long-time period stress even as mediating contact. Merkel cells are the discriminative contact gadget's small tactile receptors that provide cues for localizing tactile inputs and seeing the edges (form or form) of objects.

The vibratory feel is regularly examined throughout a preliminary medical evaluation of discriminative contact via way of means of setting a 128 Hz tuning fork over a bony prominence. Two-factor discrimination duties and neurothesiometers also are used to evaluate tactile sensitivity. Inspired via way of means of Sperling's (1960) studies on visible sensory reminiscence, some research has checked out the capability and staying power of our early recollections for contact stimuli. Hill and Bliss (1968) used a partial document paradigm with air-jet stimulators at 3 websites on every finger on each arm to take a look at sensory reminiscence in contact. For a complete document, contributors may want to do 3.5 positions of the air jets and about one extra function for a partial document. This partial vs. complete document benefit confirmed that tactile stimuli had sensory reminiscence, which dissipated after approximately 1 second. Gallace et al. (2008) used each complete document (numerosity judgements) and partial document (numerosity judgments) technique to degree reminiscence for the vicinity of vibrations across the body (spatially cued). In the whole document condition, contributors may want to not forget up to 3 stimuli, while withinside the partial document condition, they may not forget as many as five. The variety of stimuli proven and the duration

of the illustration have been additional trade-offs, with the variety of stimuli growing because the decay price increased.

To look at the ability and sturdiness of contact reminiscence, different techniques were used. Heller (1987) traced numbers onto human beings' palms at a sluggish pace, estimating digit unfold as excessive as seven. One method to check long-time period reminiscence for contact is to the degree our cap potential to call regular gadgets, due to the fact this calls for human beings to retrieve representations of these matters saved earlier than the beginning of an experiment. We are correct at spotting three-D acquainted gadgets simplest via way of means of touching them, consistent with a couple of research (Craddock & Lawson, 2008, 2009a, 2009b; Klatzky,

Lederman, & Metzger, 1985; Lawson, 2014). This research displays that three-D item haptic alerts can be effortlessly recorded and coupled to saved item representations (even though we might also additionally battle to encode and interpret 2D stimuli). Sensitivity to perceptual manipulations like intensity rotations and length adjustments have additionally been a place of study (Craddock & Lawson, 2008, 2009; Ernst et al., Newell, 2007; Lawson, 2009, 2011; Newell et al., 2001). Recent records show that tactile reminiscence may be processed independently of different reminiscence structures originating from different sensory modalities in phrases of visible vs. haptic presentation (Lawson, 2009).

## 2.7 Learning Style

The broad approaches that students adopt when learning a new language or any other subject, among other factors, are referred to as learning styles (Boneva & Mihova, 2014). As a result, learning style refers to a set of cognitive, affective, social, and physiological activities that serve as fairly constant markers of how students perceive, interact with, and respond to the learning environment (Riding & Rayner, 2013). There are several learning styles (Tuan, 2011). Students

tend to have preferred methods of learning, although they employ all of their senses to receive knowledge (Riener & Willingham, 2010). Three of the most prevalent types of learning are visual, auditory, and kinaesthetic.

### **2.7.1 Visual Learners**

The process of encoding images and visual sensory information is known as visual encoding. Before being encoded for long-term preservation, visual sensory information is temporarily retained within the iconic memory (Raiyn, 2016). The amygdala (a region of the brain in the medial temporal lobe that is important in emotional processing) is important in visual encoding because it takes visual input alongside other systems and encodes the positive or negative values of conditioned stimuli (Zhang, 2019). Visual learners are those who learn best through visual imagery and think in pictures (Dewan, 2015). They rely on nonverbal cues from the instructor, such as body language, to improve comprehension. Various interactive visual tools, such as information and communication technologies (e.g., web services) and 2- and 3-D visual environments, are used to present visual information (Raiyn, 2016).

Visual learners may prefer to sit in the classroom's front row. They also take careful notes on the information they are given (Gilakjani & Ahmadi, 2011). When visual learners' sense of sight is engaged, they learn more efficiently. They show an early interest in books and reading, beginning with picture books and quickly progressing to textbooks. Bright colours and clear schematics captivate them, and movies, demonstrations, and classroom handouts provide students with useful information (Freda, 2013; Mead, 2018). Of the three basic learning modalities, visual learning is the most similar to traditional classroom teaching methods. Reading assignments, taking and assessing handwritten notes, and many teachers' use of flip charts, diagrams, and other visual aids can all help visual learners learn more quickly. Visual learners are often found in the front of the classroom, taking in whatever their teacher writes on the board. They are drawn to vibrant colours

and activities, and they frequently use posters and cell phones to brighten their rooms (Rahayu et al., 2020). They enjoy drawing and painting. They can retell a story down to the smallest detail once they've read it. When they're trying to learn something new and want to see someone else do it before they try it themselves, they frequently say, "Show me."

### **2.7.2 Auditory Learners**

Auditory learners benefit from studying with their sense of hearing. This means that when new ideas are communicated aloud, people remember and comprehend them better, even if they are the ones speaking. They retain information much better when new concepts are combined with nonverbal noises such as music, drum beats, or clapping (Pourhosein Gilakjani, 2011; Sreenidhi & Tay Chinyi, 2017). These people learn by hearing and interpreting information using pitch, intensity, and speed (Sari, 2017). Auditory learners enjoy music and can recall song lyrics. "Tell me again," kids frequently say if they don't understand anything. Even when they are alone, auditory learners prefer reading aloud to reading silently. They prefer to have a narrative read to them rather than read it themselves. These pupils learn in the classroom by reading aloud, but they may not understand all of the information written down (Kayalar & Kayalar, 2017). When a teacher explains things to the class rather than providing a reading assignment, the auditory learner's knowledge is considerably stronger.

### **2.7.3 Tactile learners**

Tactile learning is the most physical learning technique. Touch, movement, and motion are the most effective ways for them to absorb information. Kinaesthetic sensibility refers to the ability to detect a bodily position and movement (Jacobson, 2001; Moussa, 2014). This means that to truly comprehend something, they must touch, feel, and move it around. If your child says "Let me see that," but really means "Let me hold that," he or she is most likely a kinaesthetic learner.

They are the kids who enjoy the children's museum's building sets, model kits, and interactive exhibits. They frequently dismantle things to learn more about them. If given the option in art class, kinaesthetic learners will choose modelling clay over pencils or paint. They will gravitate toward books with interactive elements, such as pop-ups, little doors that open and close, or books with textures that can be touched or petted, from an early age. A hands-on, active approach to learning is beneficial to kinaesthetic learners (Boctor, 2013). These students prefer to interact with their surroundings physically. Kinaesthetic learners frequently struggle to stay on target and can easily become disoriented (Gilakjani, 2012).

#### **2.7.4 Significance of learning styles**

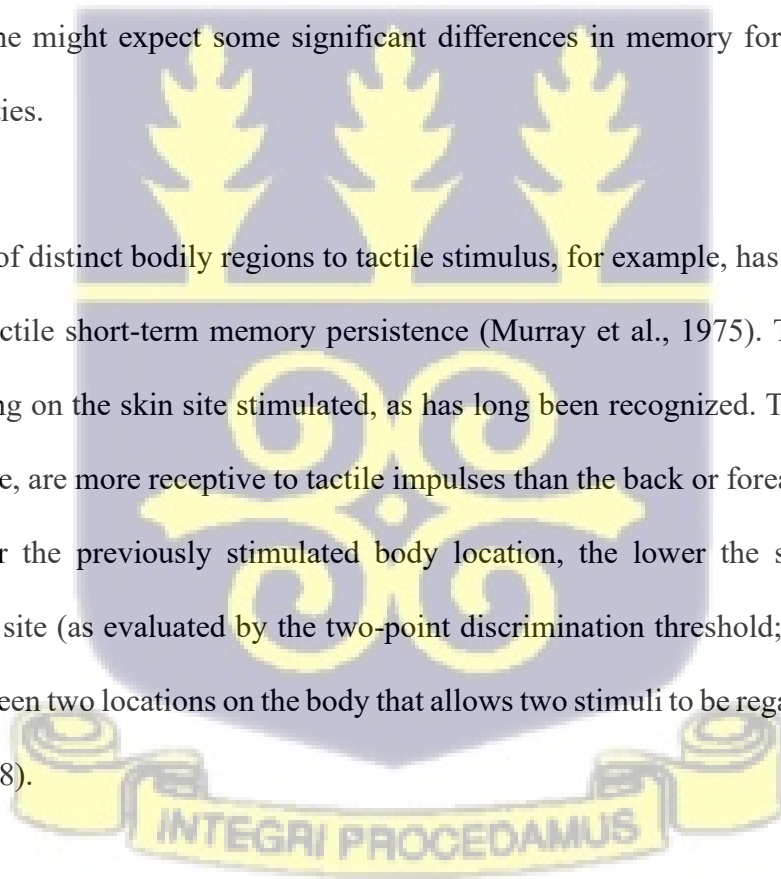
There are several reasons why learning style is significant; nevertheless, there are three that are particularly crucial. To begin with, people's learning styles will differ because everyone is unique (Pritchard, 2017). Second, it provides the opportunity to effectively teach using a variety of methods. Sticking to a single model results in a monotonous learning environment, which is detrimental to learning. Finally, being aware of students' learning styles, psychological characteristics, and motivational differences will aid in the proper and timely regulation of sessions. When a person is aware of his or her learning style, he or she can incorporate it into the learning process for a more efficient and successful learning experience.

Because all learning involves sensory information, physiological systems that mediate sensory perception must be considered. All sensory data is processed through multimodal integration, which allows the data to be contextualized to aid learning. However, several modality-specific pieces of information can affect memory development. It is important to distinguish between people's memory for micro geometric properties of stimuli (such as fine textural features), memory for macro geometric properties of stimuli (such as rough textural information and information about an object's shape, size, and so on), and memory for spatial qualities of tactile stimuli when

discussing touch memory (i.e., their memory for the location or locations on the body surface or in space where the stimulation happened to occur).

Different brain regions process each of these traits (O'Sullivan et al., 1994; Roland, 1987; Roland et al., 1998). Despite this, evidence of multimodal integration during learning suggests that at least some of the neuronal network involved in touch memory is shared across sensory modalities. The brain's storage of tactile information appears to be aided by multisensory/amodal information processing networks in particular. Given that the unique circumstances in which stimuli are presented/experienced affect the amount of information available and how that information is processed and remembered (Millar, 1978, 1999, 2006), and given that there are significant differences in how different sensory modalities are processed (Gallace & Spence, 2008; Gallace et al., 2007), one might expect some significant differences in memory formation via different sensory modalities.

