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**THE IMPACT OF MEMORY ON ARCHITECTURAL
DESIGN: EXPLORING THE RELATIONSHIP
BETWEEN RECOGNITION AND MEMORY
RECALL**

Noor Kadhim Saeed ALKHAF AJI

Master's Thesis

Supervisor

Asst. Prof. Dr. Can UZUN

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The thesis titled THE IMPACT OF MEMORY ON ARCHITECTURAL DESIGN: EXPLORING THE RELATION BETWEEN RECOGNITION AND MEMORY RECALL prepared by NOOR KADHIM SAEED ALKHAFAJI and submitted on 04/01/2024 has been **accepted unanimously** for the degree of Master of Science in Architecture.

Asst. Prof. Dr. Can UZUN
Supervisor

Thesis Defense Committee Members:

Asst. Prof. Dr. Can UZUN	Department of Architecture, Altınbaş University	_____
Asst. Prof. Dr. Ayşe Esra İDEMEN	Department of Architecture, Altınbaş University	_____
Asst. Prof. Dr. Erhan KARAKOÇ	Department of Interior Architecture and Environmental Design, Ankara Medipol University	_____

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Noor Kadhim Saeed ALKHAFAJI

Signature

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ABSTRACT

THE IMPACT OF MEMORY ON ARCHITECTURAL DESIGN: EXPLORING THE RELATIONSHIP BETWEEN RECOGNITION AND MEMORY RECALL

ALKHAFAJI, Noor Kadhim Saeed

M.Sc., Architecture, Altınbaş University,

Supervisor: Asst. Prof. Dr. Can UZUN

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The mechanism of memory for architects is fundamental to investigate and understand since it plays a crucial role in architecture and to help architects understand how their concepts, decisions and designs are formed or inspired. Architects usually catch a house on the street or an image of a building in an article that it is definitely known but there are some common details that cannot be remembered about it. Some details that are blurred sometimes, though it looks so familiar, like the architect who designed it, the year it was built at, the city where that building is located or some architectural details about that building itself, like its colour, materials used on the facades, the shape of windows or balconies and so on. Details that are related to what the architects can remember about any building or image that he sees, or details he can recognize immediately from the first sight, or other details that might take more time to be recalled or recognized. Each architect has his own storage of these details that helps him to create his own language in architecture, a language that represents a vision most of the times, but what affect this language is important, any concept, idea, detail or memory can be considered as vocabulary for that language, those details are recalled later to create that comprehended language. Those recall, retrieve, remember and recognize actions help enhance and enrich the architectural language with all the meaning and concepts that might be brought within, these actions can be gathered under the title of memory with all the divisions it might include. Since there are two classifications of memory retrieval as Psychologists mentioned: (recall and recognition), several questions might be asked:

What is recall? What is recognition?

Are recall and recognition are related procedures or not?

Do architects depend on recall, recognition or both of them while starting their early steps of any design?

An experiment on a number of architects was managed in this research to provide better understanding of the relation between recall and recognition actions and their effects on architects and design process in architecture. Though recall and recognition considered as two activities, the research investigates the relation between them and whether these procedures require separate cognitive processes or do they complete each other? Do they have any effects on architects while starting their designs?

Keywords: Recall, Recognition, Retrieve, Familiarity, Remember, Know, Guess.

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1. INTRODUCTION

Architecture can transform words, needs and desire into space, it can capture fleeting or insistent memory into tangible, buildable or unbuildable form. Architecture provide a stage on which we can enact our lives. Memory however, creates a special relationship with the space, holding on to the essence of it, the best and the worst letting the rest of details fade into grey [1].

Millay Jean [2] in her book: Multidimensional Mind, focuses on the impact of the memory on the people's behavior and architects in particular, and showed "that many of us derive our pictures from a similar memory base, when we learned to read, the pictures with the words became word – picture – symbols".

Architecture has a memory too, all the time it is trying to capture the perspective of time and events creating suitable environments to surround people by living comfortable atmosphere [3].

In his Thesis research, Mansor M. [4] Analysis the autobiographical memories and childhood recollections of famous architects like (Frank Lloyd Wright, Le Corbusier Peter Zumthor i.e.), to understand the concepts and ideas behind their architecture.

In addition Sarin S. [5] mentions that sometimes architects thinks forward to race time and generate some ideas that can be converted to projects which are considered as much ahead of its time, architects also sometimes goes backwards to memories about childhood or some images engraved in mind using those memories as a tool to create an unforgettable architecture and buildings which stand together like a silent society [5].

Despite the silence, that architecture has a clear language that can speak clearly for its silence. Memories help to preserve human architectural legacy by turning society's memories to magnificent architecture, architects depend in many times on their own memories consciously or unconsciously to start creating their own work, as Peter Zumthor mentioning his childhood memories at his aunt's "experienced architecture without thinking about it", He was recalling his memories form stories of architectural experiences: as he described the sound of gravel under his feet, the soft gleam of the waxed oak staircase [5], by gathering the architects imagination and his memories we can conclude that memory serves as a datum for his architecture , architects maybe will have fourth dimension in addition to (length, width ,depth), and it might be called memory in the near future [5].

Architecture represents the memories of civilizations like buildings, castles, churches, mosques, and any other structure that have survived through the years like a witness for the existence of these civilizations, like Turkey and Iraq that hosted many civilizations, Ottoman and Byzantine Empires that existed in Istanbul, Sumer, Babylon, Assyria, and many others in Iraq.

Those civilizations have left numerous traces helped to create a rich legacy of literature, architecture, medicine and science for its people and rest of the world serving as a reminder of their former presence there [6], [7].

1.1 MEMORY AS A TERM

Memory in general is a condition or action that follows the following steps of encoding, storing, and retrieving every day events, information, words, situations, faces, voices, names and even smells, for philosophers it is an initial act of registration that leads to an act of retrieval through the continuity presumed to be required and provided by the mechanism of storage [8].

According to Abel, Alberini, Ghirardi, Huang, Nguyen, & Kandel [9]: memory is the ability to recall knowledge that has been learned or gained through the years.

While Edridge Green[10] defines memory as the mechanism by which the outside world and ideas are stored for us to recall at another moment, in literature from centuries ago, similar definitions can be found, for instance the procedure by which knowledge, information, techniques and ideas about the world are preserved for later on use [10], Green describes the memory in his book as the main activity to the brain and without it any experience is meaningless and impractical, identity, personality and relations, relations related to memory since any man can not recognize himself in the mirror or recognize his own name without his own memories about himself and his life that leads to the fact that every single act in life directly or indirectly ends to that point of memory, memory is needed for human to go on with daily life activities like speaking! Without human's abilities to remember it would be hard to participate in any conversation, as sentences will be forgotten before being able to reply, to understand the memory mechanism, three terms mentioned by Savage M and McLeod S. A.: encoding, storing, retrieval [11], [12].

- a. Encoding: means changing, changing the data that the brain receives during any interaction with the external world into a formula that the brain can understand so it becomes easy to store.

And there are three ways to change the information or data we collect

- a. Visual (picture)
- b. Acoustic (sound)
- c. Semantic (meaning).

Remembering a building by seeing it this is an example for the visual encoding, while the acoustic encoding is process of converting sounds, words, and other auditory data into a format that can be stored and retrieved later, when the data is related with sounds it helps recalling the information easily when the certain sound is heard, for example whenever you hear a symphony is playing a concert hall is remembered, semantic encoding highly related to the high-imagery words like the words cat-car-tree, for these words you directly imagine shapes for each word and that makes it easier for the brain to remember words with images more than abstract words like principles, values and rules which considered as low-imagery words [11].

- b. Storing is related to where the information will be stored (long term memory or short term memory), for how long we can hold the information, how much information and what type of information can be stored.
- c. Retrieving it is related to the ability of recalling the data or information that has been encoded and stored earlier in the brain.

These three procedures are necessary for creating human memories hold them then recall them after a period of time, missing one of these three steps then memories won't be existed. Memory retrieval comes in a variety of forms, including recall, recognition, relearning, and reconstruction. Arranging the information in specific order (by size, by color or alphabetically) could make retrieval process much easier [12].

1.2 INFORMATION CLASSIFIED AS A MEMORY

Recalling the names, date of birth, high school and such personal information which the answers are already known cannot be called a memory, it can be called knowledge, no time needed to remember or think about the answers for such questions, but the word "memory" should only be used to describe experiences that are explicitly felt to be a reliving of the conditions from which they were obtained.

When a situation is lived in the past (when memories are created), then years later people go through the same situation (when memories are recalled), in the present it can be called a memory [8], in another simple words memory is a current mental state perceived as past,

and since memories are stored in the brain, how much information and memories can the brain hold or store? The capacity of the brain to store information and memories has recently been the subject of numerous inquiries, researchers have found that deciding the answer is complex [13], Generally speaking brain never runs out of memory, but the amount of information that the brain can hold influenced by a number of variables, such as the person's age, level of education, and general health, it is also affected by how information is encoded and saved, the more organized data encoding the easier to retrieve them.

1.3 MEMORY VS LEARNING

“I see memory squarely at the root of our learning experience” [1].

Memory plays an important role in learning procedures for human beings since it is the sum of everything humans can recall, so the ability to learn from past experiences, adapt, and form new relationships is all a result of humans' memory.

It is the archive of knowledge human has acquired and retained from past experiences or activities, as shown by changes in behavior or by things that can be recalled and recognized. (Discussion in details will be presented in chapter 2), human learning, the method through which human gain knowledge of the world and adjust future behavior based on the information retained and developed skills, is linked to but different from memory, Since memory prepare a place to store learned information and skills, and then allow to recall what have learned when needed, that is to say it helps to express what human have learned. Taking everything in account, memory and the retrieval process are equally important to learning in that they provide access and framework for connecting new information to existing information. It can be said that learning and memory two notions that go hand in hand, with the exception of learning takes long time to achieve the process, while creating memories usually happens instantly [14], [15].

1.4 MEMORY AND ARCHITECTURE

“The only reason we remember things is to make better decisions” [16].

Architecture might be a museum for time, architect pallasmaa J. says, its structures might create a new language that might express different emotions, can give the feeling of grief as in visiting some tombs or feelings of joy, fear and any other feelings the architects want to show in their designs, and all these designs depend on decisions that the architect or the engineer would make [17].

According to national center for biotechnology and information: memory of the human being is playing an essential role in the proper creating of human's cognitive map, which means his mental image or map he creates in his mind about his surrounding environment [18].

It is also crucial to situations' recognition to help the map reflects the surrounding environment accurately, the better and accurate the map is the better the decision is made.

Though complicated, memory and decision making relation however crucial, when making decisions in architecture, several elements are taken into account, including client needs, budget, aesthetics, building codes, and functionality, architects depend on their memories to collect, information and knowledge from previous experiences and apply it on their new design trying to come up with the best decisions, memory assists architects in comparing many design options, evaluating their advantages and disadvantages, and choosing the optimal option for the project.

Furthermore, memory sometimes helps solving problems, architects use memory to recall past solutions, strategies, and techniques they have used in similar situations, this enables them to use their experience to create original answers for challenging designs [19].

Additionally, a sense of context and continuity in an architect's work is also maintained by using their memories, architects can develop a cohesive and consistent body of work by thinking back to earlier projects and benefiting from common themes, aesthetic trends, and architectural principles [19].

In order to create original design solutions, architects rely on their memory in combining existing ideas, concepts, and styles with earlier experiences and ideas, using their memories, Architects have the opportunity to combine many concepts, producing unique and contemporary designs.

It might be added to what mentioned earlier emotional connection, emotions and individual experiences are frequently incorporated into memories, architects may use elements or features in their designs that evoke particular feelings or give users a sense of familiarity depending on their memories, this could create a greater connection between the space and its users, also there is the cultural context, architects' perspective may be influenced by memories of cultural experiences and heritage, especially when combining local traditions, materials, or architectural features, these memories may assist in the developing designs that are respectful of the cultural identity of a place.

Without memories, architects would not be able to store any type experiences or retrieve relevant information when making decisions, and it is important to note that while memories can influence an architect's designs, they should also be open to new ideas, innovation, and the specific requirements of each project, the integration of memories with fresh perspectives and current design principles can lead to unique and successful architectural outcomes.

While memories might affect architects' designs, it's crucial to remember that they should also be open to fresh ideas, approaches, technical progress, innovation, and the specific requirements of each project, eventually to come up with innovative and efficient architectural outcomes, memories can be combined with fresh perspectives and contemporary design concepts.

In addition memory might be resembled to the storehouse of experiences and impressions that a person has obtained throughout his life from the surrounding environment, these impressions are made in the form of mental images associated with pleasant or unpleasant feelings, architects might consciously or unconsciously restore to that store to seek a solution for a certain challenge, expressing an idea, translating a concept, as the ultimate aim of an architect is to create spaces that evoke positive emotions and not only practical and useful but also memorable and significant to those who occupant it [19].

1.5 MEMORY AND INSPIRATION

“Memory and history should be architects’ main sources of inspiration” says Mario Botta [20]. Memories have the power to shape our lives, shaping our identities, guiding our decisions, and influencing our actions, memories bridge the gaps between our past and present, helping us to make sense of the world and to propel us forward, in general memories can inspire creativity, this applied also on architecture, memories can spark inspiration that is reflected in buildings which might serve as repositories of memories for individuals and communities, it gives architecture the power to evoke emotions, to transport users back in time, and to connect them to their heritage, buildings can act as tangible reminders of past experiences and emotions, architecture also has the power to shape our identities and preserve our cultural heritage, so it should be meaningful. Architects can incorporate personal meanings into their designs by connecting their buildings to their memories, “I remember the Cordoba Mosque, a mosque with large spaces and in which he left tremendous impressions in my memory through the unusual white marble used inside those mysterious and incomprehensible spaces, which is similar to the modern hybrid projects that I have

created today.” Zaha Hadid [19], the aforementioned spot the light on the architects’ childhood memories that had the power to shape and reflect the nature of their work, some of them were able to translate these memories into a beautiful architectural formation that allowed them to portray the way they lived in their own unique ways.