The sensitivity of distinct bodily regions to tactile stimulus, for example, has been explored as a function of tactile short-term memory persistence (Murray et al., 1975). Tactile sensitivity differs depending on the skin site stimulated, as has long been recognized. The fingertips and lips, for example, are more receptive to tactile impulses than the back or forearms. The greater the amnesia for the previously stimulated body location, the lower the sensitivity of the stimulated skin site (as evaluated by the two-point discrimination threshold; i.e., the smallest separation between two locations on the body that allows two stimuli to be regarded as separate) (Weinstein, 1968).



This research suggests that sensory information processing and tactile memory are tightly linked. However, studies show that this is not the case with the visual system and that changes in visual sensitivity are not always linked to changes in visual memory (Applebaum et al.,

2013). Furthermore, whereas therapies that improve the sensitivity of one modality may promote multimodal integration, they do not improve memory in other modalities (Ho et al, 2003). Sensory sensitivity has also been researched, in addition to the impact of sensory integration on memory. Many scientists have studied sensitivity to each modality separately, but only a few have delved into the relationship between cross-modal sensitivity and memory.



## CHAPTER THREE

### MATERIALS AND METHODS

#### 3.1 Study Design

This is a cross-sectional study which collected quantitative data for learning style assessment and memory formation.

#### 3.2 Study Site

The study was conducted at the Korle-Bu Campus of the University of Ghana Medical School, specifically the Department of Physiology.

#### 3.3 Study Subjects

The Study Subjects were undergraduate medical students at the Korle-Bu campus of the University of Ghana.

#### 3.4 Sample Size Calculation

Using the 3<sup>rd</sup> year medical students with an average population of 250, using a power of 80% and confident level of 95%, the minimum sample size for the study was calculated by the use of the formula below

$$n = \frac{2\sigma^2(Z_\beta + Z_\alpha)^2}{d^2}$$

Data used is from a previous study of learning styles in students of medical sciences based on scores from the VARK questionnaire (Shahrakipour et al., 2017) With,

$Z_\beta$  = value on the standard normal distribution at the power of 80% = 0.84

$Z_\alpha$  = value on the standard normal distribution at the 95% confidence level = 1.96

$d$  = mean difference between the three groups = 3

$\sigma$  = standard deviation = 6

$$n = \frac{2\sigma^2(Z_{\beta} + Z_{\alpha})^2}{d^2}$$

$$n = \frac{2 \cdot 6^2 (0.84 + 1.96)^2}{3^2}$$

$n = 62.3 = 63$

The minimum sample size required for this study was exceeded.

### 3.5 Inclusion Criteria

Undergraduate students aged 17 to 28 years old, English speakers, normal senses of hearing, vision (with or without correction), and touch, and no self-reported history of neurological or learning abnormalities were employed in the study.

### 3.6 Exclusion Criteria

The exclusion criteria specifically excluded persons outside this age range, who have a postgraduate degree and required visual or hearing aids.

### 3.7 Data Collection Approach

Medical students in the Korle-Bu campus of the University of Ghana were recruited for the study. Notices to partake in the research were pasted across the Korle-Bu campus of the University of Ghana Medical School. Participants were spoken to on a one-on-one basis to explain the purpose and importance of the study. Once recruited, participants filled out a personal detail form and also signed an informed consent form. The study required

approximately one (1) hour thirty (30) minutes to complete all the tasks. Participants were refreshed at the end of every day.

These various tests were carried out as indicated below.

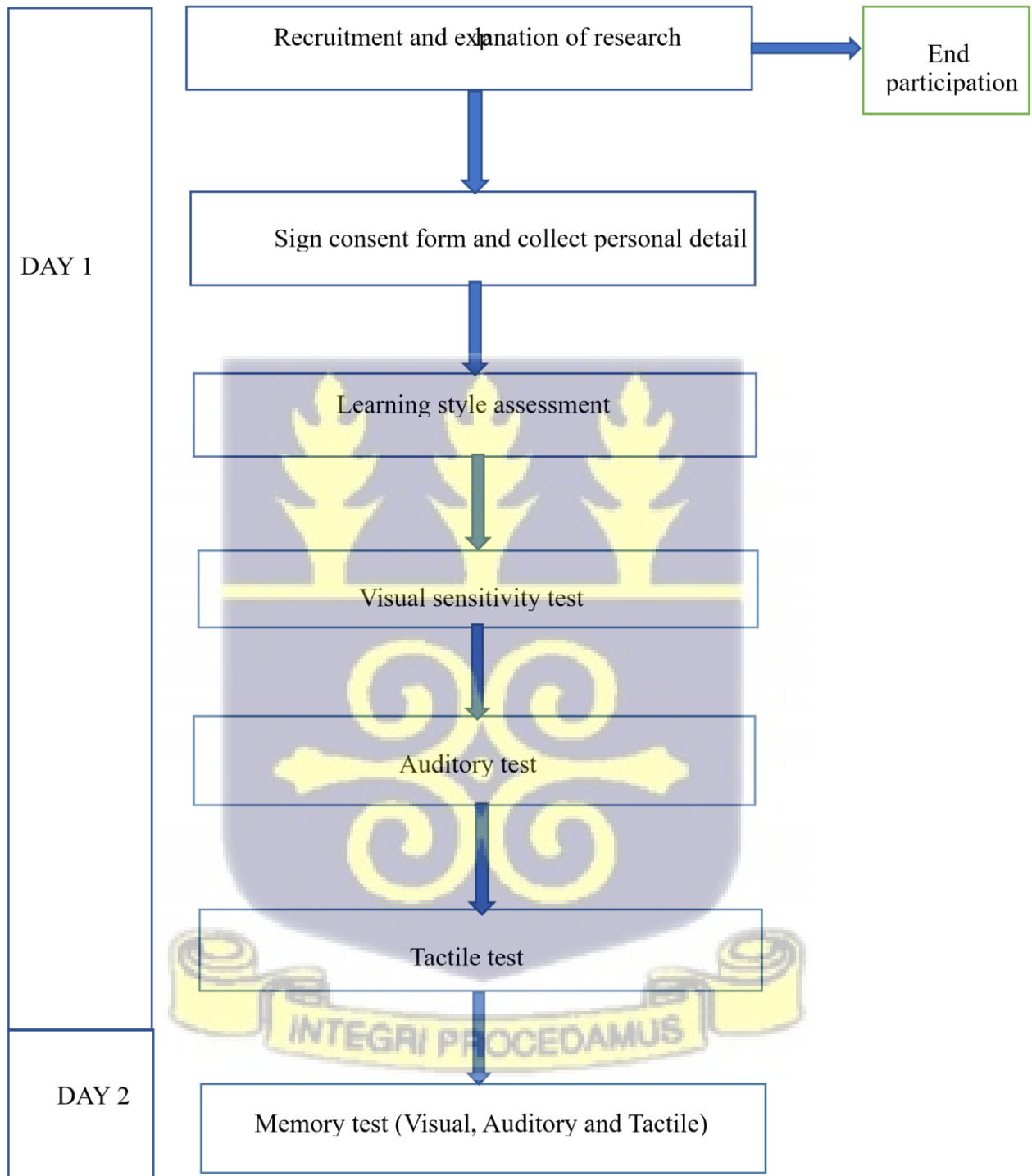


Figure 3. 1 : Conceptual framework

### 3.8 Learning Style Assessment

The participants' learning styles were assessed using the Barsch Learning Styles Inventory as an objective measure. The student's preferences in terms of the three basic senses utilized to take in information: visual, aural, and tactile, were explored and reported in this survey. This survey contains 24 three-point Likert-type scale items with response options of frequently, occasionally, and rarely. Each response is given a point value (five (5) for frequently, three (3) for occasionally, and one (1) for rarely). Participants were given a score based on their responses to a series of questions (Appendix 2), with a maximum score of forty (40) and a minimum score of eight (8) for each modality. The individual's learning style is determined by the highest score obtained among the three modality types. Based on their ratings, participants were classed as having an auditory, tactile, or visual learning style.

### 3.9 The Pelli-Robson chart test

The threshold between the visible and invisible is defined by contrast sensitivity, which has clear implications for basic and clinical vision science (Pelli & Bex, 2013). It's a test to see how well you can tell the difference between two things (Wang et al., 2009). The Pelli-Robson contrast sensitivity charts include a series of triplets of uniformly big (20/680 Snellen equivalent size) letters of diminishing contrast. There were two triplets per line, with the same contrast level for all letters within each triplet. The chart was hung on the wall, and the participant sat in a chair 1 meter in front of it to read it.

The participant completed a single attempt to name each letter on the chart, beginning with the dark letters in the upper left-hand corner and reading horizontally throughout the entire line. On the scoring sheet, each letter read correctly was circled, while those read wrongly were crossed out. Participants were examined three times: once for each eye and, once for both eyes

concurrently. One eye was checked while the other was covered for the single-eye testing. The participant's sensitivity was mirrored in the faintest triplet, for which two of the three letters were properly characterized. The log contrast sensitivity for the triplets was decided by the number closest to the triplet on the scoring sheet; the number might be on the right or left of the triplet; the score was determined by the number closest to the triplet. A Pelli-Robson score of 2.0 indicates that the contrast sensitivity is completely normal. If the score is less than 2.0, the contrast sensitivity is weaker. A Pelli-Robson contrast sensitivity scale score of less than 1.5 indicates visual impairment, while a score of less than 1.0 indicates visual disability (Thompson et al., 2017).



Figure 3. 2 : A sample picture of the Pelli-Robson chart

### 3.10 Auditory Test

Hearing tests assess a person's ability to distinguish between the loudness and pitch of sounds. The data are graphed (audiogram) to help determine the severity and causes of hearing problems. Pure tone audiometry, utilising an audiometer, and speech discrimination tests are among the tests available. (Medalia et al., 2023)

Pure-tone thresholds (PTTs) reflect the weakest sound that a person can hear at least 50% of the time (Musiek et al., 2017). It is an air conduction test that assesses the faintest tones a person can hear at different pitches or frequencies. For this study, Pure-tone testing was carried out in a sound-proofed room where participants wore headphones connected to an Audiometer. The Audiologist presented tones of different frequencies (low and high) ranging from 250Hz to 8000Hz through the headphones. Subjects were asked to respond by pressing a button each time they hear a sound. When the participant heard the tone, the intensity was decreased by 10 dB. When the participant does not hear the tone, the intensity was increased by 5 dB. The intention was to seek the lowest intensity at which the participant hears the tone at least 50% of the time. A pure tone average was found by using the scores of tones from 500Hz to 4000Hz and the value obtained (ranging from 10 to 25 dB) was used for the study.

### 3.11 Tactile Test for Memory

The tactile test was carried out using a neurothesiometer to determine the vibration perception threshold (VPT). The neurothesiometer delivers vibration at various intensities to identify a threshold, this indicates an individual's sensitivity to tactile stimuli. Participants were seated comfortably, a table was placed before them with the neurothesiometer placed on top of the table, with the eyes closed a probe was placed on the thumb of the participant, the volume of the vibration was turned up (from 0.5 to 5.0 volts) and participants were asked to indicate when

they felt the buzzing sensation. The tactile assessment was done three times and an average of the vibration value was found and recorded.