An example of those numerous architects whose memories and upbringing had an impact on them and were carried over into their architectural designs, is Aldo Rossi “I have long had an interest in modern architecture, but I think that perhaps this style of architecture is linked in my mind with some buildings of my childhood” , and Zaha Hadid “Memories can be consciously retained as part of a creative identity, or triggered by an image, sound or scent, or slowly uncovered in a sequence of layers, like materials stored inside a box,” Zaha Hadid [21], [22].

The process of creativity is primarily the result of the imagination, but as Viollet le Duc points out, there are two types of imagination: passive imagination, which is often referred to as memory, and active imagination.

The relation between active and passive imagination is like this: What the passive imagination (memory) presents as a disorganized mass is compared, picked, and organized by the active imagination [23], [24].

Viollet-le-Duc demonstrates the connection between recall and creativity in his use of the centaur as an example (figure 1.1), saying that it extends back to the time of Babylonians and Greeks, a human's passive imagination or as it might called as a memory, bring back an image of a man riding a horse, the active imagination recommends merging the two into one creature, after using reason to figure out how to join the torso of one to the breast of the other and generates a centaur. The centaur is a creation of the imagination, but it is the artist's role to give this fiction a credibility by using his ability for reasoning to examine how an animal's various components are fused and welded or attached together.



Figure 1.1: The Centaur [76].

People sometimes appeal to their memory in order to answer questions, however depending on memories only to create architecture is not sufficient, and since we are constantly learning from previous architectural experiences.

Great architecture that might be witnessed today is not just an individual work, rather, it is a cooperation of the designers and their memories, experience, art, science, and technology, this collaboration most probably conscious or unconscious.

1.6 MEMORY AS A DESIGN ELEMENT

As previously mentioned, Aldo Rossi was an architect whose work frequently drew inspiration from his memories, as he explained in his book: *A Scientific Autobiography*, where lights are shed on his architecture and projects taking advantage of the power of his memories to explain Rossi's architectural designs, these "examples from memory" in which Rossi uses his own past to explain how and where his conception of architecture originated. as Rossi mentions in his book how he was interested in modern architecture which he thought that this style was always related to some buildings back to his childhood as he remember. In order to make his work comprehensible, Rossi had to explain certain aspects of his memories, according to him, it was impossible to escape recalling the influence others had on him when he was a boy, because he is writing an autobiography of his initiatives that conflicts with his personal history.

Because of Rossi's personal information about history of architecture he used to remember and compare old historical element like Filarete's Colum at the Grand Canal in Venice and

the Roman ruins at Budapest for instance helped him to realize new concepts and expanding his conception of architecture and his method for producing it.

Example include his comparison of what he remembered about both roof of Zurich University (figure1.2), and roof of the Kunsthhaus (figure 1.3), from inside the buildings, as he said they are similar to one another.



Figure1.2: Zurich University and the Kunsthhaus [77-78].

Rossi's past experiences with architecture not only shaped his present ones, but also served as inspiration for his own designs, he remembered once visiting a convent in Spain (Santa Clara at Santiago de Compostela), and then mentioned how he was thinking all the time about it while he was designing a cemetery, he was inspired by the nature lightning of the convent and was trying to create the some atmosphere for the cemetery.

In Rossi's designs, memory is incredibly significant and crucial, it is used as a tool to create new architecture out of the ones in his memories, his designs "any project which I would like to do is also a memory of some other thing) [21].

Rossi's memory recalls an architectural experience and nearly acts as a guide to replicate that sensation in that experience in his own design processes.

Also architecture has a main role for memory, it helps to fulfil the concept of recreating the past in the present, by this architecture preserve identity.

Rossi's architecture is not only about himself and his personal memories only, at the same time it is preventing the loss of identity, as he always tries to go back to his heritage, origins, traditions, and his old experiences of his life to preserve identity against being forgotten [25]. Even though Rossi had been trying to use his personal memories as a tool that guided the design behavior to relive his childhood pleasant moments, Rossi understood that time cannot go back and the world cannot resist or deny changes, the changes which form the present, the past has its unique nature which cannot be recreated in every detail, there will be always something missing.

1.7 BUILDING INSPIRED BY PERSONAL EXPERIENCES AND MEMORIES

Felix Nussbaum Museum, Osnabrück, Germany, 1998, designed by the architect Daniel Libeskind, which is an expansion for Osnabrück's Museum of Cultural History, focusing on the work of the Jewish painter (Felix Nussbaum).

The architect was trying to embody the life of Nussbaum, the years of his artistic career in Berlin in the 1920s, Nussbaum's sheltered upbringing in Osnabrück, the looming political changes in Germany, and the start of the European War, where Libeskind chose three major components for his design: (a-long narrow corridor, b- a bridge connecting the old and the new museums, and finally the repetitive pattern of several tiny corridors, unexpected crossings, dead ends, and separations), representing Felix Nussbaum's stages of life, (figure 1.3), (figure 1.4)

- a. The long corridor was designed as a solid mass with no single window and the lighting of that space depends only on the soft light coming from openings on the ceiling, hence Libeskind was capable of achieving his concept about claustrophobia, which is a mental condition that results from the fear of being trapped in and suffocated in closed rooms which the painter was suspected to suffer from it, (Figure 1.5).

The wall is empty with no paintings to be displayed for only a few meters referring to the death of the painter and how he couldn't finish his work due to his murder.

That corridor was designed with a certain slope for two reasons:

- 1st it was referring to Nussbaum's difficulties and challenges he had to face in his life.
- 2nd related to religious belief of the architect himself, and also we can notice the dead end of the corridor.

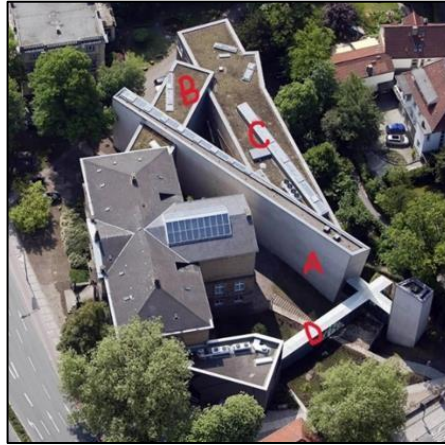


Figure1.3: Felix Nussbaum Museum [79].

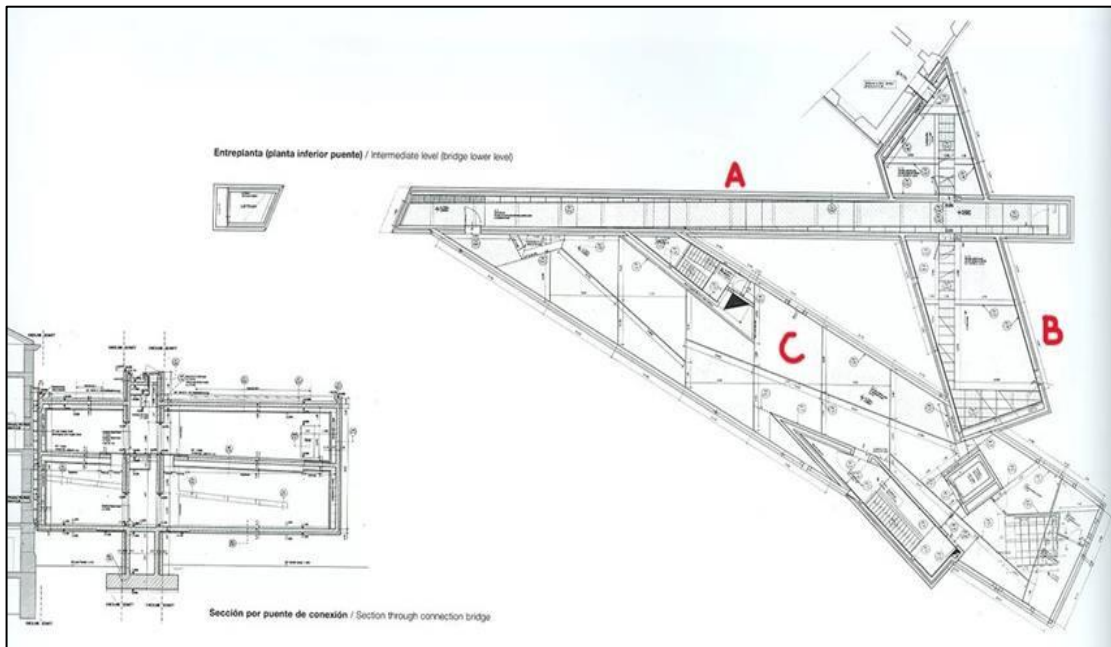


Figure1.4: Felix Nussbaum Museum plan and section [80]



Figure 1.5: Felix Nussbaum Museum [79]

- a. Bridge connecting the old and the new side of the museum made of concrete and covered with zinc, the function of this bridge is to connect the old part of the museum to the new part built with concrete not covered with any material, and he chose different materials for the new part to emphasize on his concept about continuity between the past and the future.
- b. The great hall of the museum where we can notice an acute angle is created as a concrete wedge goes into the exhibition area, so light floods the hallway at the end of the tapering corner, and the window slit is unusual for a window since it is long, narrow, and runs diagonally from top to bottom. (Figure 1.6) where we can notice also the dead ends in the hall [26].



Figure1.6: Felix Nussbaum Museum [79]

The architect intended to design that narrow corner trying to resemble this to the life experience of the artist and all the challenges faced him while he was trying to enter Belgium as a refugee.

Then in 2010 a new check out point was added, an aisle made of a glass referring to the new culture attached to the old structure made of glass as a sign of how to combine human present with their heritage, (figure1.7).



Figure1.7: Felix Nussbaum Museum [79]

Thus the architect was capable of utilizing his memories about the artist, his personal experience and life events to achieving the concept (Dynamic Dialogue between Past and Future) in this museum [19].

2. FORMS OF HUMAN MEMORY

Human memory is a complex system that plays a vital role in our lives forming who we really are, it involves the ability to store, retrieve, and encode information as mentioned in detail in the first chapter.

Memory plays a crucial role in our cognitive functioning, without memory any attempt of learning won't be useful, memory also important for problem-solving and even in problem recognition, it involves the brain's processing of information as well as its application to decision-making.

The main focus of this thesis is on visual memories because they account for a large portion of our memory and the information we retain.

There are some theories about forms of human memory division Baddeley, A. [27] & Norris D. [28], each type with its own unique characteristics and functions, according to psychologists different sorts of memories are retained by humans for varying amounts of time, so they categorized memories in to different types, considering this categorization is more like stages of transmitting memories within the brain:

The steps start with the sensory memory then transmit to Short term memory (STM), then ends in Long term memory (LTM), which are considered as the main types, these three different types of memory can be further divided into more different forms as shown in figure (2.1) [27], [28].

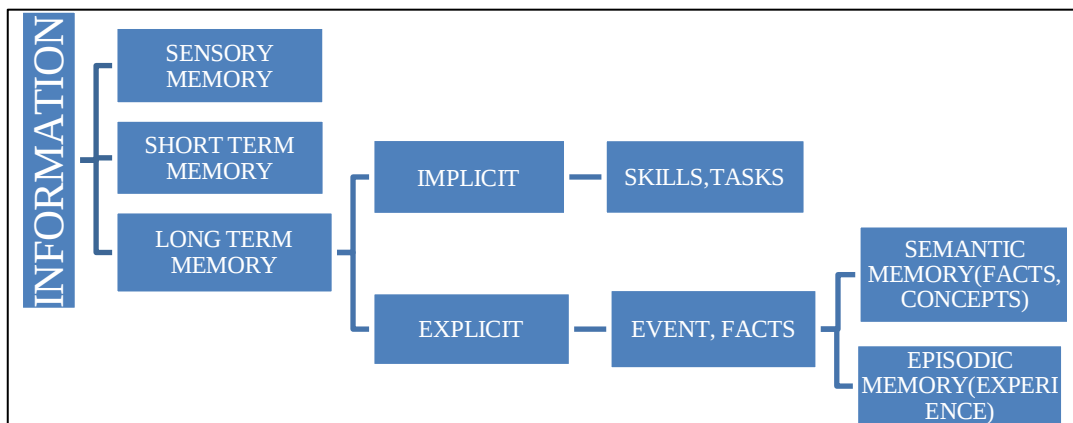


Figure 2.1: Memory Model – Modal Model by Atkinson and Shiffrin 1968 [26-27].

This model assumes that information, images, sounds, and other types of data that humans gather through their interaction with their surroundings go initially to sensory memory stores, where they can be modified, before moving on to the short-term memory, where they

can be related to the long-term memory, the short-term memory is crucial to this model because, without it, neither learning new material nor remembering old information is possible, each term will be explained separately in detail in the next [27].

2.1 SENSORY MEMORY

It is that type of memory that is being formed depending directly on the five human senses, which can store a tremendous quantity of data for a relatively brief period of time, time measured in milliseconds.