The assessment was done on both the dominant and non-dominant hands of participants.

### 3.11.1 Memory Tests

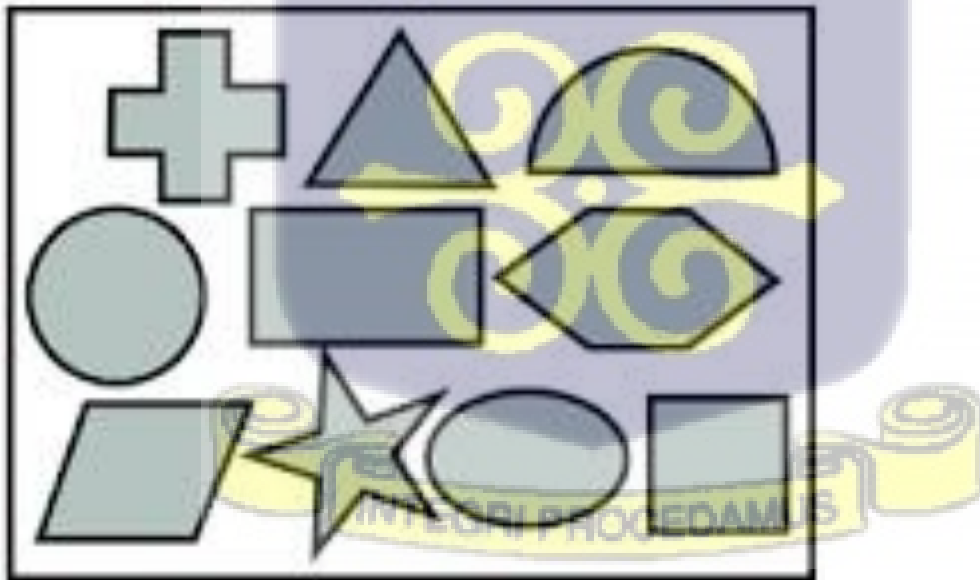
The Self Ordered Pointing Task based on Thai numerals was used to assess visual memory. Participants were shown a grid of Thai numerals and asked to look at them for 10 seconds. The individuals were then shown another web page with identical styles in a different order and asked to select any numeral. The layout of the numeral was changed and presented again with individuals asked to select a numeral not previously selected. This method was repeated until each player had a chance to select all of the designs once; as a result, six (6) designs with six (6) pages were proven. The order in which the stimuli were pointed to was recorded, as was the time it took to complete the entire trial (i.e., ordinary reaction time) and the number of errors made.

Just as in Petridis and Milner's (1982) study, participants were told that accuracy, not speed, was critical in completing the test. It was explained that maintaining a comfortable pace was critical for passing the exam (i.e., not so fast that they were unable to examine each item carefully, and not so slow that they would forget which items they had already touched). The above test was replicated using cuneiforms. The test was graded based on the number of errors made.

To assess auditory memory, the Babcock test was used (Babcock, 1930; Babcock & Levy, 1940). Each participant was given a short story that was recorded and read aloud to them. The participant then recounts the story in as much detail as possible. After a 20-minute interval, the narrative is read to the individual a second time before being asked to once again recount

the story in as much detail as possible. This test is scored by assigning one point for each item in the story that the participant correctly recalls, up to a maximum of 21 points.

Tactile memory was tested using the Tactile Performance Test (TPT) (Arthur, 1947). It consists of a wooden board with 10 different geometric forms carved into it (similar to a 3-D puzzle for children). The participants were blindfolded and were not permitted to see the board or the ten shapes that were placed to the side of the board. Each participant was timed as he or she picked up each carved out piece and placed it in its matching position on the board. To complete the test successfully, participants would have to identify the shape of the piece based on tactile perception and in the same process, identify the matching hole on the board which matched each shape. Each participant completed this activity three times: once with his or her dominant hand, once with the non-dominant hand, and finally with both hands. At the conclusion of the third trial, the board and the ten geometric pieces were removed, the subject was blindfolded, and he or she sketched the forms and the board as exactly as possible.



**Fig. 3.3:** Schematic drawing of the board with carved-out objects used for the tactile performance test.

The test's sketching section began immediately after the last section of the TPT was completed. This test resulted in two scores: one for the total amount of time it took to insert the pieces into the correct slots, and another for the representation and positioning of the forms in the drawing (maximum score 20). The scores for the timed portion and the drawing portion were calculated and examined separately.

### **3.12 Quality Control Measures**

All data were handled anonymously to ensure confidentiality. Participants were identified with number codes instead of their names. The investigator ensured that all data/information about the study participants and the completed code list were kept private and password protected.

### **3.13 Statistical Analysis**

The data generated was entered into Microsoft Excel and analysed using the statistical package for social sciences version 22 (SPSS).

To determine the preferred learning style of participants, ANOVA was used to compare the means of scores for the three categories of learning style followed by Turkey's post hoc analyses from the learning style questionnaire if the data assumes a normal distribution. To determine the relationship between the individual self-reported learning styles based on sensory-specific memory performance, again a one-way ANOVA was used.

To find the association between Barsch's learning style and the memory processing of medical students, Pearson's Product Moment Correlation Coefficient was used.

Lastly, to differentiate between the subject's perceived memory performances after conducting a post-test self-reporting survey, an independent T-test was used.

### 3.14 Ethical Considerations

Ethical clearance and administrative approval were obtained from the Ethical and Protocol Review Committee of the College of Health Science, University of Ghana. Voluntary written informed consent was sought from participants before including them in the study. The researcher was at hand to explain some terms of the study which needed further clarification. The details of the study, its benefits, and potential risks were declared to participants. Also, throughout the data collection and handling process, extreme respect was demonstrated for the rights and confidentiality of study participants. Once all questions were asked and clarifications made, the signature of the participant was taken on the consent form.



### 4.1 Demographic characteristics

A total of 94 medical students were enrolled in this study. Of this, 60 (63.8%) were within 18-22 years of age, 22 (23.4%) aged between 22-26 years while 12 (12.8%) were within 26-30 years of age. In the study, the female students 54(57.4%) dominated the study participants compared to 40(42.6%) males. The data as presented in Table 1 indicates that 43(45.7%) were

second-year medical students, 21(22.3%) were in their first year, 12(12.8%) were third-year medical students and 18(19.1%) were 4th year and above medical students (Table 1).

Table 1 : Demographics of study participants

N=94	Frequency	Percentage (%)
<b>Gender</b>		
Female	54	57.4
Male	40	42.6
<b>Age (years)</b>		
18-22	60	63.8
22-26	22	23.4
26-30	12	12.8
<b>Medical school year</b>		
1st	21	22.3
2nd	43	45.7
3rd	12	12.8
4th and above	18	19.1

Source: (Field Data, 2022)

N= total number of participants

#### 4.2 Learning style preference of medical students

Based on self-reported data, evaluation of learning styles preference of the medical students showed that 33(35.1%) preferred the visual learning style, 15(16.0%) preferred the auditory learning style, 43(45.7%) had equal learning style preference for any two of the identified styles and only 3(3.2%) students preferred the tactile learning style (Table 2).

Table 2 : Self-reported learning style preference among study participants

	Frequency	Percentage (%)
--	-----------	----------------

**Learning styles**

Visual	33	35.1%
Auditory	15	16.0%
Tactile	43	45.7%
Equal preference (all)	3	3.2%

Source: (Field Data, 2022)

Data, as presented in Table 3, indicates that those who preferred the visual learning style were predominantly males 17(51.5%), between 18-22 years of age 23(69.7%) and were second-year medical students 13(39.4%). For participants who preferred the auditory learning style, 67% (10) were females and aged between 22-26 years while auditory learning style preference among different year groups was similar (Table 3). Again, medical students who preferred the tactile style of learning in this study were mainly males 2(66.7%) and students aged between 18-22 years 3(100%). Findings of the study also showed that females 27(62.8%), between 18-22 years 31(72.1%) and second-year 25(58.1%) medical students dominated those who had equal preference the learning styles (Table 3).

Table 3 : Learning style preference of medical students (self-reported)

Descriptive Variables	Learning styles			
	Visual N (%)	Auditory N (%)	Tactile N (%)	Equal preference N (%)
<b>Gender</b>				
Female	16(48.5)	10(66.7)	1(33.3)	27(62.8)
Male	17(51.5)	5(33.3)	2(66.7)	16(37.2)
<b>Age (years)</b>				
18-22	23(69.7)	3(20.0)	3(100.0)	31(72.1)
22-26	4(12.1)	10(66.7)	0(0.0)	8(18.6)
26-30	6(18.2)	2(13.3)	0(0.0)	4(9.3)

**Year of study**

1 <sup>st</sup>	8(24.2)	4(26.7)	0(0.0)	9(20.9)
2 <sup>nd</sup>	13(39.4)	4(26.7)	1(33.3)	25(58.1)
3 <sup>rd</sup>	3(9.1)	3(20.0)	1(33.3)	5(11.6)
4 <sup>th</sup> and above	9(27.3)	4(26.7)	1(33.3)	4(9.3)

Source: (Field Data, 2022)

N = frequency

The study also assessed the learning ability of medical students based on the Barsch learning style scoring criteria. This serves as an objective measure of learning style as opposed to the self-reported data shown in Table 2. As presented in Table 4, no significant difference ( $p > 0.05$ ) was detected between the gender of the students and the Barsch learning styles, thus, visual (female:  $26.2 \pm 5.4$  vs. male:  $26.7 \pm 4.9$ ;  $p = 0.694$ ), auditory (female:  $24.8 \pm 3.8$  vs. male:  $24.1 \pm 4.9$ ;  $p = 0.446$ ) and tactile (female:  $22.7 \pm 4.5$  vs. male:  $22.8 \pm 4.6$ ;  $p = 0.961$ ). Again, the results revealed that across the three age brackets (18-22, 22-26 and 26-30), Barsch learning style scores were relatively the same among visual [( $26.0 \pm 5.3$ ,  $27.0 \pm 5.1$  and  $27.2 \pm 5.1$  respectively;  $p = 0.655$ ), auditory [( $24.1 \pm 4.4$ ,  $25.0 \pm 3.6$  and  $25.8 \pm 5.2$  respectively;  $p = 0.371$ )] and tactile [( $22.5 \pm 4.8$ ,  $23.6 \pm 3.6$  and  $22.3 \pm 5.2$  respectively;  $p = 0.594$ )] learners

( $p > 0.05$ ). However, Barsch tactile learning style scores of second-year medical students ( $21.2 \pm 4.2$ ) were significantly lower and different ( $p = 0.020$ ) than the tactile learning scores of students in the other year groups (1<sup>st</sup> year -  $24.1 \pm 5.6$ , 3<sup>rd</sup> year -  $24.8 \pm 3.7$  and 4<sup>th</sup> year and above -  $23.3 \pm 3.4$ ). For both visual and auditory learning styles, no significant differences ( $p > 0.05$ ) in the Barsch learning style scores were detected among the different year groups of medical students (Table 4).

Table 4 : Barsch learning style scores of participants

VISUAL

AUDITORY

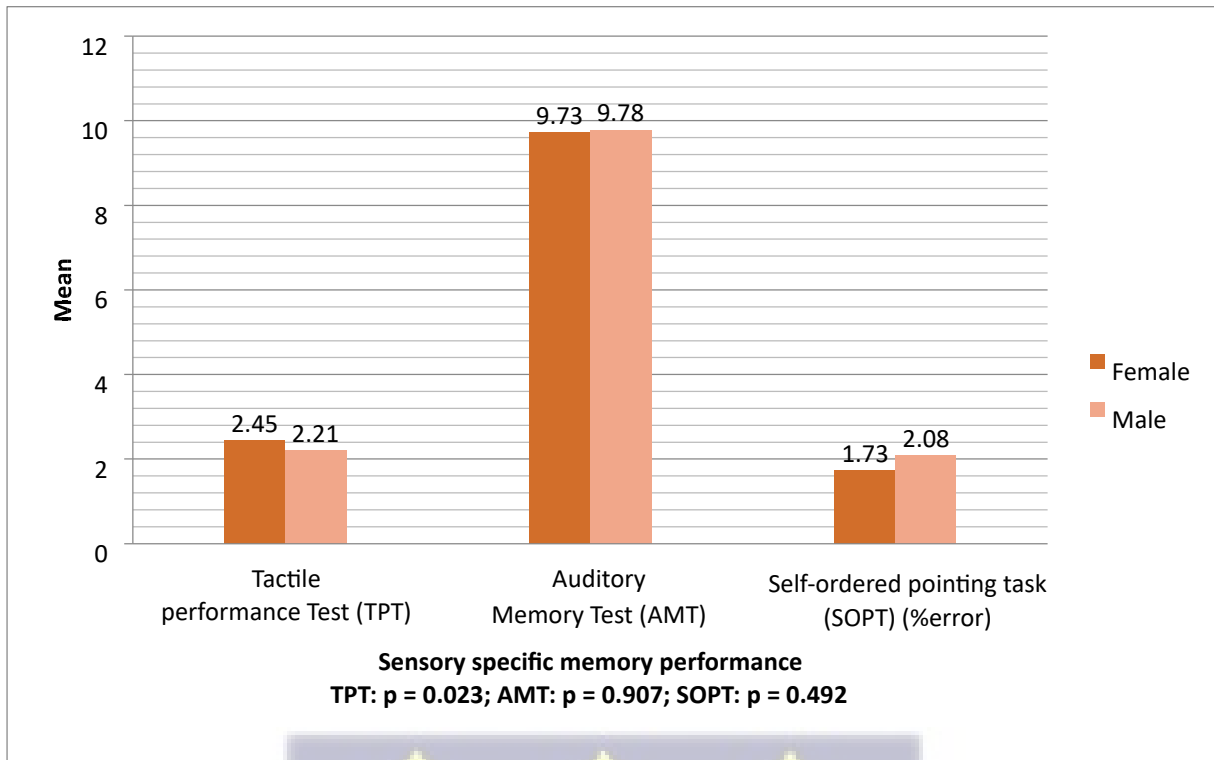
Student characteristics	Mean±SD	P Value	Mean±SD	TACTILE	
				P Value	Mean±SD
<b>Gender</b>		0.694		0.446	0.961
Female	26.2±5.4		24.8±3.8		22.7±4.5
Male	26.7±4.9		24.1±4.9		22.8±4.6
<b>Age (years)</b>		0.655		0.371	0.594
18-22	26.0±5.3		24.1±4.4		22.5±4.8
22-26	27.0±5.1		25.0±3.6		23.6±3.6
26-30	27.2±5.1		25.8±5.2		22.3±5.2
<b>Year of study</b>		0.368		0.802	0.020
<sup>a</sup> 1st <sup>b</sup> 2nd <sup>c</sup> 3rd	27.7±4.5		23.8±5.7		24.1±5.6 <sup>ab</sup>
<sup>d</sup> 4th and above	25.7±5.6		24.6±3.4		21.2±4.2
	27.7±5.5		24.7±3.9		24.8±3.7 <sup>cb</sup>
	25.8±4.5		25.1±4.9		23.3±3.4 <sup>db</sup>

Source: (Field Data, 2022)

SD = Standard Deviation; statistically significant at  $p < 0.05$  on post hoc. One-way ANOVA analysis

### 4.3 Sensory-specific memory performance of medical students

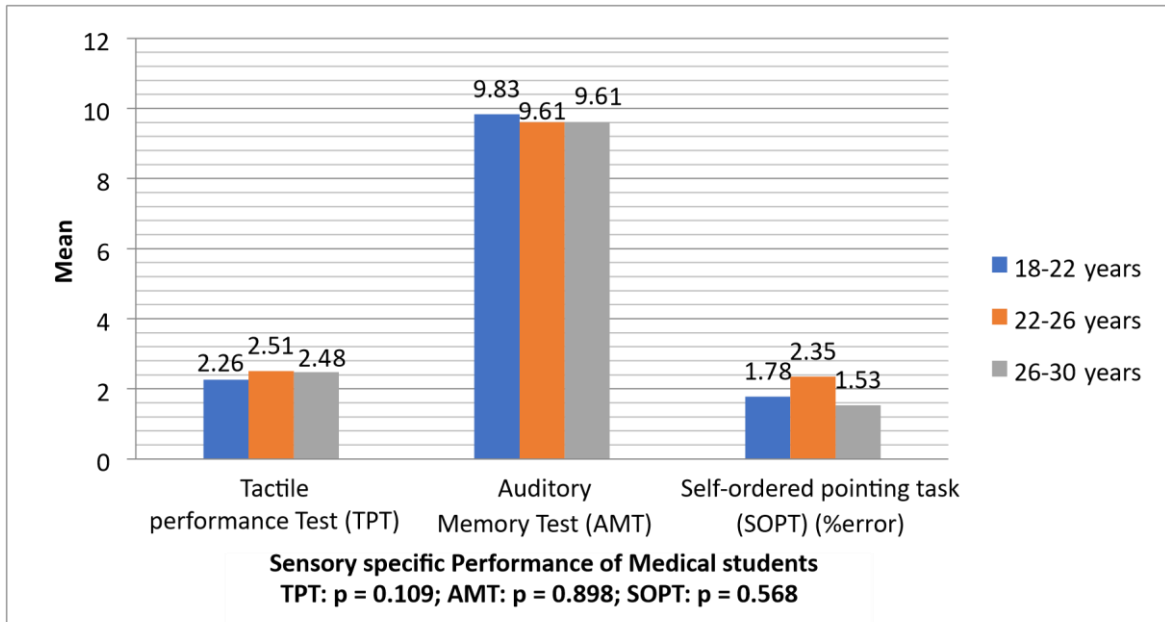




Source: (Field Data, 2022)

Figure 4.1: Gender disparities of sensory-specific memory performance of medical students Tactile performance test (TPT), Auditory Memory Test (AMT), Self-Ordered pointing Task (SOPT).

One of the objectives of this study was to evaluate the sensory-specific memory performance of medical students. As indicated in Figure 4.1, the mean tactile memory performance of the female students was significantly higher (mean =  $2.45 \pm 0.59$  min;  $p = 0.023$ ) compared to the male students ( $2.21 \pm 0.38$  min) using an independent student's T-Test. However, for both male and female students, auditory memory performance (males =  $9.78 \pm 2.07$  vs females =  $9.73 \pm 0.38$ ) and self-ordered pointing task (males =  $2.08 \pm 2.53\%$  error vs females =  $1.73 \pm 2.42\%$  error) scores were relatively the same ( $p > 0.05$ ).



Source: (Field Data, 2022)

Figure 4. 2 : Age disparities of sensory-specific memory performance of medical students

As shown in Figure 4.2 above, the sensory-specific memory performance of medical students did not differ significantly irrespective of their age brackets.

#### 4.4 Self-reported learning styles based on sensory-specific memory performance

Analysis of the individual learning styles based on sensory-specific memory performance of medical students as indicated in Table 5, showed that medical students' tactile memory performance scores of visual [2.23(IQR-2.13, 2.54)], auditory [2.27(IQR-2.13,2.56)] and tactile learners [2.96(IQR-2.31,3.15)] were similar ( $p > 0.05$ ). Auditory memory performance scores of medical students among visual [9.33(IQR-8.00, 12.00)], auditory [9.33(IQR-8.00, 10.67)] and tactile [8.00(IQR-8.00, 8.67)] learning styles were relatively the same in this study. Also, no significant difference in the self-ordered pointing task scores of medical students among those who were using visual [1.72(IQR-0.00, 2.50)], auditory [2.67(IQR-0.00, 4.17)]

and tactile [2.22(IQR-0.83, 3.33)] learning styles was recorded as presented in Table 5 of the study results.

Table 5 : Comparison of individual Learning styles (Barsch) based on sensory specific memory performance

Variables	Learning styles			P Value
	Visual Median (IQR)	Auditory Median (IQR)	Tactile Median (IQR)	
Tactile performance (Time/min)	2.23(2.13, 2.54)	2.27(2.13,2.56)	2.96(2.31,3.15)	0.567
Auditory Memory (Score)	9.33(8.00,12.00)	9.33(8.00, 10.67)	8.00(8.00, 8.67)	0.445
Self-ordered Pointing Task (%Error)	1.72(0.00, 2.50)	2.67(0.00, 4.17)	2.22(0.83, 3.33)	0.483

Source: (Field Data, 2022)

IQR = interquartile range;  $p < 0.05$  on one-way ANOVA

The table below (Table 6) indicates the measurement of hearing sensitivity or threshold of medical students using the pure tone audiometry test. From the data, mean scores of right ear hearing sensitivity for visual (18.49±2.65 dB), auditory (17.67±4.17 dB), tactile (18.33±2.89 dB) learners and those with equal learning preference (18.14±2.68 dB) were relatively the same ( $p > 0.05$ ) and within normal (0-25 dB) ranges. Similar findings on hearing sensitivity scores were detected for the left ear among the individual learning styles of medical students (Table 6).