Recent research shows that those data directly represents the phenomenal complexity of our visual experience rather than being implicit or unconscious, it is also depending on what a person can hear, smell, taste and touch, but mostly on what he sees [29], and it is either reflecting our interpretations about what we see or it just reflects what the world really looks like [30], Sensory memory divides into several sub-categories figure (2.2):

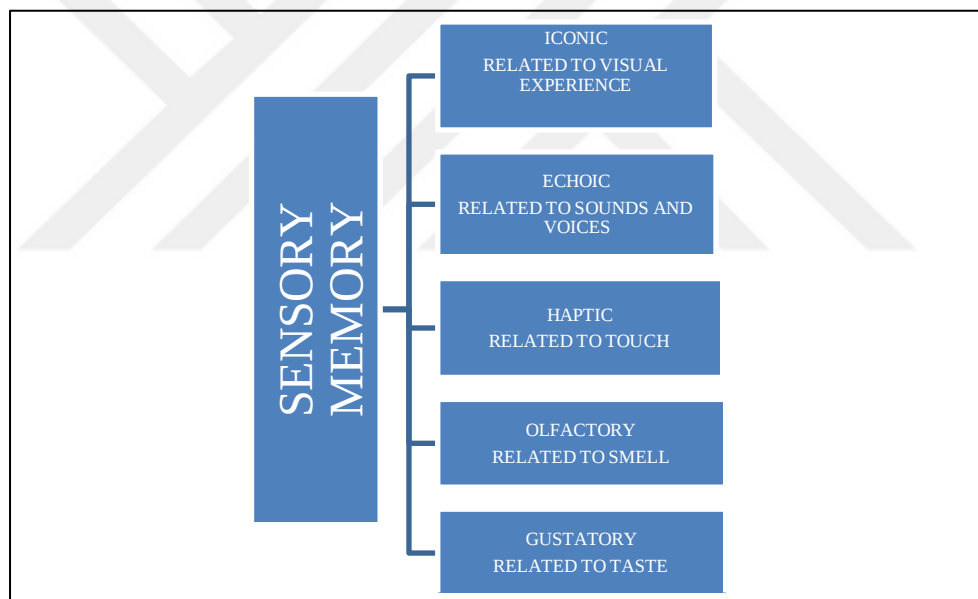


Figure2.2: The Divisions of the Sensory Memory [29].

recognizing someone's on the phone from their voices, this is when echoic memory is activated, or once someone is able to recognize certain language or use that language it means people totally depend on their echoic memory, also as the brain starts to identify words and sentences that can be understood and pronounce by keeping a record of each sound or syllable and correlating it to the next sound or syllable, while recognizing any sensations as pain, pressure, itching, that's when haptic memory is working.

Since iconic memories are the kinds of memories that the brain stores automatically, without any attempt to analyze or make sense of them, iconic memories primarily responsible for forming sensory memories, they can provide a valuable role, when the observer and everything around them is static, when the observer's eyes, head, body, and external objects are moving, it cannot store any useful data (images) that are usually coded to iconic memory, it will be creating only blurry flashes as in image (2.3) [29].



Figure 2.3: Blurry Flashes as in Image [81].

When a particular sensory experience keeps happening, memories usually move to the short term memory, which is the second stage in the process of making memories [31].

2.2 SHORT TERM MEMORY (STM)

The second stage of creating a memory starts when various sensory systems receive and process data that humans obtain for their environment.

Data then stored in the short-term memory for a short period of time, would not be more than 30 seconds, though humans can maintain a certain amount of data in the short-term store for more time up to few hours by practicing one or more of item/rehearsing, but it has so limited capacity. For instance, the majority of normal people can remember (5-9) figures, numbers, words or any kind of data [32], and increasing this capacity is possible by using the chunking method that was suggested by Miller G. A. [32] to make information clearer and simpler to recall. This is the technique of putting several pieces of information together into more smaller or relevant pieces, as an illustration of that method, while trying to memorize a phone number (7727727575), instead of memorizing all digits separately, it can be made like pairs:(77), (27),(72),(75),(75).

In that way the chunking method is applied by creating five groups or chunks of data which is laying between 5-9, instead of 10, and this would be too much for STM to store.

Chunking includes all kind of data: visually or when numeric or alpha-numeric attributes are combined.

It is worth mentioning that information retrieval from short-term storage is fairly quick and precise, on the other hand, any data might be lost from the short-term store cannot later be restored from it.

Each memory goes through this stage, where it is either deleted since it won't be used for long or it is retained and moved into long-term memory stores [33].

Some researchers consider the working memory (WM) is a classification that lies under the term of short term memory, but since STM is considered as storing units, the working memory is more related to the cognitive tasks like processing information and memories allowing to recall them when needed to solve problems or make decisions [28], [33], [34]. For instance solving a challenging mathematical problem that requires multiple numbers to be remembered, this process would activate the working memory, while memorizing a phone number would activate the short term memory only, where is no need for any mental process more than memorizing that number.

Both short term memory and the working memory are used interchangeably [28].

2.3 LONG TERM MEMORY (LTM)

The 3rd step of creating a memory is transferring the data of all kinds from the STM to LTM, which the data lasts more than 30 seconds and not forgotten quickly.

In order to allow this procedure of transferring data to be done, conscious effort must happen, such as repeating or rehearsing that data, for instance the students need to study and repeat the information many times so that the information can be moved to their LTM and recall it later on the exam day, or another conscious effort that help the data to be transferred to LTM is through emotional and physical experiences, just like knowing that electric shock is painful, it doesn't need to happen many times to know this information, such kinds of experiences is enough to help the data transfer.

Unlike the STM, LTM is a storage for data with no certain limit or capacity, and it is in charge of preserving all the memories a person has accumulated during their lifetime [35], long term memory can be further divided into two more categories:

Explicit memory is a conscious memory including, recollections of specific past events, facts from our life, or new information, and implicit memory, which is unconscious memory controlling how a person thinks or behaves: [8- 36] as detailed in (Figure 2.4):

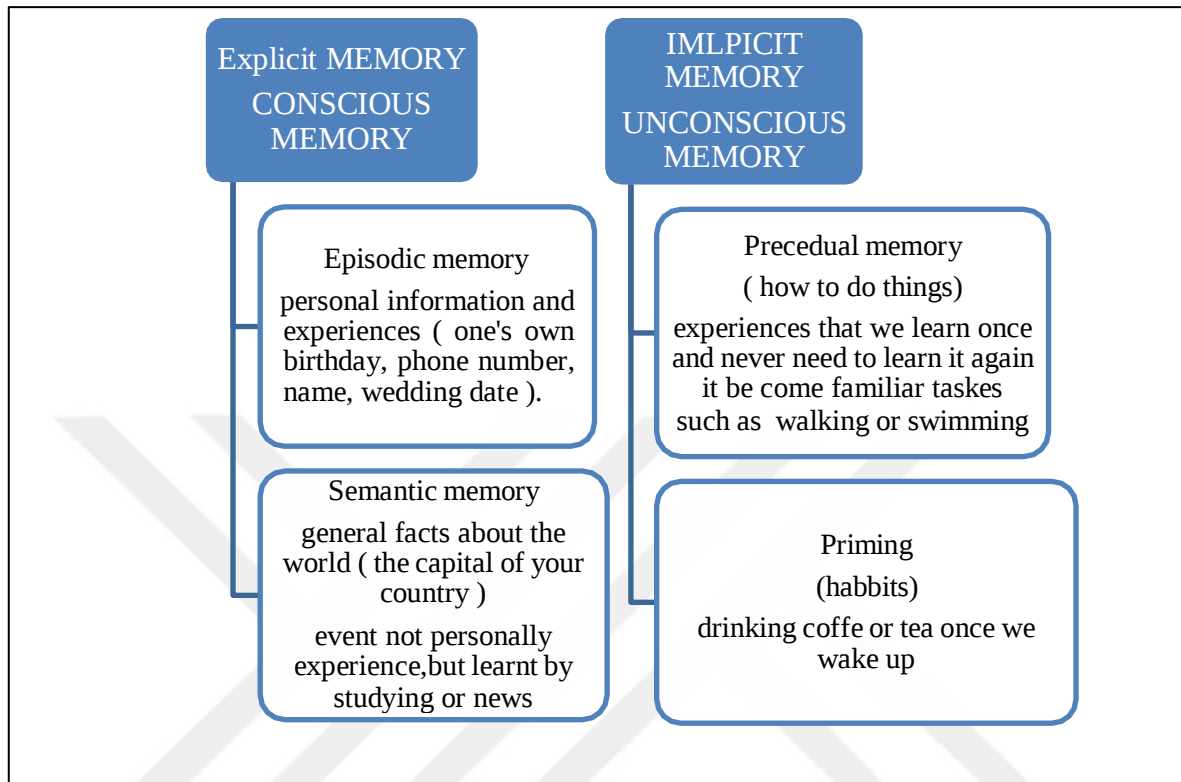


Figure2.4: Long Term Memory Subdivisions [8-36].

After storing the data or information in the LTM, at the time that any cue related to that data entered to the sensory system (visual cues, auditory cues, etc.)

Later on, it would be activated in the LTM and would be sent back to STM, and that how memories are retrieved [33].

Taking everything in account we can say that there are differences between short- and long-term memory stores, it could be due to differences in both terms of capacity and duration. A duration difference indicates that the decay of data stored in the short term memory depends a lot on time element, while capacity differences indicate that some data which short-term storage can accommodate is limited, if there is a capacity limit, some data that are smaller than the capacity limit might still be kept in short-term storage and won't be transmitted to the next stage [37].

Short-term store could be viewed as nothing more than the temporary activation of a section of the long-term store [33].

2.4 RECALL AND RECOGNITION

According to psychologists, Recognition and recall are two different terms used to describe how people retrieve memories [38].

Evidence of functional differences between various performance measures throughout the past century has greatly aided theories regarding the composition and organization of human memory. The correlation between recall and recognition memory has been an essential field of investigation.

In simple words the ability to recognize an event, place, name or information previously seen or heard marked by a sense of familiarity is referred to as recognition [38].

Recognition does not need any kind of processes or remembering details about the event, it is enough to identify it as familiar or not, whereas recall refers to the retrieval of the necessary details that have been heard or seen from the past, bringing back memories from long term memory, for instance recognizing a certain design or building as familiar is recognition while retrieving the name of the architect who designed it, is called recall [34], [38].

How the human memory functions will be briefly examined, and how the memory content is activated in order to better comprehend the relation between recognition and recall.

2.5 MEMORY CONTENT ACTIVATION

Psychologists frequently consider that memory is composed of fundamental, related parts or chunks, some chunks or parts are highly active some are not, that means each chunk can be described by its activation, activation indicates how quickly that chunk may be recalled back to memory.

Simple example of this procedure is remembering your name, you would answer the question “what is your name?” so quickly without any hesitation or thinking each time, that means this piece of information is stored in an active chunk that can be recalled so easily each time without much cognitive effort.

while try to answer the question “ what is your first grade friend’s name?” might take much longer time and cognitive effort to recall that information, it means it is stored in lower activated chunk [38], three major factors affect how a chunk is activated, figure (2.4):

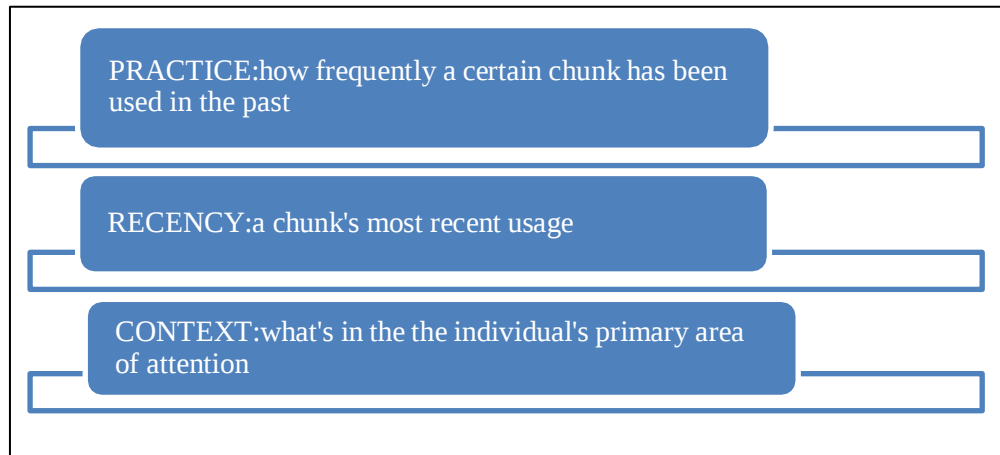


Figure2.5: Major Factors Affect How a Chunk is Activated [38].

In fact, the more that piece of information is used, the more likely to be remembered, due to the fact that a chunk's activation is based on how much practice it has experienced, that's why your name is more familiar than your first grade friend's name, quite a bit more practice has been given to this chunk where this information has been stored.

In addition there is the recency factor that affecting the chunk activation procedure, it means how recent you used that chunk of your memory influencing how to recall that information, the most recent the information is used the higher activation the chunk has [38], furthermore there is the 3rd factor which is called context, which is related to the term (association).

In order to understand what context means we have to explain more about what association means, as mentioned in the previous paragraph, memory consists of chunks or parts and the relation joining each two chunks called association, for instance when we say the name Zaha Hadid, what comes to your mind directly might be: White, futuristic, curves, Heydar Aliyev Center, concrete, glass, these words might be considered as associated words to her name.

Whoever it must be mentioned that these associations definitely change from one person to another, and maybe some other people will mention totally different associations because they are extremely individual and based on prior knowledge.

The name activates the relations (associations) between memory chunks, the first answer you think of is considered as the most active chunk of the memory [38].

In psychology and architecture, the idea of association is crucial since it serves as the foundation for both learning and problem-solving, it serves as a bridge between the present and our past knowledge and experiences, so context has a strong effect on retrieving

information from memory, a memory chunk becomes more active and spreads activation when anything in the present moment is strongly related with it [38].

It is mentioned that recognition is easier than recall because it includes much more cues that help to remember the information quickly, those cues help the activation process between the memory chunks [39].

For instance two questions might be asked about the same topic to explain how recall depending more on cues than recognition:

Who wrote (The Language of Post-Modern Architecture)?

Did Jencks write a book titled (The Language of Post-Modern Architecture)?

A person must recall a specific name for the first answer, however for the second question, he just needs to determine or recognize whether the response is correct or incorrect.

In daily life people rely on both recall and recognition to find answers, like searching for a specific book on a website, but in case of not remembering the full title or the writer's name, normally people might start their search by retrieving any information that can be remembered about the book, such as a word from the title or the author's last or first name, or any other information that helps to start the search and then they might be able to recognize the book they are looking for from the suggested titles that show on the searching bar, it means that in recognition there is a focal point present like a general information allowing to decide whether this subject is familiar or not, while in recall process the focal element is missing and need cognitive effort to be done in order to recall that detail or information.

Memory as an action would be fully completed if both recall and recognition complete each other to give the final decision or information [40].

So, the differences between the two processes can be sum up in the diagram below (2.6):

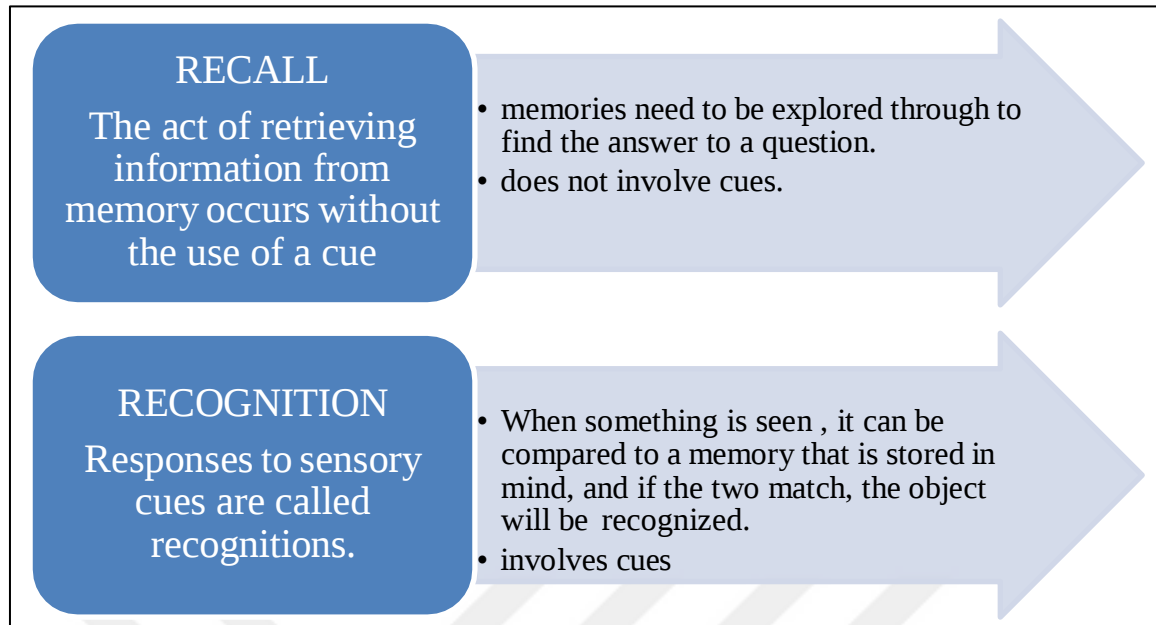


Figure2.6: Differences Between Recall & Recognition [40].

2.6 FORMS OF MEMORY RECALL

Being able to recall information that has been stored in memory is referred to as memory recall. We can learn, recall, and comprehend information due to this crucial cognitive function. Depending on the conditions in which the information was learnt and the kind of cued used to retrieve the memory, memory recall is divided into many types.

These memory recall processes include free recall, cued recall, and serial recall.

In the free recall: people recall a list of objects in any order using free recall, in free recall, there are three different kinds of impacts:

First, the primacy effect refers to remembering the first thing on the list or the item that appears more frequently on the list.

Second, the term "recency effect" describes the tendency to remember recent things from a list of items that are listed last.

Third, the term "cognitive effect" refers to the successive remembering of items that are nearby.

For the cued recall: cued recall is the process of remembering a list of things while utilizing cues and assistance, so people tend to recall items in cued recall that they do not recall in free recall more frequently, because cues allow the recovery of memories that were

previously believed to be lost, and a strong connection between the item and the cue increases the likelihood that it will be remembered.

It can be drawn the conclusion that cued recalling is considerably easier than free recalling since cues increase the likelihood of accessing information from the long term memory [41].

Finally there is a serial recall: The act of remembering things or events in the sequence they occurred is known as serial recall, in this approach, remembering the first thing in the list serves as a prompt to remember the second, it is especially beneficial for remembering life events in the sequence they occurred, but it is worth to mention that serial recall of short-term and long-term memories differs.

Numerous studies have shown that people are better at remembering recent events in the order they occurred, and also as the number of items on the list expands, memory recall drops [42].

3. METHODOLOGY

To investigate the recall and recognition effect in the design process an experiment was conducted with number of architects (18) who are familiar with the tools needed to be used in this experiment, they were asked if they could easily think aloud while they are doing the experiment, the numbers of samples were decided according to Cohen, Manion, Morrison and Gall, Borg, Gall, J. [43], [44].

The architects were introduced to number of images (20 images) , images for some famous houses, castles, villas and mansions around the world and the architects will be given a period of time (one day) before the experiment to memorize and study the group of images. Architects were asked to design (with any technique they feel comfortable to use) a new house façade depending on recalling details from the images they already saw and studied one day before the experiment, with no particular order.

Architects were asked to mention while designing whether they (remember- know- guess) the details they retrieve and use in their new design, (Figure 3.1).

This experiment is similar in one part with the one used by (O. Uner and H. L. Roediger III) but was revised and edited according to this thesis proposal purposes [45].



Figure 3.1: Set up Before Starting the Sketching Process.

3.1 DESIGN OF THE EXPERIMENT

The architect was asked to think aloud, and try to explain how they retrieved the details they used in their new facades, by (remembering- knowing or guessing) depending on some explanations that were given before starting the experiment about the meaning of each term above so the participants know how to describe what they are doing accurately.

No cues were given, architects will depend only on what they can remember by themselves.

This experiment was (audio and video) recorded after signing a consent letters from the participants to allow the use of their data, a coding scheme was prepared according to those data collected from the recordings to be analyzed.

The Coding scheme used in this thesis is taken from the one used by Gül, Uzun, & Halıcı, and Sauder, J., Lian, & Jin, but were revised according to experiment purposes [46], [47].

3.2 SEGMENTATION AND CODING SCHEME

The 1st step is: data transcription, and then dividing the design protocol into smaller units which means (segmentation phase).

The data contains continues stream of dialogues and video recordings, this paper aims to investigate the impact of the recall and recognition on architects' work this experiment has to be done to understand that impact.

The 2nd step is: code for each segmentation is assigned to examine the changes of the architect's activities [46].

After the segmentation of the design protocols, the activities were examined using a coding scheme, as shown in (Table 3.1).

The segments were coded in Tables: from table (3.2) to table (3.15) in a coding process that includes checking segments in mathematical order by listening to and viewing audio-video recorded data as well as reading segment transcripts, according to how the researcher understands the segments and the coding scheme, each segment was assigned with a code from the scheme below.

codes were investigated with excel sheet analysis done manually gives us information about the specific time period referring to the changes in the architect's activity as shown in tables: (3.2.1) to table (3.15.14), That analysis was done manually by excel sheet indicating each activity with a certain color according to the duration mentioned in the coding scheme done before, as shown in Tables: from table (3.2) to table (3.15) Which was determined from the video recordings of the experiment showing the architect's activities durations with numbers and colors.

Table 3.1: Coding Scheme [46-47].

Experiment	Codes	Description
The recall and recognition actions during the design process		
Design process Design action	Study- memorize	Study all the given images trying memorize as many images as possible
	propose	Starting a new idea about the facade
	Discuss	Discuss whether the architect remember-know-guess the details used in the new design with or without cues
	Evaluate	Determinate whether to continue or make changes to the design
	Analyze	Checking the current step of the design
Design space	2D	Designing action in two dimensional space
	3D	Designing action in three dimensional space
Mental imagery Mental process Mental action	Recognizing (Recognition)	Familiarity -Knowing the details without any cues
	Recalling (Free Recall)	Retrieving details from memory without any cues
	Guess	Estimate the detail without being certain of it
Realization action Cognitive process	Create	Generating a visual proposal for the first time
	Delete	Erasing a part of the facade
	Continue	Continue designing with created facade

In this scheme the codes are chosen according to the experiment's process, as a start the participants are given one day period of time to study all the images given to them and try to memorize as much details as possible that might be used in creating the new design the participants are asked to come up with, while the propose action related to the ideas, elements or masses the architect proposing during the task.

Discussing action about all the comments or explanations the architect provides while he/she is sketching the façade, although the evaluation action is about how the architect wants to pursue the whole new design by making changes like adding or removing some elements to the façade he/she is sketching.

The analyzing action is about considering the current step of the design and taking some decisions about what the architect does in the current step of the sketch.

The design space is related to the tool the participant uses to start the experiment whether it is 2D space or tool like sketching on paper, or 3D space like using a certain program 3d max for instance to complete the task.

The mental action related to how the architect processes the information trying to categorize the details used in the design by three terms (remember, know, guess) the participant is asked to use while running the task.

The actions related to what the participant decide to do while sketching, like drawing lines, deleting, removing unwanted parts of the sketch, or using colors etc. is called the cognitive actions.

Know, remember and guess explanation:

Know: be aware of through observation, inquiry, or information= be familiar with [49].

Remember: The act of recalling relevant information from memory, or the ability of bringing a piece of information back into mind, or to keep a piece of information in memory [48], [50].

Guess: estimate or draw a conclusion about (something) without having enough knowledge to be certain of its accuracy [49].

3.3 EVALUATION

The evaluation process includes analyzing the excel sheet prepared depending on the audio and video data collected from the participants, as shown in the tables below, but before analyzing three actions must be explained which are as following:

Total duration: refers to the time that was taken to accomplish the task from beginning to end, and it is measured in seconds.

Appearances: refers to how many times a certain action appeared in the sheet.

While frequency shows the occurrence metric of a code, by looking at the frequency level it can be measured how frequently this code appeared.

3.4 PARTICIPANTS

We based our sample size on Cohen [51], and Gall [52] studies which had 15 participants / architects who are familiar with all the tools needed to be used in this experiment, all participants were asked to report whether they have some memory conditions or medical

issues related to memory to be excluded from the experiment and replaced in order not to affect the final results.

3.5 MATERIAL

[20] Images of houses of different styles, materials and designs were collected from different sources as following, based on being well known for architects and has a historical or architectural values:

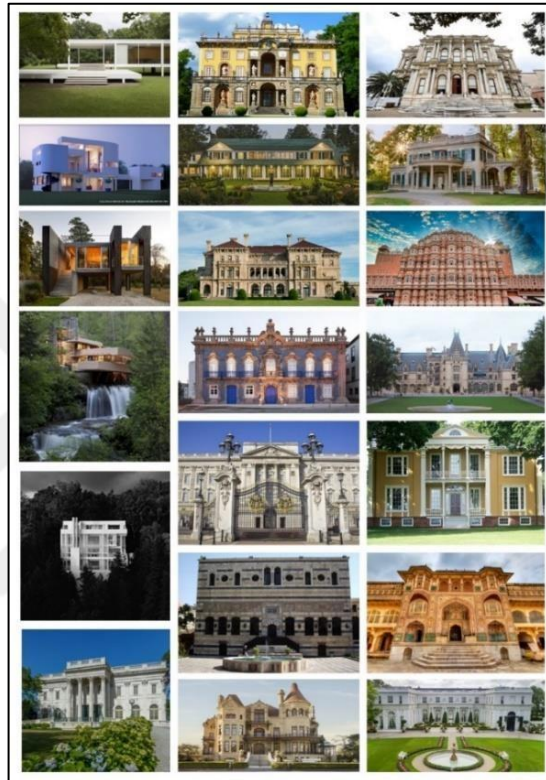


Figure 3.2: Material.

a. Farnsworth-House

It was built by Ludwig Mies van der Rohe (1945 – 1951) in Illinois- USA, the client was Dr. Edith Farnsworth, so the house named after the owner eventually, the house represent the architect's vision of creating a unit between nature and human [53].

b. Villa Torrigiani

This villa located in Italy built by using stone around 1550 for the Buonvisi family, almost stone was the main material in the façade but it was used in many different styles and techniques in order not to look boring, mosaic was used also in the façade [54].

c. Beylerbeyi Palace

This palace is considered as one of the landmarks of the neighborhood which also has the same name, Istanbul, Turkey - Asian side of the Bosphorus, built by Sultan Abdul-Aziz, 1863-1865 by both Sarkis Balyan and Agop Balyan (architects), it was the guest house who visit the sultan at that time, stone, brick, wood, marble and iron were used to build the palace [55].

d. The Saltzman House

It is located in Long Island, Hampton-USA, it can be considered as one of his earliest houses, winning an award in 1972 AIA New York “citation for excellence in residential design, it is famous for its circulation systems, the bridge linking the guest house with the main house and the outside stair makes the distinction between the public and private zones [56].

e. Reynolda House Museum of American Art

A historic house museum in NY-USA it is used also to hold temporary exhibition also, surrounded by well-designed green areas and it originally belongs to the Reynolda family [57], [58].

f. Montgomery Place

It was built in 1910 in Brooklyn – New York exactly at the Hudson valley and it was owned by one of the richest families in the states the Montgomery family designed by architect Alexander Jackson Davis [59].

g. House- Hampton

A house built in Northwest Harbor - US by Bates Masi Architects in 2013, one floor house design on the modern style, 2.4 m elevated above the ground providing successful air circulation [60].

h. h.The Breakers

It was built by the architect Richard Morris Hunt for one of the richest family in America at that time between the years (1893-1895), in Newport - USA, the architect used Brick with Indiana limestone while designing the façade, and the structure was made of steel to resist fire, and it was owned by the preservation society [61].

i. Hawa Mahal

It is also called (The Palace of Winds) in English in Jaipur- India, its distinctive architectural resemblance to the pyramid's honeycomb structure. It was a residence for

some queens, it has 953 windows which were called (Jharokhas), built in 1799 by Maharaja Sawai Pratap Singh using pink sandstone [62].

j. The Water Fall House

It belongs now to the western Pennsylvania conservancy, it was designed by Frank Lloyd Wright on a stream called Bear Run in Pennsylvania [63].

k. The Raio Palace

A baroque palace in Braga-Portugal, now it is used as a museum built in (1755-1774), it was designed in the late baroque style and Rococo style was used to decorate the facades, granite, wood was used in the facades also [64].

l. Biltmore House -Asheville

This house built in North-Carolina-USA, by the architect Richard Morris Hunt and for the landscape design there was another architect who took this responsibility and he was Frederick Law Olmsted in 1898, brick, ceramic tiles, stone and steel were used in building the house while iron roof trusses were used to construct the roof, wood only used in the doors [65].

m. Douglas House

Richard Meier has a reputation for developing an identifiable design language across a variety of building types over the course of a five-decade career, he built the house between the years (1971-1973), for the Douglas family in Harbor Springs – Michigan-USA he used white color for the facades with glass, concrete and steel [66].

n. Buckingham Palace

In order to create a backdrop for the Queen Victoria Memorial statue, English architect Webb reconstructed the current major facade of Buckingham Palace, which was built by Blore in 1850- UK-London, and it became the formal residence of the royal family in 1937 [67].

o. Boscobel House

It was built around 1900 on the east side of the Hudson River, now it is a house museum and regarded as a remarkable example of American Federal architecture [68].

p. Marble House

It was built in 1892 Newport- USA, it was built as a gift for Alva Vanderbilt from her husband William Vanderbilt in her birthday, and now it is considered as a landmark

witnessing the changes in Newport architectural style from wooden house to the age of luxurious mansions [69, 70].

q. Azem Palace

This palace is in Damascus – Syria and it was built in 1751 by asad pasha al azam whom the palace was named after him, now it was turned into a museum for art [71].