Table 6 : Pure tone audiometry

LEARNING STYLES (Self-reported)	P value	VISUAL			AUDITORY	TACTILE
		EQUAL	Variable	PREFERENCE		
Mean± SD		Mean± SD	Mean± SD	Mean± SD	Mean± SD	
Right M		18.49±2.65	17.67±4.17	18.33±2.89	18.14±2.68	0.845

(dB) 19.70±3.52 19.67±3.52 20.00±5.00 19.77±3.08 0.998

Left M

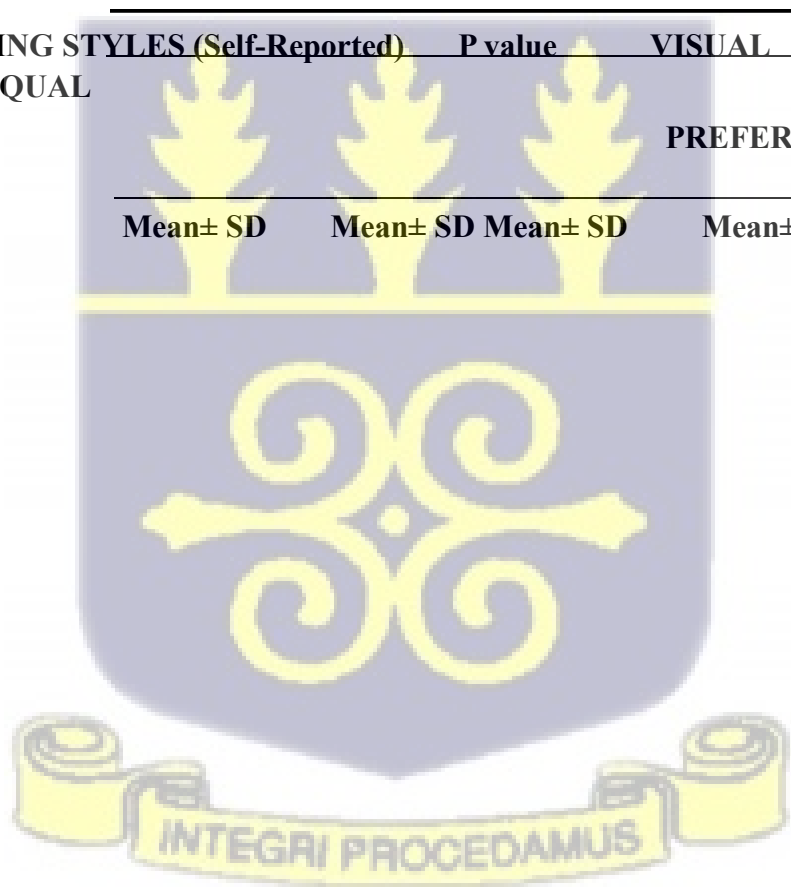
(dB)

Source: (Field Data, 2022)

Results presented in Table 7 shows that for vibration perception test scores, the differences between visual (2.80±0.61 v), auditory (2.77±0.53 v), tactile (2.67±0.58 v) and equal learning style preferences (self-reporting) were not significantly different (p>0.05). Again, right descending thumb vibration perception test scores for visual (2.97±0.60 v), auditory (2.93±0.42 v), tactile (3.17±0.58 v) and those with equal learning style preference were also not significantly different (p=0.130).

Table 7 : Vibration perception test

LEARNING STYLES (Self-Reported)				P value	VISUAL	AUDITORY
TACTILE	EQUAL				PREFERENCE	
		Mean± SD	Mean± SD	Mean± SD	Mean± SD	



Left Ascending 2.80±0.61 2.77±0.53 2.67±0.58 2.70±0.51 0.859 Thumb  
 Right Descending 2.97±0.60 2.93±0.42 3.17±0.58 2.72±0.49 0.130

Thumb

Source: (Field Data, 2022)

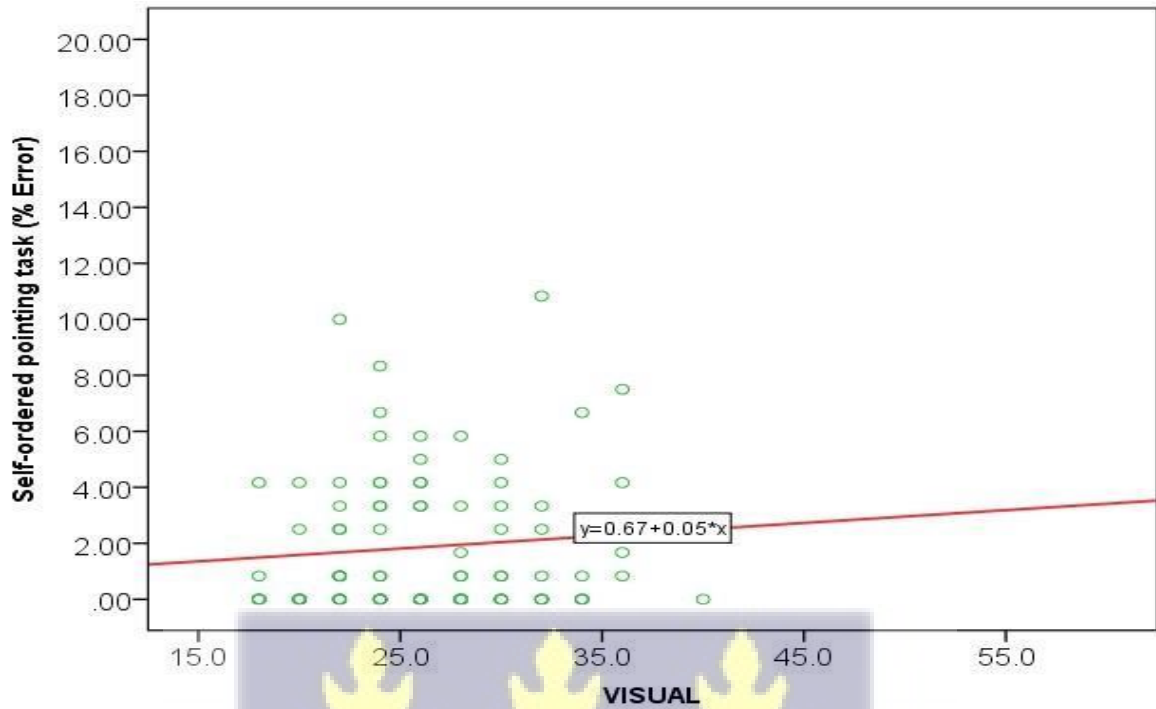
From the results as presented in Table 8, Pelli-Robson performance for the Left eye, Right eye and both eyes of visual learners [(1.65 (1.50-1.95 log unit) vs 1.65 (1.50-1.95 log unit) vs 1.80 (1.80-1.95 log unit)], auditory learners [(1.65 (1.50-1.95 log unit) vs 1.50 (1.50-1.95 log unit) vs 1.80 (1.80-1.95 log unit)], tactile learners [1.65 (1.50-1.95 log unit) vs 1.50 (1.50-1.95 log unit), 1.95(1.80-1.95 log unit)] and the equal learning style [1.80 (1.50-1.95 log unit) vs 1.65 (1.50-1.95 log unit) vs 1.80 (1.80-1.95 log unit)] preference was below the normal contrast sensitivity value (2.0). This indicates a slightly poorer contrast sensitivity, though no significant differences were found between the individual learning style preferences ( $p > 0.05$ ).

Table 8 : Pelli-Robson performance

	LEARNING STYLES (self-reported)			P value	EQUAL	Visual
	AUDITORY	TACTILE	PREFERENCE			
	Median (IQR)	Median (IQR)	Median (IQR)		Median (IQR)	
Left eye (log)	1.65 (1.50-1.95)	1.65 (1.50-1.95)	1.65 (1.50-1.95)		1.80 (1.50-1.95)	0.701
Right eye (log)	1.65 (1.50-1.95)	1.50 (1.50-1.95)	1.50 (1.50-1.95)		1.65 (1.50-1.95)	0.951
Both eyes (log)	1.80 (1.80-1.95)	1.80 (1.80-1.95)	1.95(1.80-1.95)		1.80 (1.80-1.95)	0.928

Source: (Field Data, 2022)

#### 4.5 Association between Barsch learning style and memory processing of medical students



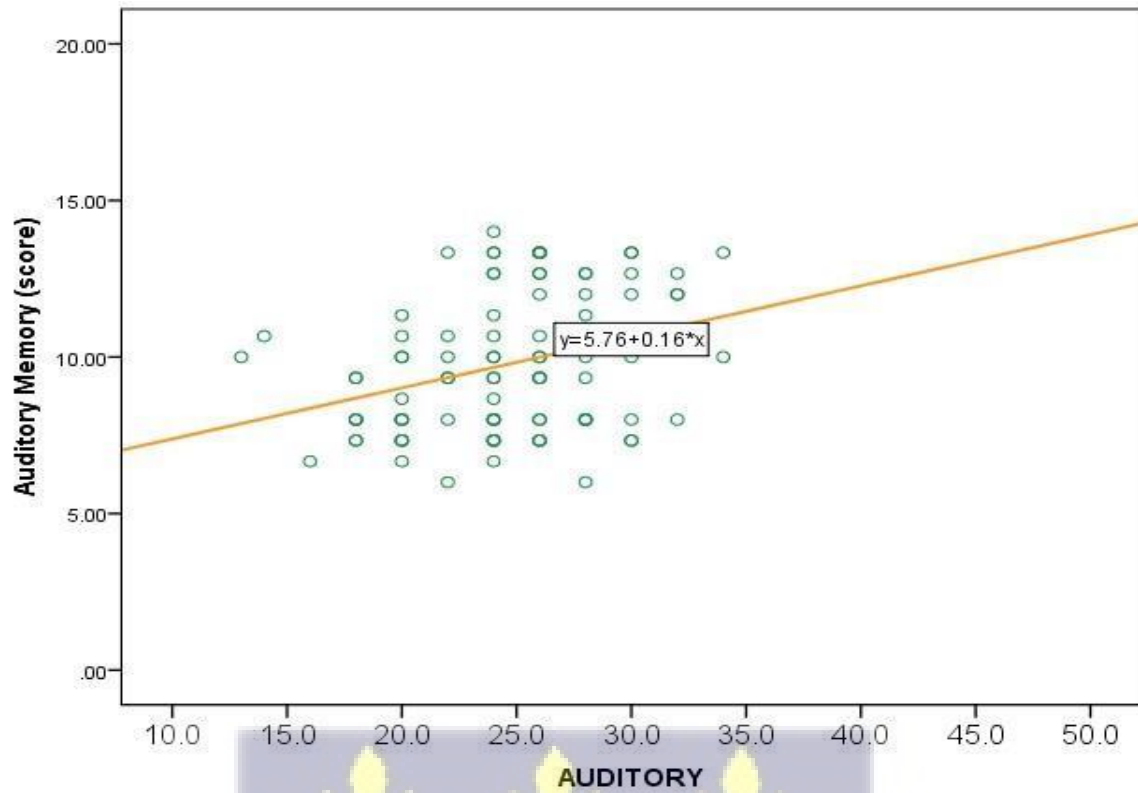
Source: (Field Data, 2022)

(Pearson  $r = 0.096$ ;  $p > 0.05$ )