Different types of marble and stones were used in the façade like using the black basalt and limestone [72].

r. Bishop's Palace

This palace was built in 1892 in Texas for a congressman, granite and limestone were used in building the house it is considered as a landmark in the area, now opened to public as a museum of history [73].

s. The Amber Fort

One of the most important landmarks of the city Jaipur in India, mosaic and mirrors were used in the façade with different shapes of cutouts were used to set out the arches built in 1592 by Man Singh I who used sandstones and marble to create this masterpiece [74].

t. Rosecliff,

Built in 1902 by the architect Stanford White in New port - USA, it was the residence of the silver heiress of Nevada, Theresa Fair Oelrichs, and the gardens surrounding the mansion were inspired by the Versailles, and it was owned by preservation society [75].

4. RESULT

Eighteen architects volunteered to participate in this thesis project fifteen of them were able to follow the instructions and complete the sketch with the time limits and give clear results with the exception of three architects who did not fully understand the requirements and they just copied one of the facades that drew their attention and liked the most, despite the fact that their data were coded and shown some results they were excluded and will be referred to as unsuccessful attempts/ odd results.

The following sketches with tables mentioned in sequence with charts which were stemmed and originated from the coding schemes and excel sheets to help understanding the relations between recall and recognition in particular and the impact of recall and recognition on the designs in general.

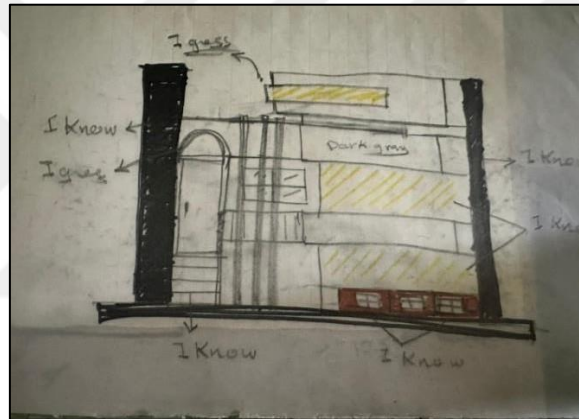


Figure 4.1: Result of Experiment 1.

Table4.1: Excel Sheet Analysis for Experiment 1.

DURATION (SECONDS)		###	16	13	21	16	11	26	15	44	19	16	12	25	21	23	21	16	24	27	12	13	22	10	19	27	31	31	9
DESIGN SPACE	2D																												
	3D																												
DESIGN PROCESS	STUDY-MEMORIZE																												
	PROPOSE																												
	DISCUSS																												
	EVALUATE																												
	ANALYZE																												
MENTAL PROCESS	RECOGNIZE																												
	RECALL																												
	GUESS																												
ALIZATION ACTION	CREATE																												
	DELETE																												
	CONTINUE																												

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.1) the highest activities are: designing in 2D space, discussing, creating.

While it can be noticed that there is no activities in 3D action and evaluation action.

The architect in this experiment prefers to sketch in 2D space while sketching he/she was successful in explaining what was happening in each step of the process as it is shown in the discussion activity.

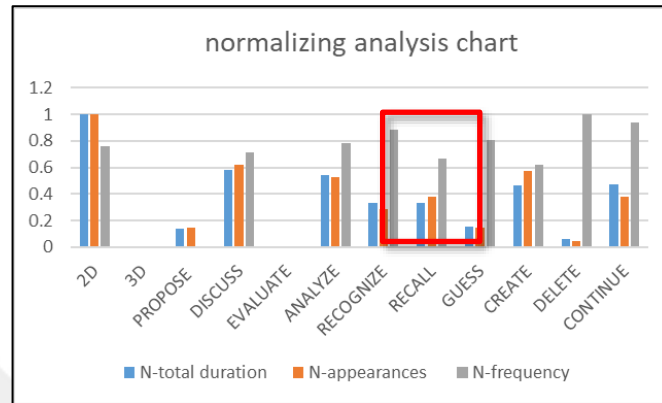


Figure 4.2: Normalizing Analysis Chart for Experiment 1.

In figure (4.3) while checking the architect's activity it is easy to notice that the maximum values of total duration and appearances are shown in 2D action, while the minimum values for total duration and appearances are shown in delete action, for recall action it shows a slightly higher value of appearances than recognize action while both of those actions almost showing similar values for duration, and because of those similar values it can be said that: architect in this sketch depends on both recall and recognition and prefers to sketch in 2D which is obvious from the chart above , architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values of total duration and appearances at the discuss and create actions, as the architect explains every step while he was sketching, there is no values in the 3D and evaluate actions.

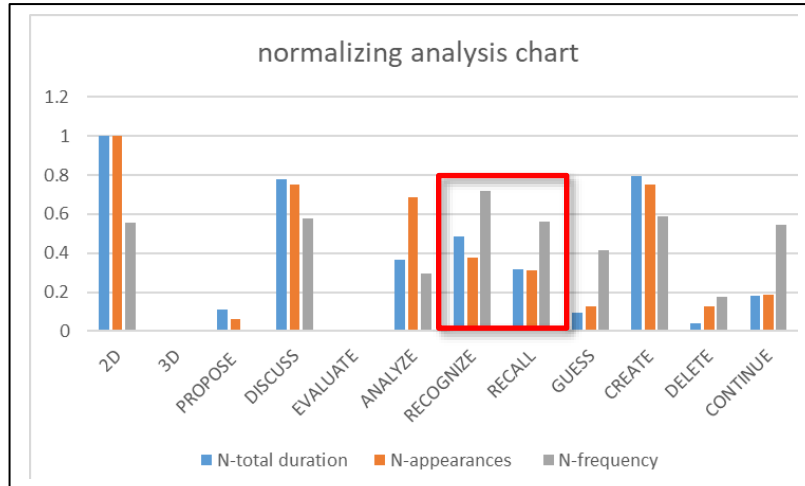


Figure4.4: Normalizing Chart for Experiment 2.

In figure (4.5) while checking the architect's activity it is noticed that in 2D action the maximum values for both total duration and appearances while there is no values in 3D action, the minimum values for total duration and appearances are shown in the delete action, also the create action shows a high values for both total duration and appearances, for recognize action it shows slightly higher values in both total duration and appearances than recall action, which means: the architect depends in this experiment on both recall and recognition, while the guessing action is showing low values in both total duration and appearances than recall and recognize actions values, the architect in this sketch prefers to sketch in 2D which is obviously in the chart and that explains why there is no values in the 3D action , architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required from them and that explains the high values at the discuss action for both total duration and appearances, as the architect explains every step while completing the task.

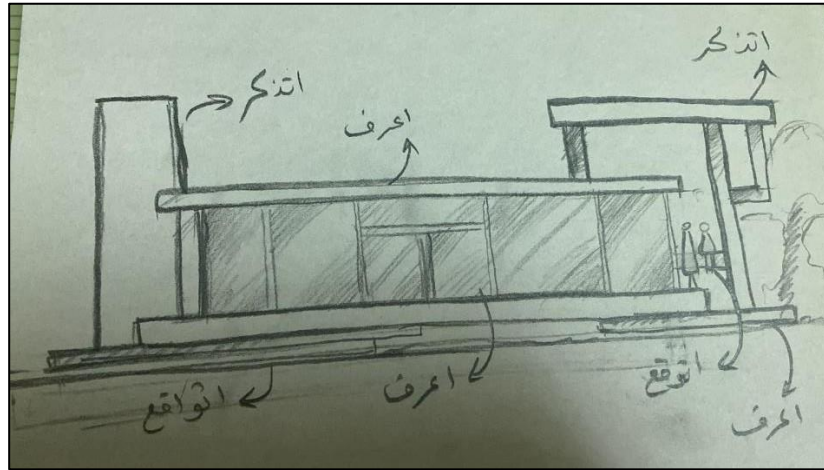


Figure 4.5: Result of Experiment 3

Table 4.3: Excel Sheet Analysis for Experiment 3.

DURATION (SECONDS)		###	7	9	8	18	18	17	9	14	36	47	40	23	6	16	11	51	13	57	56
DESIGN SPACE	2D																				
	3D																				
DESIGN PROCESS	STUDY-MEMORIZE																				
	PROPOSE																				
	DISCUSS																				
	EVALUATE																				
	ANALYZE																				
MENTAL PROCESS	RECOGNIZE																				
	RECALL																				
	GUESS																				
	CREATE																				
REALIZATION ACTION	DELETE																				
	CONTINUE																				

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.3) maximum values for activities are: designing in 2D space, discussing and creating, while no activities are shown in 3D action and minimum values are shown in evaluating and analyzing actions which indicates that the architect knows exactly what he/she wants to design they proposing ideas continuously as shown in pink color.

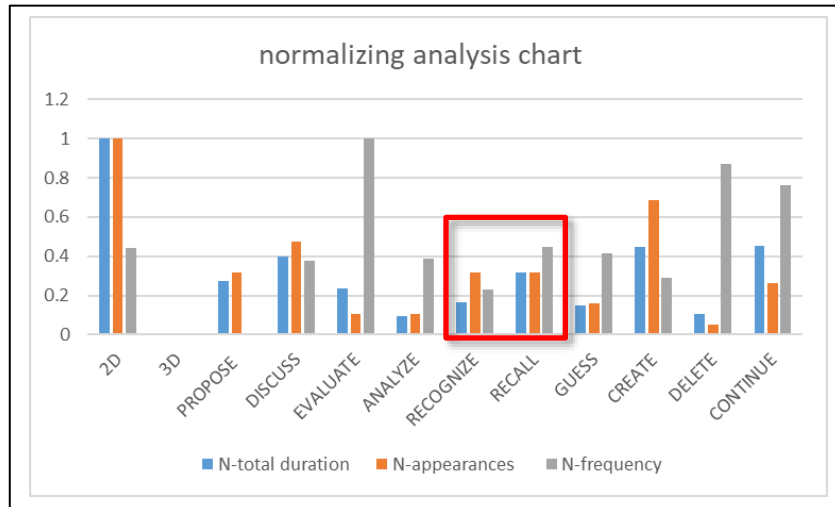


Figure 4.6: Normalizing Analysis Chart For Experiment 3.

In figure (4.6) while checking the architect's activity it is easy to notice the recall and recognize actions appearing closely similar in the appearances values but recall action seems to be higher in total duration value than the recognize, the 2d action as shown in chart has the maximum values for both total duration and appearances, there are no values in 3D action, Which means:

the architect in this experiment depends equally on both his memory and what he knows about the images that were displayed, while the guessing action comes in less values than recall and recognize, the architect in this sketch prefers to sketch in 2D which is obviously the maximum values in the chart and that shows why there is no values in the 3D action, architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values of appearances at the discuss and create actions, as the architect is explaining every step while creating the new façade.

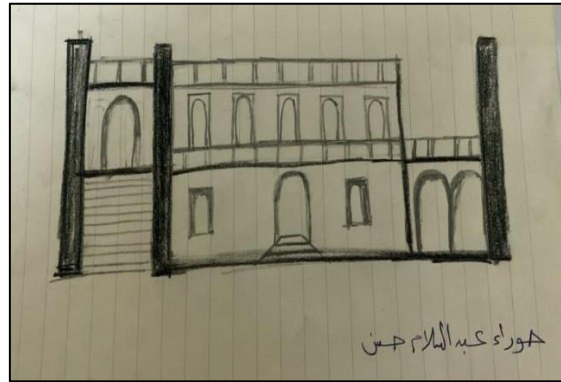


Figure 4.7: Result of Experiment 4.

Table 4.4: Excel Sheet Analysis for Experiment 4.

DURATION (SECONDS)	###	11	26	12	26	13	24	20	4	19	16	6	29	23	6	18	10	39	15	12	20	75	21	14	11	95	8	3	15	60	82
DESIGN SPACE	2D																														
	3D																														
DESIGN PROCESS	STUDY-MEMORIZE																														
	PROPOSE																														
	DISCUSS																														
	EVALUATE																														
	ANALYZE																														
MENTAL PROCESS	RECOGNIZE																														
	RECALL																														
	GUESS																														
REALIZATION ACTION	CREATE																														
	DELETE																														
	CONTINUE																														

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.4) the maximum values for activities are shown in designing in 2D space, proposing, discussing, recognizing, recalling and creating activities, this refers to the fact that the participant in this experiment depends on what he can remember and recognize about the images shown earlier.