Figure 4. 3 : Relationship between the Barsch visual learning style and self-ordered pointing task (%error)

As presented in Figure 4.3, there was no correlation between the self-ordered pointing task of medical students and the visual learning style (Pearson  $r = 0.096$ )





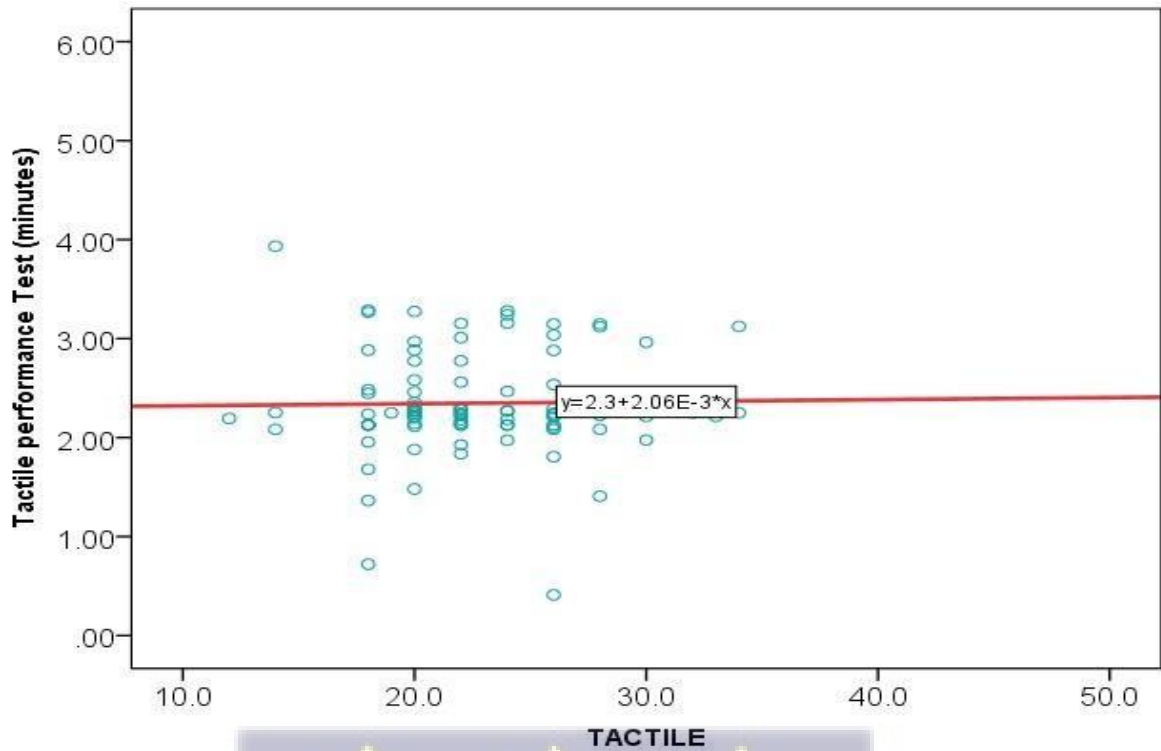
Source: (Field Data, 2022)

(Pearson  $r = 0.314$ ;  $p < 0.01$ )

Figure 4. 4 : Relationship between the Barsch Auditory learning style and auditory memory score of medical students

Results presented in Figure 4.4 indicate a strong correlation between students' auditory memory processing and the Barsch auditory learning style of medical students.



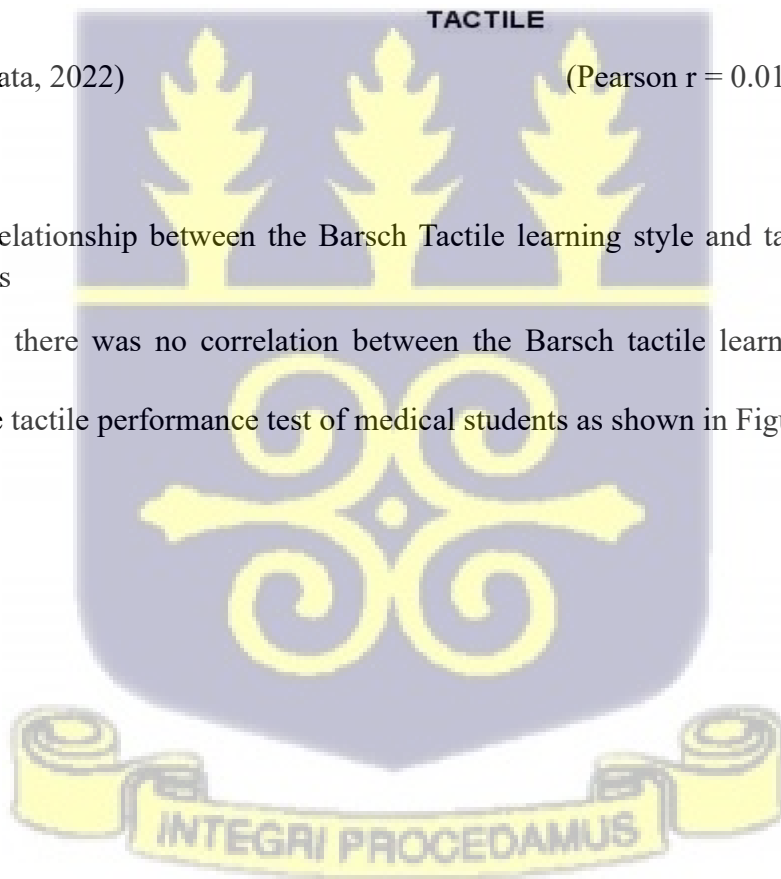


Source: (Field Data, 2022)

(Pearson  $r = 0.018$ ;  $p > 0.05$ )

Figure 4. 5 : Relationship between the Barsch Tactile learning style and tactile performance of medical students

From the data, there was no correlation between the Barsch tactile learning style of medical students and the tactile performance test of medical students as shown in Figure 4.5.



## CHAPTER FIVE

### DISCUSSION

The sensory modalities that students choose when internalizing information are an important part of learning theory. Teachers who understand and integrate their students' preferred sensory modalities are expected to be more effective at communicating with students and educating them. This study investigated learning style and assessed sensory modality preferences among medical students at various levels of their medical school training to better understand the nature and impact of sensory processing differences. It also looked at the link between learning preferences and memory performance.

The result of this study is similar to that reported by Dobson (2010). Although their study used a small sample of 67 students, it revealed that 45 students preferred a mixed learning style of visual, auditory, reading and tactile. This is attributable to concerns expressed by Esewe and Ogunleye (2021) that whilst students in the first year of medical school may exhibit a preference for abstract conceptualization and active experimentation, a final-year student may show a significant preference for active experimentation and concrete experience regardless of gender disparities. However, where Dobson (2010) reported a significant difference in response to sensory modalities between male and female participants, the current study did not explicitly test for such differences. Nonetheless, it has been proposed that males learn better through practical applications to ideas, concepts and theories compared to females who exhibit a considerable level of accommodative learning style (Esewe & Ogunlege, 2021). This accommodating learning approach depends on intuition rather than logic. Such persons are drawn to new challenges and experiences, as well as the execution of plans. (Chen, 2017) Similar sex-related differences were also reported by Ezekola (2010) in Nigeria. Males aged

between 18-22 years and in their second year leaned towards visual learning compared to females who were more likely to be auditory learners.

The mixed learning style preference observed in this study may be because medical students were in their first to fourth year in school. During this period of their studies, learning is largely through assimilation, abstract thinking and experimentation (Esewe & Ogunlege, 2021). In that regard, memory formation and processing is predominantly due to cortical activities in the occipital and temporal lobes together with the hippocampus which plays a central role in memory formation.

Vielsmeier et al., (2015) reported that a PTA of 15 dB or less represents normal hearing sensitivity and hearing is apparent at a PTA of above 15 dB. In this study, PTA was within normal values among students with visual ( $18.49 \pm 2.65$  dB), auditory ( $17.67 \pm 4.17$  dB), tactile ( $18.33 \pm 2.89$  dB) learning styles and those with equal learning preference ( $18.14 \pm 2.68$  dB). This signifies that students had intact peripheral and central auditory systems and exhibit normal auditory sensitivity.

Feedback from tactile areas to the central nervous system is dependent on multiple afferent fibres and cutaneous receptors, the Meissner and Pacinian corpuscles being responsible for vibration stimulus detection (Ekman et al., 2021). Abnormal Vibrating Perception Threshold (VPT) may indicate various degrees of neuropathies, especially in patients with diabetes mellitus. In this study, no significant difference was detected among the various learning style preferences of the students in relation to VPT. This could be due to the age of participants who were relatively young and may demonstrate higher sensitivity to cutaneous receptors.

In this study, Pelli-Robson's performance for the Left eye, Right eye and both eyes of visual learners and the equal learning style preference were different from the normal contrast sensitivity value (2.0) (Wang et al., 2009). This may indicate a slight reduction in contrast sensitivity, though no significant difference was found between the individual learning styles and preferences. It is

worth noting that the Pelli-Robson test is recommended to be performed in a room with a luminescence value ranging from of 60-120 candelas/m<sup>2</sup>. All tests were performed in a well-light room during the day but luminescence was never recorded. Therefore how variations in the luminescence could have affected the comparison of the findings here with other studies cannot be emphatically stated. Typically, a decreased PelliRobson performance test may indicate an agerelated macular degeneration and impaired vision which may affect the visual learning ability of participants as indicated in previous studies (Faria et al., 2015; Maynard et al., 2016). As part of the exclusion criteria, none of the students used in this study wore glasses or reported visual deficits, therefore no conclusions can be made on how clinically recognized visual deficits may impair visual learning.

It is imperative to observe that, compared with previous investigations that also reported overall sensory modality preferences of 130 students, about 45% of the unimodal learners were auditory (Kayalar & Kayalar, 2017). In contrast, this current study reports the single highest unimodal learners being visual learners at 37%. This difference begs the question of whether or not most unimodal learners will prefer auditory or visual learning styles. Considering that the human environment has evolved to be a largely visual-based society, more credence can be given to an abundance of unimodal visual learners. There is also the potential of this difference being due to the differences in populations used for this study. Nonetheless, a larger study will be able to investigate differences that could be due solely to the study design.

This study revealed that the tactile learning style is the least preferred style among the students. This trend was consistent with the results of previous studies. For instance, it was reported in Tehran (2016) that only 15% of students employed a tactile learning style in which males are the dominant group (Nosratinia & Soleimannejad, 2016). To some extent, this is the case because the population consists of medical students who do not engage in many tactile activities

in their line of work. As medical students, they must understand the theory and pass the required exams. Based on how experience-dependent learning occurs, one would expect that had the study population involved persons who utilize fine motor and sensory skills on a regular basis, more tactile learners would have been identified (Calik, B., & Birgili, B. 2013). As students progress to their clinical years where they would require more practical and technical skills as part of their training, the transition from virtual and auditory learning styles to tactile learning styles is very likely (Haggard et al., 2003).