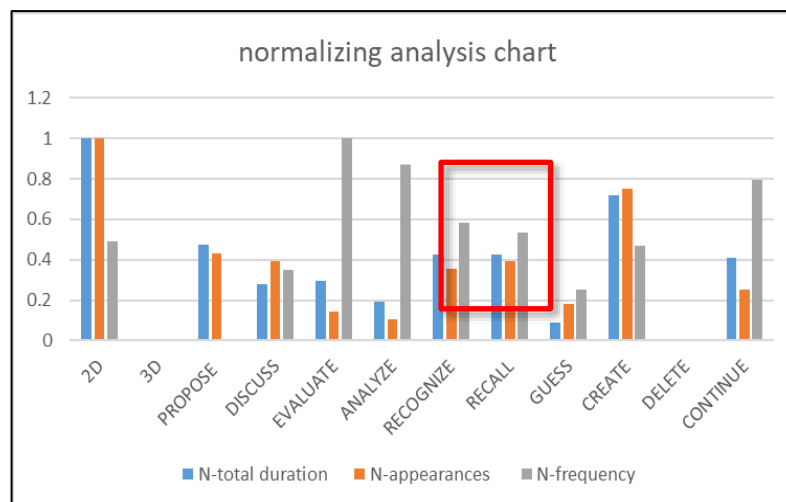


Figure 4.8: Normalizing Analysis Chart for Experiment 4.

In figure (4.8) while checking the architect's activity it is easy to notice the recall action has slightly higher value than the recognize action in appearances and because of that slight

difference it can be said that the architect in this experiment depends almost equally on both recall and recognition in this experiment.

While the guessing action comes in less values of the other two action of recall and recognize, Architect in this sketch prefers to sketch in 2D which has the maximum values in both total duration and appearances as shown in the chart, and no values in 3D action as the architect chooses to work in 2D space, also there is no values in delete action.

Architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required, and that explains the high values of appearances at discuss, propose actions, as the architect explains every step while he was sketching.

Also the create action almost appear in a high values when it comes to appearances and total duration as shown in charts because the architects keep sketching the whole process.

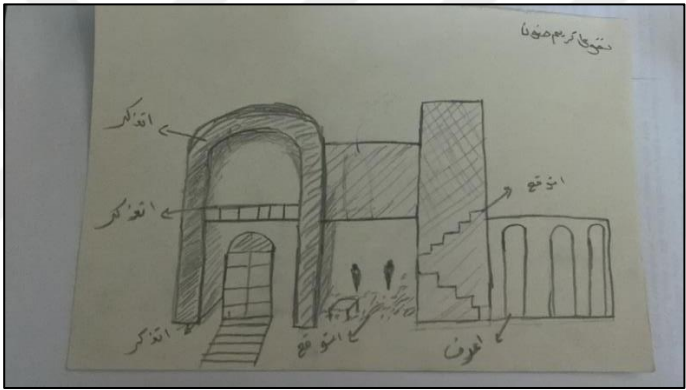


Figure 4.9: Result of Experiment 5.

Table 4.5: Excel Sheet Analysis for Experiment 5.

DURATION (SECONDS)		###	3	6	32	20	39	11	26	30	30	75	38	40	17	16	67	22	14	15	60	14	60	64
DESIGN SPACE	2D																							
	3D																							
DESIGN PROCESS	STUDY-MEMORIZE																							
	PROPOSE																							
	DISCUSS																							
	EVALUATE																							
MENTAL PROCESS	ANALYZE																							
	RECOGNIZE																							
	RECALL																							
	GUESS																							
REALIZATION ACTION	CREATE																							
	DELETE																							
	CONTINUE																							

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.5) the maximum values for activities are shown in designing in

2D space, proposing and creating activities explaining that the participant has a vision of the new design as he/she directly propose, sketch and discuss what was done in the task. The recall and recognition activities show high values also indicating that the participant depend on both terms (remember and know) about the images shown before while creating the new design.

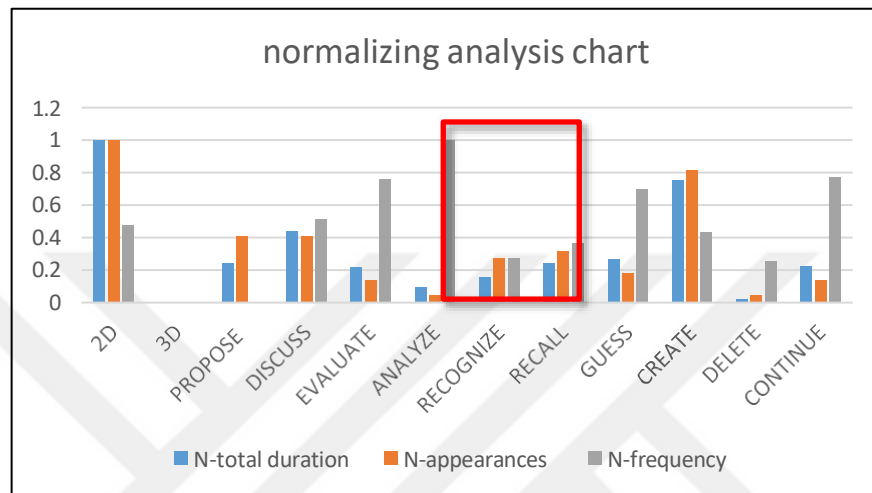


Figure 4.10: Normalizing Analysis Chart for Experiment 5.

In figure (4.10) while checking the architect's activity it can be noticed that: recall action has slightly higher values the recognition action and that means: the architect in this experiment depends on both recall and recognition in this experiment.

While the guessing action has less values than the previous two actions.

Architect in this sketch prefers to sketch in 2D which is obviously in the chart that explains why there are no values in 3D action, architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required, and that explains the high values of total duration and appearances in discussing and proposing actions, as the architect explains every step while he was sketching.

Also the create action almost appear to show the maximum values for both total duration and appearances in most of the charts because the architects keep sketching the whole process.

Also delete action shows the minimum values of all actions in the chart.

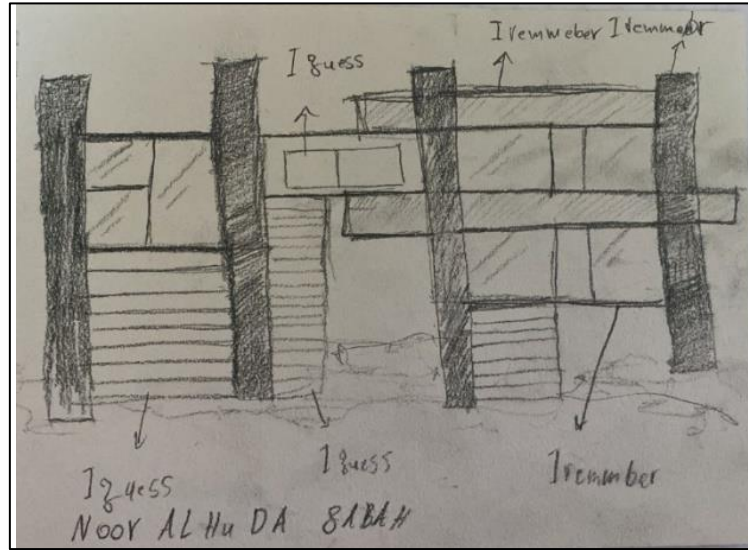


Figure 4.11: Result for Experiment 6.

Table 4.6: Excel Sheet Analysis for Experiment 6.

DURATION (SECONDS)		###	4	16	10	7	29	11	24	36	14	14	8	60	72	31	34	5	13	42	17	90
DESIGN SPACE	2D																					
	3D																					
DESIGN PROCESS	STUDY-MEMORIZE																					
	PROPOSE																					
	DISCUSS																					
	EVALUATE																					
	ANALYZE																					
MENTAL PROCESS	RECOGNIZE																					
	RECALL																					
	GUESS																					
UTILIZATION ACTION	CREATE																					
	DELETE																					
	CONTINUE																					

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.6) the maximum values for activities are shown in designing in 2D space, discussing, recalling and creating activities, while the architect sketching the design he/she applied the think loud method in this task by proposing and discussing every step is done in the task, showing equal values for the recalling and recognizing activities and that indicates that the participant is able to remember and also able to recognize details from the images to create the new façade asked to be designed in the task.

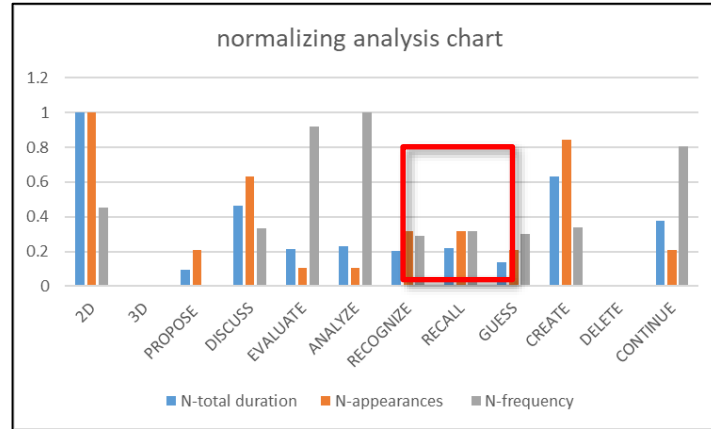


Figure 4.12: Normalizing Analysis Chart for Experiment 6.

In Figure (4.12) while checking the architect's activity it can be noticed the recall and recognize actions appearing closely similar when it comes to appearances while in total duration recall shows more value than recognize, because the architect takes more time to remember details from the images, which means that the architect in this experiment depends equally on both his memory and what he knows about the images that were displayed, but there are slight differences in the time spent in both actions.

While the guessing action shows less values in both total duration and appearances. architect in this sketch prefers to sketch in 2D which is obviously the highest action in the chart, explaining why there are no values in 3D action, architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values of appearances at the discussion and creating actions, as architect explains every step while he was sketching.

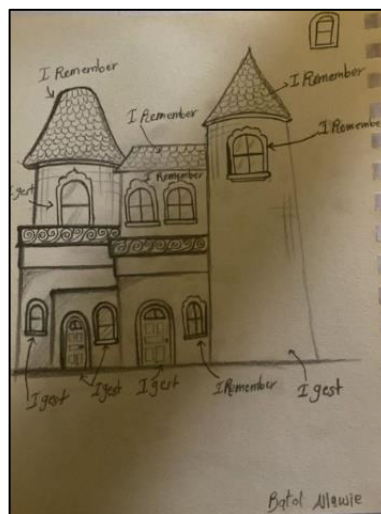


Figure 4.13: Result of Experiment 7.

Table 4.7: Excel Sheet Analysis for Experiment 7.

DURATION (SECONDS)		###	12	23	48	49	79	29	44	43	30	45	60	60	36	60	60	60	60
DESIGN SPACE	2D																		
	3D																		
DESIGN PROCESS	STUDY-MEMORIZE																		
	PROPOSE																		
	DISCUSS																		
	EVALUATE																		
MENTAL PROCESS	ANALYZE																		
	RECOGNIZE																		
	RECALL																		
	GUESS																		
REALIZATION ACTION	CREATE																		
	DELETE																		
	CONTINUE																		

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.7) the highest values for activities are: designing in 2D space, discussing, recalling, recognizing and creating, this indicates that the participant while sketching is successful to apply the think loud method by explaining the process depending on what he/she is able to remember and what he/she is certain about from the images shown earlier.

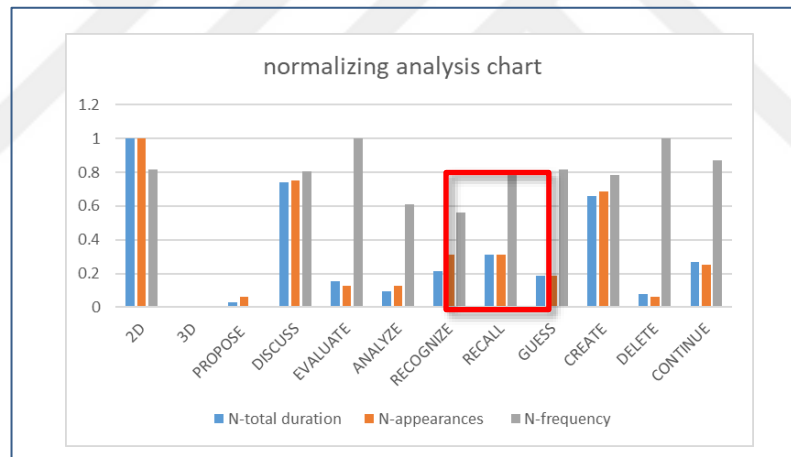


Figure 4.14: Normalizing Analysis Chart for Experiment 7.

In Figure (4.14) while checking the architect's activity it is shown that recall and recognize actions appearing closely similar in values of appearances which means that the architect in this experiment depends equally on both his memory and what he knows about the images that were displayed, but there is difference in the total duration for both actions where recall action take more time than recognizing action, While the guessing action comes at less values of total duration and appearances than the other previous actions of recall and recognize.

architect in this sketch prefers to sketch in 2D which is obvious in chart with no values for 3D action, architects intend to draw or sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values of appearances and total duration in both discussing and creating actions, as the architect explains every step while he was sketching, guess action show less values than recall and recognize also delete action and propose action show minimum values of all other actions.

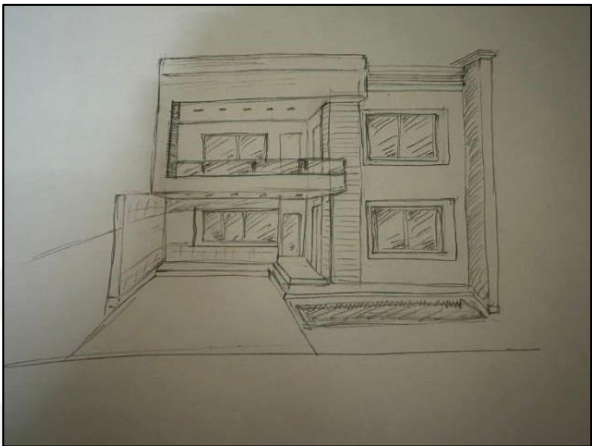


Figure 4.15: Result of Experiment 8.

Table 4.8: Excel Sheet Analysis for Experiment 8.

DURATION (SECONDS)		###	7	18	18	18	27	35	40	26	12	25	13	30	22	22	46	17	30	38	36	17	38	30	19	18	25	48	20	12
DESIGN SPACE	2D																													
	3D																													
DESIGN PROCESS	STUDY-MEMORIZE																													
	PROPOSE																													
	DISCUSS																													
	EVALUATE																													
	ANALYZE																													
MENTAL PROCESS	RECOGNIZE																													
	RECALL																													
	GUESS																													
REALIZATION ACTION	CREATE																													
	DELETE																													
	CONTINUE																													

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.8) the maximum values for activities are: designing in 2D space, discussing, recognizing and creating, indicating that the architect chooses to sketch in 2D space and is able to apply what he is asked to do by applying the think loud method, while the recalling activity shows less values than recognizing meaning that the participant depends more on what sound logical more than what is remembered in completing the task.

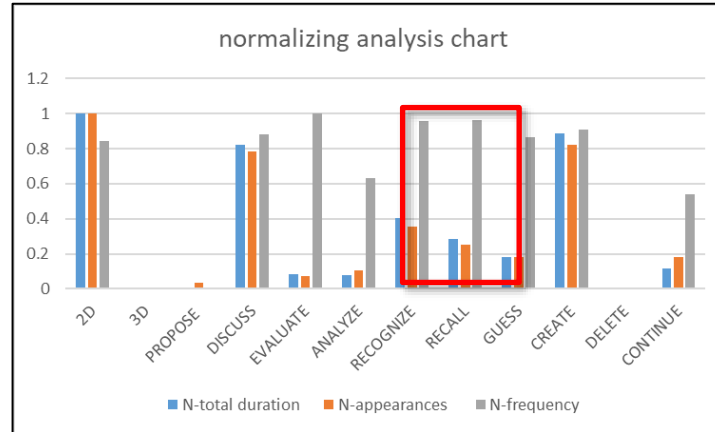


Figure 4.16: Normalizing Analysis Chart for Experiment 8.

In figure (4.16) while checking the architect's activity it is easy to notice the recognize action has higher values in both total duration and appearances than the recall action, meaning that the architect in this experiment depends on what is recognized from the images that were displayed more than what is recalled, while the guessing action has less values in both total duration and appearances than recall and recognize actions.

Architect in this sketch prefers to sketch in 2D which is obvious in the chart, architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values of total duration and appearances in both create and discuss actions, as the architect explains every step while he was sketching.

No values show in 3D and delete action, the minimum values appear in the propose action as the architect intend to discuss the design not propose while sketching.

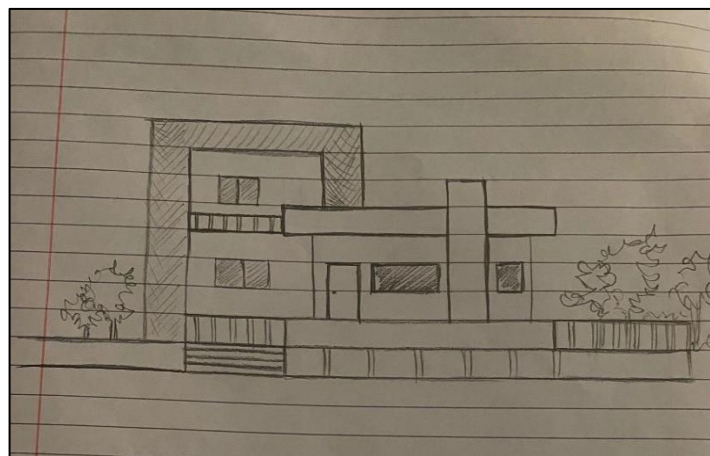


Figure 4.17: Result of Experiment 9.

Table 4.9: Excel Sheet Analysis for Experiment 9.

DURATION (SECONDS)		###	15	41	53	18	5	16	24	22	12	28	16	18	37	22	12	30	12	40	20	40	20	35	26	24	10	20	22	26	43
DESIGN SPACE	2D																														
	3D																														
DESIGN PROCESS	STUDY-MEMORIZE																														
	PROPOSE																														
	DISCUSS																														
	EVALUATE																														
	ANALYZE																														
MENTAL PROCESS	RECOGNIZE																														
	RECALL																														
	GUESS																														
	CREATE																														
REALIZATION ACTION	DELETE																														
	DELETE																														
	CONTINUE																														

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.9) the maximum values for activities are: designing in 2D space, discussing and creating, while comparing recalling activity to recognizing shows that the participant depends on what he is certainly shown in the image more than what is remembered.

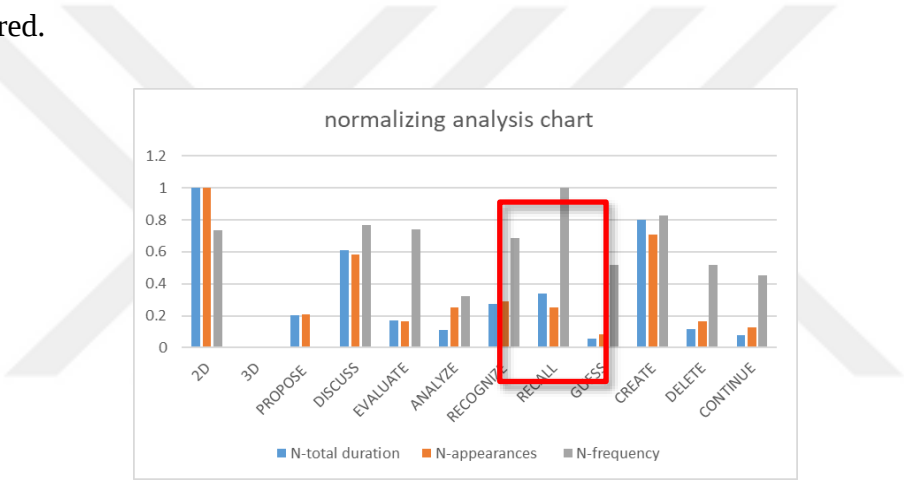


Figure 4.18: Normalizing Analysis Chart for Experiment 9.

In figure (4.18) while checking the architect’s activity it is easy to notice the recognize action is slightly higher in values than the recall action which means that the architect in this experiment depends on recall and recognition equally.

While the guessing action comes in a lowest level, architect in this sketch prefers to sketch in 2D which is obviously the highest action in the chart, architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required from them and that explains the high level at the discuss and proposing actions, as the architect explains every step while he was sketching.

Also the create action almost appear in a high level in most of the charts because the architects keep sketching the whole process.

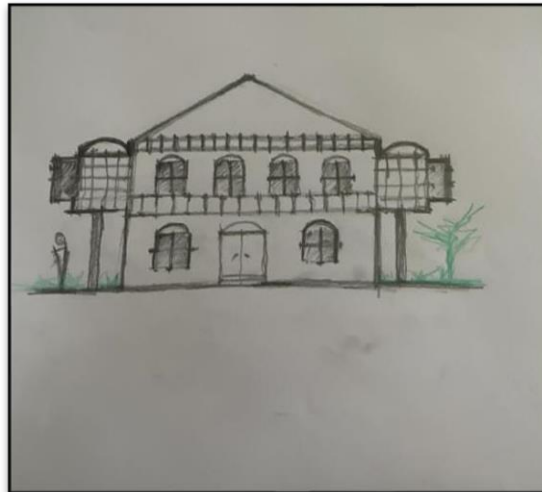


Figure 4.19: Result of Experiment 10.

Table 4.10: Excel Sheet Analysis for Experiment 10.

DURATION (SECONDS)		###	10	4	24	12	18	13	10	24	15	10	18	37	29	12	10	6	29	31	24	51	34	16	21	12	14	10	6	30	5	20	16	25	22	4																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																														
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Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.10) the maximum values for activities are: designing in 2D space, discussing and creating, while the two activities of recall and recognition shows equal values indicating that the participant in this experiment depends on both what is remembered and recognized from the images shown one day before the experiment.

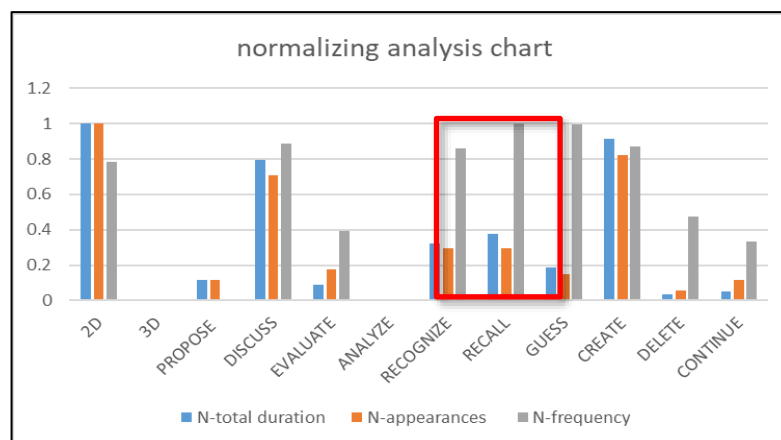


Figure 4.20: Normalizing Analysis Chart For Experiment 10.

In figure (4.20) while checking the architect's activity it is noticed that recall and recognize actions appearing closely similar in appearances values but differ in total duration with the high value to recalling action which means that the architect in this experiment depends equally on both his memory and what he knows about the images that were displayed, but spends more time in remembering details, While in guessing action less values show in both total duration and appearances.

architect in this sketch prefers to sketch in 2D which is obviously the maximum values in the chart for both total duration and appearances, architects intend to draw and sketch while discussing sketching process applying the (think loud method) as it is required and that explains the high values in total duration and appearances for the 2D action and discussing action, as the architect explains every step while he was sketching.

Also, the create action almost appear in to show high values for both total duration and appearances, because architects keep sketching the whole process.

No values available in 3d action as the architects never sketch in 3d space the same goes on the analyzing action, the minimum values for total duration and appearances show in delete and propose actions.



Figure 4.21: Result of Experiment 11.

Table 4.11: Excel Sheet Analysis for Experiment 11.

DURATION (SECONDS)		###	12	6	10	8	14	20	32	4	27	13	4	18	6	21	11	22	52	76	9	72	60	32	36	64
DESIGN SPACE	2D																									
	3D																									
DESIGN PROCESS	STUDY-MEMORIZE																									
	PROPOSE																									
	DISCUSS																									
	EVALUATE																									
	ANALYZE																									
MENTAL PROCESS	RECOGNIZE																									
	RECALL																									
	GUESS																									
REALIZATION ACTION	CREATE																									
	DELETE																									
	CONTINUE																									

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.11) the maximum values for activities are: designing in 2D space, discussing and creating, while comparing the recall activity to the recognize activity shows that the recalling activity has the highest values indicating that the participant depends on what he/she remembers about the images shown one day before the experiment.

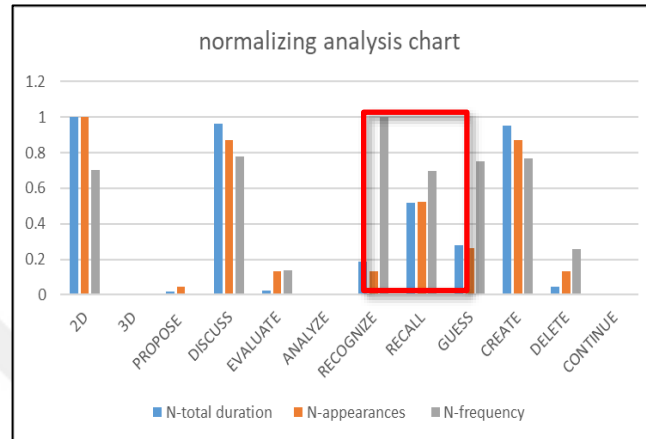


Figure 4.22: Normalizing Analysis Chart for Experiment 11.

In Figure (4.22) while checking the architect's activity it is easy to notice the recall action shows the higher values in both total duration and appearances than the recognize action which means that the architect in this experiment depends on what is retrieved more than what is recognized from the images that were displayed, while the guessing action comes in less values for both total duration and appearances in the chart.

Architect in this sketch prefers to sketch in 2D which shows the maximum values for total duration and appearances the chart.

Architects intend to draw and sketch while discussing sketching process applying the (think loud method) as it is required and that explains the high values at the discuss action, as the architect explains every step while he was sketching.

Also creating action almost appear shows high levels in total duration and appearances in most of the charts because the architects keep sketching the whole process.

No values are shown in 3D action as the architect chooses to sketch in 2D space the same for the analyzing action when architects prefer to propose and discuss their work rather than analyzing what there are doing in think loud method.

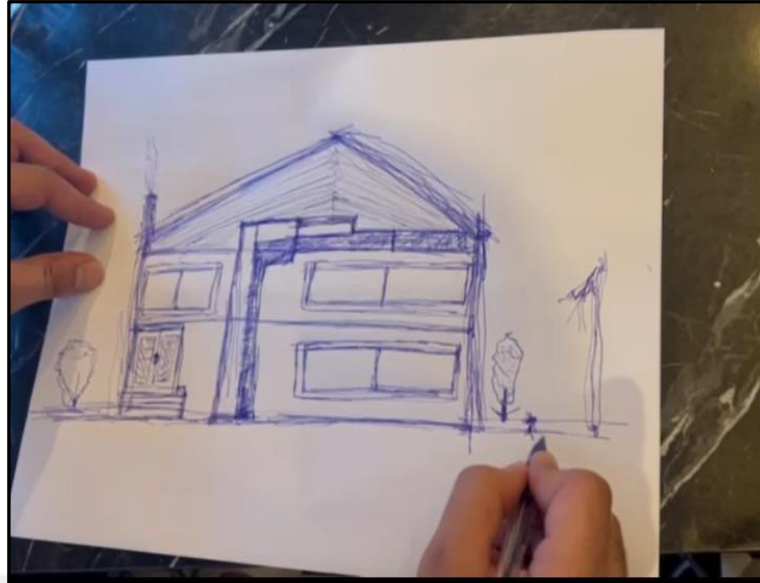


Figure 4.23: Result of Experiment 12.

Table 4.12: Excel Sheet Analysis for Experiment 12.