Another intriguing finding from this study was that those who preferred tactile learning tended towards having poorer scores in the auditory and visual learning tests, although this was not significant (Table 5). It's worth noting that this tendency only applied to sensory modality preferences based on Barsch learning style ratings, and that actual academic achievement may differ. Regardless, there are reports that students with tactile perceived sensory modality preferences are more likely to perform poorly in class (Najmah et al. 2016). It is unclear why this pattern was noticed in these pupils in this study, and there is unfortunately little evidence to consult in Ghana. However, there is growing data from other parts of the world to rely on for a better understanding that most tactile learners perform poorly in class, according to the research. In the United States of America, for example, two studies on sensory modality preferences and academic performance have been undertaken with similar findings.

Previous reports have shown no statistical link between learning style preferences and course performance among physiology students (Dobson, 2010), however, students with multimodal sensory preferences did well in a nursing course (Fatemah and Shiva, 2019). Although the samples in these two experiments were not the same, they both measured the students' sensory modality preferences, suggesting that there could be some relationship between the learning style one is predisposed to and positive results in a given course that leans towards that style.

All cortical and thalamic levels of sensory processing are subject to strong top-down influences, with more complex information having a greater impact on lower-level processes (Gilbert & Sigman, 2007). These cortical areas function as adaptable processors because they are subject to attention, expectation, and perceptual task. Interaction between these cortical areas via feedback processes may also contribute to intrinsic circuit enhancement and modification (Gilbert & Sigman, 2007). Despite this, intrinsic circuit dominance in occipital and temporal lobe cortical areas can cause prefrontal and parietal lobe depression, impairing tactile learning ability. In this sense, students who indicated a preference for tactile learning style in the current study will require more instructional support to activate the primary visual and auditory memory areas. Tactile learners should be considered for technical education in fields like electrical engineering, civil engineering, computer science, and construction technology, among others.

The varied memory scores of medical students were found to have a weak but positive link with Barsch learning styles. Meaning that Barsch discovered that medical students' learning styles are related to their memory performance and should be considered when giving instructions and selecting appropriate teaching techniques. Males' tactile memory performance was significant ( $p=0.023$ ) for both perceived and measured sensory modality preferences, indicating a link between sex and sensory modality preferences. Auditory memory performance (males = 9.61 vs females = 9.83) and self-ordered pointing task (males = 2.35 vs females = 1.78) scores were similar ( $p > 0.05$ ) for both male and female students.

Therefore, the results of this current study may be said to be inconclusive to support whether or not there is a significant association between sex and sensory modality preferences.

However, Torrano and his colleagues in 2017, revealed that males preferred the visual learning style over their female counterparts. Thus, it does show that even the high proportion of women in this current sample could not invalidate the results of sex indifference. This is the first research study that has directly compared sensory modality preferences among medical students in Ghana.

### **5.1 Strengths of the study**

The study focused on medical school students. As medical school is often noted for its rigorous academic requirements, identifying individual differences which can be capitalized on to enhance performance through targeted teaching and learning is a good starting point to explore. This has also laid the foundation to investigate an equally rigorous program such as engineering which balances theory and practical skills from the onset of the course. This way impact of developing motor skills on tactile learning can be better explored and juxtaposed of the findings of this current study.

Secondly, the study used a Pelli-Robson measure for assessing vision rather than the often used Snelly chart. This measure for contrast sensitivity rather than visual acuity is able to assess visual processing in the peripheral nervous system in a manner that is better related to the physiological mechanisms that underlie learning and memory in the central nervous system. Lastly by collecting multiple types of data related to sensory processing, sensory specific memory formation, subjective and objective learning styles, the study will be able to begin a longitudinal research that tracks students over a the duration of the medical school period. This will reveal in a more robust manner how lived experiences alter learning process over time. It will also feed into long standing debates about the role of environmental enrichment on neuroplasticity.

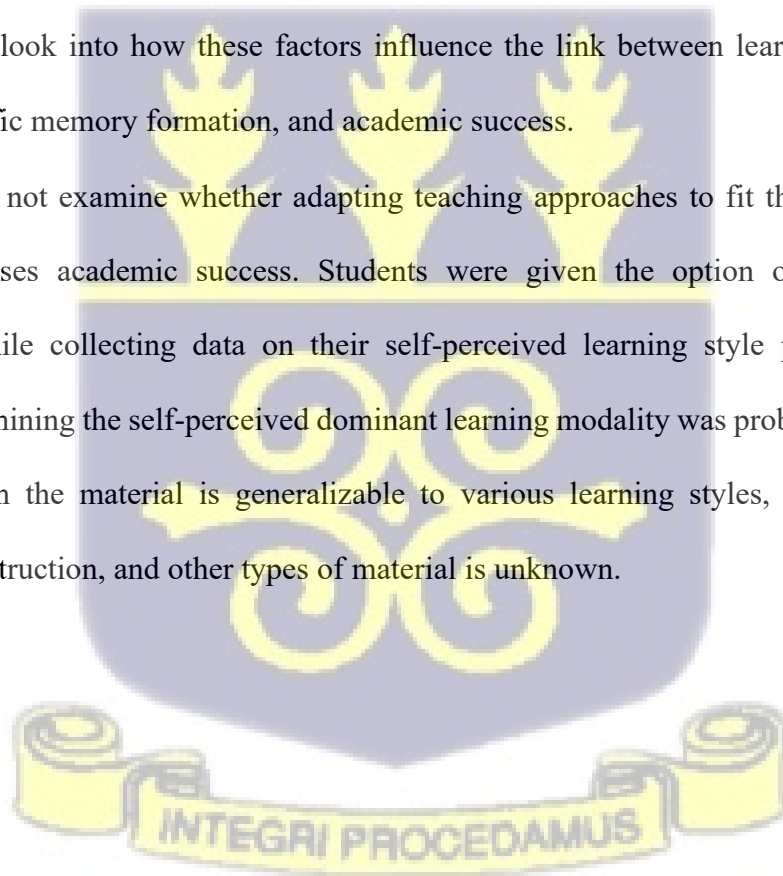
### **5.2 Limitation and future research**

This study looked at the learning style preferences of medical students to conclude a diverse group of students. As a result, such findings may not be representative of all medical students in all medical schools, as well as in various geographical locations and learning contexts around the world. Furthermore, participants were chosen using convenience sampling approaches, limiting the generalizability of the findings.

A bigger sample size could reveal significant gender differences. Future research will benefit from including more samples and examining a wider range of participants. It will also be persuasive to do longitudinal research to examine how the medical student's preferred learning style changes over time and how this affects his or her performance in different courses.

During the performance of the Pelli-Robson test for this study, the background luminescence was not recorded although the test was performed in a well-lighted room. Assuming the luminescence was below what is required, this could account for the lower-than-normal contrast sensitivity reported. It is worth noting that this study didn't account for variables like intellect or personality, both of which have a consistent predictive potential for academic performance. Future research could look into how these factors influence the link between learning styles, sensory modality-specific memory formation, and academic success.

This study did not examine whether adapting teaching approaches to fit the learning styles of students increases academic success. Students were given the option of selecting various preferences while collecting data on their self-perceived learning style preferences. In that scenario, determining the self-perceived dominant learning modality was problematic. Finally, the extent to which the material is generalizable to various learning styles, kinds of education, durations of instruction, and other types of material is unknown.



## CHAPTER SIX

### CONCLUSION AND RECOMMENDATION

There are various approaches to learning, and it should be understood that as effective learners, we will use a variety of learning styles in all scenarios. The study discovered different learning styles among medical students at the University of Ghana by using a learning style questionnaire.

#### 6.1 Conclusion

The outcome of the study revealed that distinct student learning styles are linked to specific memory performance and processing. Furthermore, the majority of children learned in visual ways, followed by aural and tactile approaches. As a result, it is anticipated that this knowledge will be valuable in assisting individual medical students, as well as the school as a whole, in improving their performance by implementing innovative methods and global learning skills to maximize learning. This result will also aid teachers and instructors, as they will be able to benefit from adjusting and adapting more relevant teaching approaches in various disciplines; however, further research and validation of this observation are required.

#### 6.2 Recommendation

The outcome of this thesis revealed that visual learners make up the majority of medical students at the University of Ghana Medical School. This thesis' conclusion suggests a threelevel recommendation: individual students, instructors, and institutions.

##### *Individual level*

Individual students should recognize that there are several approaches to learning, and it should be understood that, in order to be effective learners, one cannot constantly employ the same

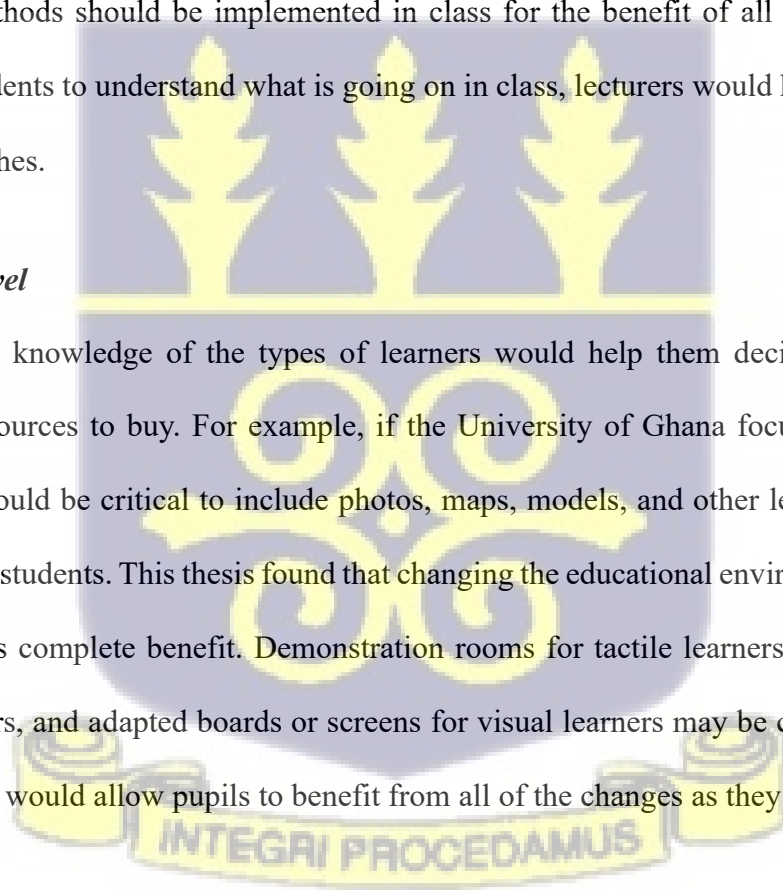
learning style in all settings. Understanding one's learning style should provide you with a clearer picture of yourself as a learner, and this insight may help you learn more effectively. While one cannot control how the lecturer delivers his or her lecture and knowledge in any specific class (e.g., textbook, classroom, lecturer, web-based content, group work, etc.), one can control how he or she processes that information while learning. This can be accomplished by adapting your learning activities to your preferred method of learning.

### ***Instructors/lecturer level***

This thesis provides a preliminary glimpse of what may have occurred in a number of classrooms at a single school. Once instructors are satisfied with the results, various changes to teaching methods should be implemented in class for the benefit of all students. For the majority of students to understand what is going on in class, lecturers would have to alter their lecture approaches.

### ***Institutional level***

An institution's knowledge of the types of learners would help them decide what kind of educational resources to buy. For example, if the University of Ghana focused on textbook purchases, it would be critical to include photos, maps, models, and other learning tools that would assist all students. This thesis found that changing the educational environment is critical for the student's complete benefit. Demonstration rooms for tactile learners, auditoriums for auditory learners, and adapted boards or screens for visual learners may be considered by the university. This would allow pupils to benefit from all of the changes as they study.



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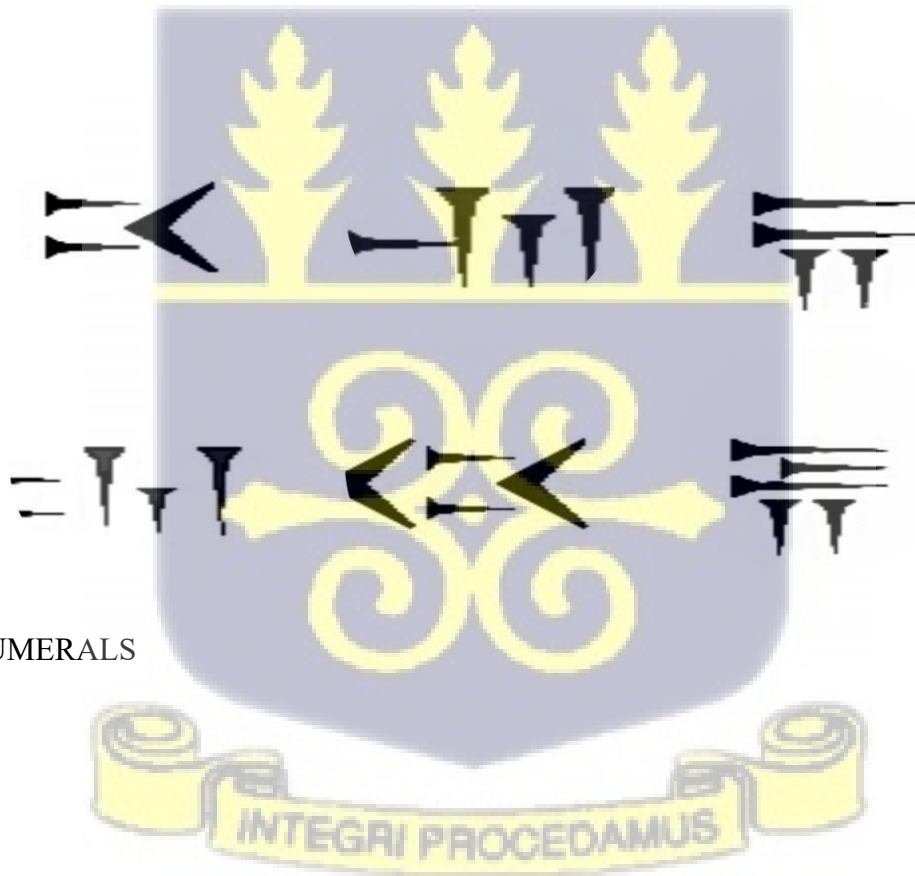
## APPENDIX

### APPENDIX I: ASSESSMENT TOOL I

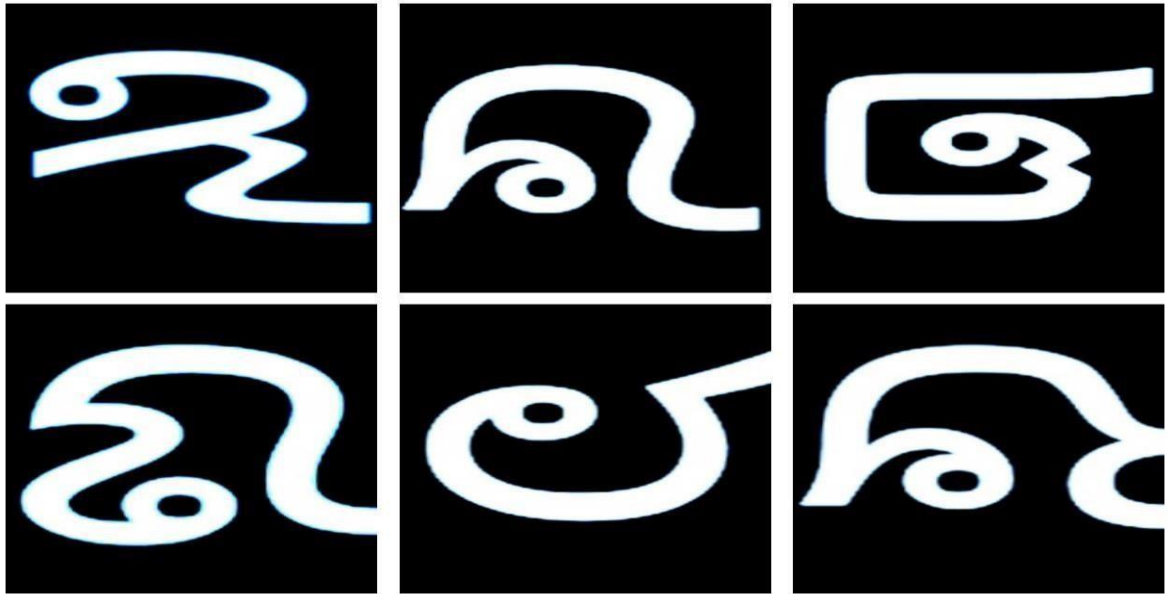
#### BABCOCK; STORY RECALL TEST

December 6<sup>th</sup> /last week /a river /over flowed /in a small town/ ten miles / from Albany. /Water covered the streets / and entered the houses. /Fourteen persons / were drowned/ and 600 persons / caught cold / because of the dampness / and cold weather. / In saving / a boy / who was caught / under a bridge / a man / cut his hands.

#### CUNEIFORMS



#### THAI NUMERALS



**APPENDIX II: ASSESSMENT TOOLII**

**Barsch Learning Styles Inventory**

This inventory examines and reports your preferences in terms of the three primary senses you use to take in information: visual, auditory, and tactile/kinesthetic (touch and movement). Check the appropriate line for each.

often	sometimes	seldom	
___	___	___	1. Can remember more about a subject through listening than reading.
___	___	___	2. Follow written directions better than oral directions.
___	___	___	3. Like to write things down or take notes for visual review
___	___	___	4. Bear down extremely hard with a pen or pencil when writing.
___	___	___	5. Require explanations of diagrams, graphs or visual directions.
___	___	___	6. Enjoy working with tools.
___	___	___	7. Are skillful with and enjoy developing and making graphs and charts.
___	___	___	8. Can tell if sounds match when presented with pairs of sounds.
___	___	___	9. Remember best when I write things down several times.
___	___	___	10. Can understand and follow directions on maps.
___	___	___	11. Do better at academic subjects by listening to lectures and tapes.
___	___	___	12. Play with coins or keys in pocket.
___	___	___	13. Learn to spell better by repeating the letters aloud than by writing the word on paper.
___	___	___	14. Can better understand a news article by reading about it in the paper than by listening to it on the radio.
___	___	___	15. Chew gum, smoke, or snack during studies.
___	___	___	16. Feel the best way to remember is to picture it in your head.
___	___	___	17. Learning to spell by "finger spelling" the words.
___	___	___	18. Would rather listen to a good lecture or speech than read about the same material in a book.
___	___	___	19. Are good at solving and working on jigsaw puzzles and mazes.
___	___	___	20. Prefer to be shown rather than told.
___	___	___	21. Prefer listening to the news on the radio rather than reading about it in the paper.
___	___	___	22. Obtain information on an interesting subject by reading relevant materials.
___	___	___	23. Feel very comfortable touching others, hugging, handshaking, etc.



**Scoring**

OFTEN = 5 points

SOMETIMES = 3 points

SELDOM = 1 point

Place a point value on the line next to its corresponding item number. Next, add the points to obtain the preference scores under each heading.

Visual Preference		Auditory Preference		Tactile/Kinesthetic	
No.	Points	No.	Points	No.	Points
2.	_____	1.	_____	4.	_____
3.	_____	5.	_____	6.	_____
7.	_____	8.	_____	9.	_____
10.	_____	11.	_____	12.	_____
14.	_____	13.	_____	15.	_____
16.	_____	18.	_____	17.	_____
20.	_____	21.	_____	19.	_____
22.	_____	24.	_____	23.	_____
Total Visual _____		Total Auditory _____		Total Tactile/ Kinesthetic _____	

If the scores in each modality (i.e. visual, auditory, tactile) are within a few points of each other, you probably use all your modes equally. On the other hand, the inventory suggests you have a preference if one score is significantly higher than the others.

**Visual Learners...**

Like to see words in writing or have concepts presented pictorially. They remember what they *see*. They are attuned to physical elements in a classroom. They like illustrations, diagrams, charts, etc. Visual Learners benefit from overhead transparencies, handouts, charts, diagrams and board work. They take lots of notes and are able to recall information by reviewing them.

**Auditory Learners...**

Use their voices and ears as the primary modes for learning. They remember what they *hear*. They express themselves verbally. They understand things by talking them through. Auditory learners love class discussion and are not as likely to take notes. They often "vocalize" what they read. Auditory learners often benefit when they can obtain information from audio tapes or lectures.

**Tactile/Kinesthetic Learners...**

Learn better when they touch and are physically involved in what they study. They want to handle material, make products, do projects, etc. They understand and remember what they *do*. They learn best by trying things out, experimenting and practicing. Tactile/kinesthetic learners benefit from taking notes because it is something they can do in the learning experience, but they may never -- and never need to -- reread them. Fidgeting and doodling may help them think clearly. A tactile/kinesthetic learner does best when subject matter can be applied to real-life situations.

INTEGRI PROCEDAMUS

**APPENDIX III: QUESTIONNAIRE**

**DEMOGRAPHIC/SELF-REPORTED LEARNING STYLES**

Gender

Male  Female

Other

Age (years)  18- 22(exactly 22 not a day

older)  22-26(exactly 26 not a day older)

26-30

Year of study

1st

2nd

3rd

What word would best describe the type of learner you are

Visual  Auditory  Tactile

Equal preference

Email.....

Contact.....