DURATION (SECONDS)		###	39	18	26	47	36	14	13	13	14	18	50	27	20	27	20	60	38	34	28	17	88	32	22	10	37	18	39	25	98
DESIGN SPACE	2D																														
	3D																														
DESIGN PROCESS	STUDY-MEMORIZE																														
	PROPOSE																														
	DISCUSS																														
	EVALUATE																														
MENTAL PROCESS	ANALYZE																														
	RECOGNIZE																														
	RECALL																														
	GUESS																														
REALIZATION ACTION	CREATE																														
	DELETE																														
	CONTINUE																														

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.12) the maximum values for activities are: designing in 2D space, discussing, and creating, for recalling and recognition activities as it is shown in the sheet the recalling activity has the maximum value in the pink color which means that the participant in this experiment depends on his memory to achieve this task.

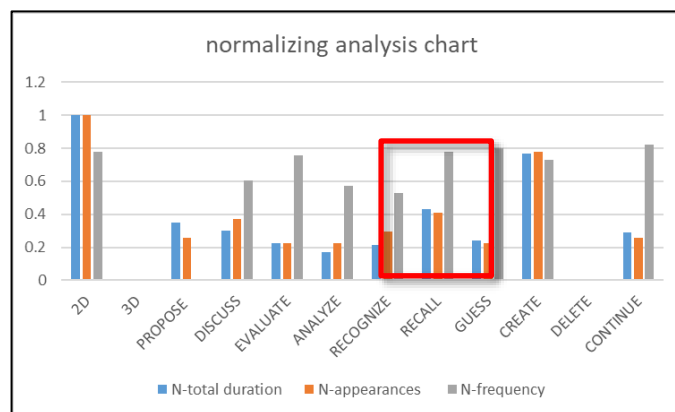


Figure 4.24: Normalizing Analysis Chart for Experiment 12.

In figure (4.24) while checking the architect's activity it can be noticed that: recall action has higher values in both total duration and appearances than the recognize action which means that the architect in this experiment depends on what is retrieved- remembered more than what is recognized from the images that were displayed, while the guessing action comes in lower values of total duration and appearances than the previous two actions.

Architect in this sketch prefers to sketch in 2D which is obviously has the maximum values of total duration and appearances in the chart, and that also explain why the create action has a high values also in most of the charts because the architects keep sketching the whole process.

There are no values for delete and 3D action as the participant uses 2D space to complete the task.

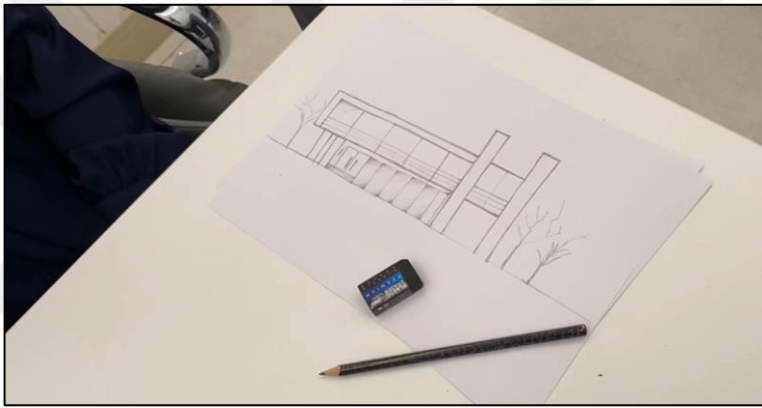


Figure 4.25: Result of Experiment 13.

Table 4.13: Excel Sheet Analysis for Experiment 13.

DURATION (SECONDS)		###	17	39	19	10	5	34	25	10	6	18	33	25	27	34	8	30	17	16	10	46	52	28	42	48	19
DESIGN SPACE	2D																										
	3D																										
DESIGN PROCESS	STUDY-MEMORIZE																										
	PROPOSE																										
	DISCUSS																										
	EVALUATE																										
	ANALYZE																										
MENTAL PROCESS	RECOGNIZE																										
	RECALL																										
	GUESS																										
	CREATE																										
REALIZATION ACTION	DELETE																										
	CONTINUE																										

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.13) the highest activities are: designing in 2D space, discussing, and creating, for recalling and recognition activities as it is shown in the sheet the recalling activity has the maximum value in the pink color which means that the participant in this experiment depends on his memory to achieve this task.

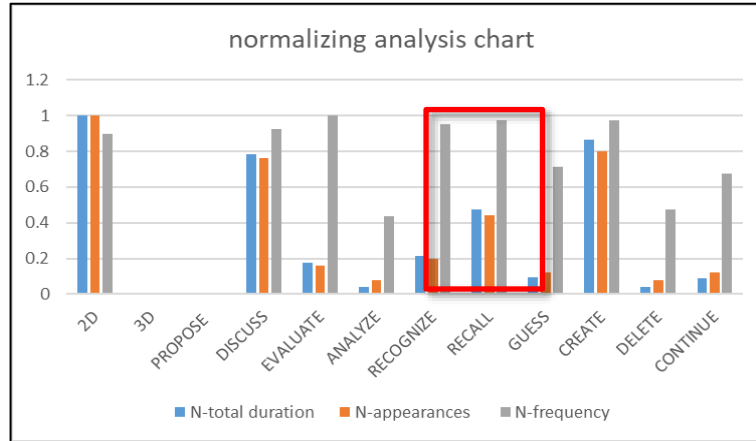


Figure 4.26: Normalizing Analysis Chart for Experiment 13.

In figure (4.26) while checking the architect's activity it is easy to notice that: recall action has higher values in both total duration and appearances than the recognize action which means that the architect in this experiment depends on what is retrieved- remembered more than what is recognized from the images that were displayed, while the guessing action comes in lower values of total duration and appearances than the previous two actions.

Architect in this sketch prefers to sketch in 2D which is obviously has the maximum values of total duration and appearances in the chart, and that explains why 3D action has no values. architects intend to draw and sketch while discussing their sketching process applying the (think loud method) as it was required and that explains the high values for total duration and appearances in discussing action, as the architect explains every step while he was sketching.

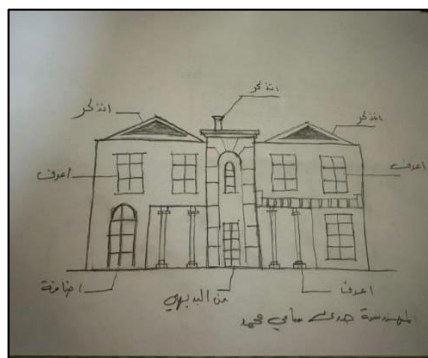


Figure 4.27: Result of Experiment 14.

Table 4.14: Excel Sheet Analysis for Experiment 14.

DURATION (SECONDS)		###	29	21	32	26	33	12	36	18	37	27	25	40	34	16	39	35	24	38	47	57
DESIGN SPACE	2D																					
	3D																					
DESIGN PROCESS	STUDY-MEMORIZE																					
	PROPOSE																					
	DISCUSS																					
	EVALUATE																					
	ANALYZE																					
MENTAL PROCESS	RECOGNIZE																					
	RECALL																					
	GUESS																					
	CREATE																					
REALIZATION ACTION	DELETE																					
	CONTINUE																					

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.14) the highest activities are: designing in 2D space, discussing, and creating, while there are no values shown in this sheet to the following activities: proposing, analyzing, and the participant only explains what is happening while designing the façade depending on his memory to achieve this task, as shown in the maximum value for the recalling activity in pink color.

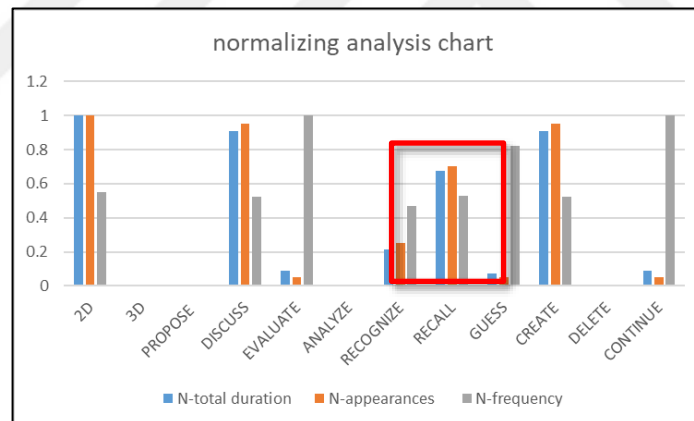


Figure 4.28: Normalizing Analysis Chart For Experiment 14.

In figure (4.28) while checking the architect's activity it can be noticed that: recall action has higher values in both total duration and appearances than the recognize action which means that the architect in this experiment depends on what is retrieved- remembered more than what is recognized from the images that were displayed, while the guessing action comes in lower values of total duration and appearances than the previous two actions.

Architect in this sketch prefers to sketch in 2D which is obviously has the maximum values of total duration and appearances in the chart, and that also explain why the create action has

a high values also in most of the charts because the architects keep sketching the whole process.

There are no values for delete and 3D action as the participant uses 2D space to complete the task.

The discussing action also has high values for both total duration and appearances as shown in chart as the participant apply the think loud method by explaining the process of sketching till the end of the task.

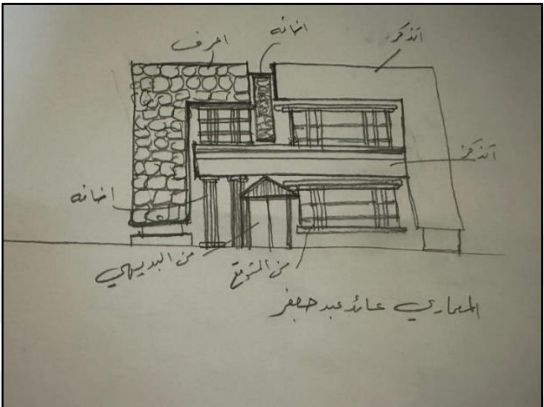


Figure 4.29: Result of Experiment 15.

Table 4.15: Excel Sheet Analysis for Experiment 15.

DURATION (SECONDS)		###	8	17	3	10	25	23	70	28	10	63	26	15	44	38	23	52	20	74
DESIGN SPACE	2D																			
	3D																			
DESIGN PROCESS	STUDY-MEMORIZE																			
	PROPOSE																			
	DISCUSS																			
	EVALUATE																			
	ANALYZE																			
MENTAL PROCESS	RECOGNIZE																			
	RECALL																			
	GUESS																			
REALIZATION ACTION	CREATE																			
	DELETE																			
	CONTINUE																			

Excel sheet is used to show how the coding scheme is analyzed, each color indicates an activity, as shown in table (4.15) the highest activities are: designing in 2D space, discussing, and creating, for recalling and recognition activities as it is shown in the sheet both activities has the same values as shown in green and pink explaining that the participant depends on both recalling details from the images and recognizing other details that are exist in the same images to help create new design as it is required.

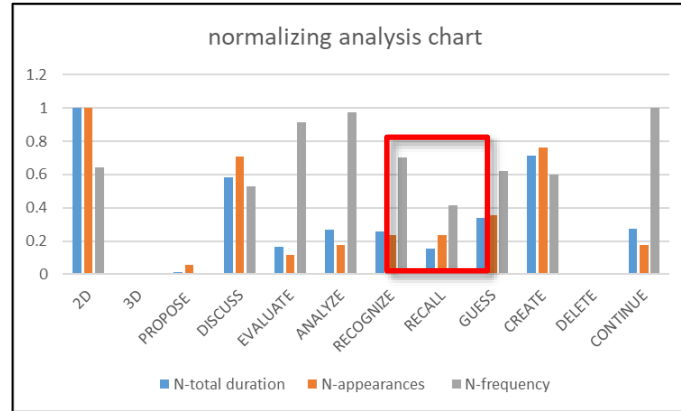


Figure 4.30: Normalizing Analysis Chart for Experiment 15.

In Figure (4.30) while checking the architect's activity it is easy to notice the recall and recognize actions have closely similar values for the appearances that means that the architect in this experiment depends equally on both his memory and what he knows about the images that were displayed, but there is slight difference in the total duration for both actions where the participant takes more time trying to recognize if some details are available in the images or not.

While the guessing action shows higher values for both total duration and appearances, which means the participant makes guesses about the details more than what can he remember or recognize in this task.

Architect in this sketch prefers to sketch in 2D which is obviously has the maximum values of total duration and appearances in the chart, and that also explain why the create action has a high values also in most of the charts because the architects keep sketching the whole process.

There are no values for delete and 3D action as the participant uses 2D space to complete the task.

The discussing action also has high values for both total duration and appearances as shown in chart as the participant apply the think loud method by explaining the process of sketching till the end of the task.

Three odd results were shown in the sheets due to misunderstanding the procedure by the architects that led to different results as shown below:

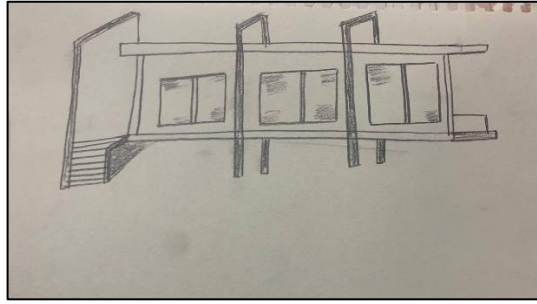


Figure 4.31: Result of Experiment 16.

Table 4.16: Excel Sheet Analysis for Experiment 16.

DURATION (SECONDS)		####	11	15	26	13	27	10	11	5	50	25	8	24	50	23	30			
DESIGN SPACE	2D																			
	3D																			
DESIGN PROCESS	STUDY-MEMORIZE																			
	PROPOSE																			
	DISCUSS																			
	EVALUATE																			
	ANALYZE																			
MENTAL PROCESS	RECOGNIZE																			
	RECALL																			
	GUESS																			
REALIZATION ACTION	CREATE																			
	DELETE																			
	CONTINUE																			

In this experiment the architect ended the whole procedure within five minutes only, while the minimum timing for the other participants was about (10-13) minutes.

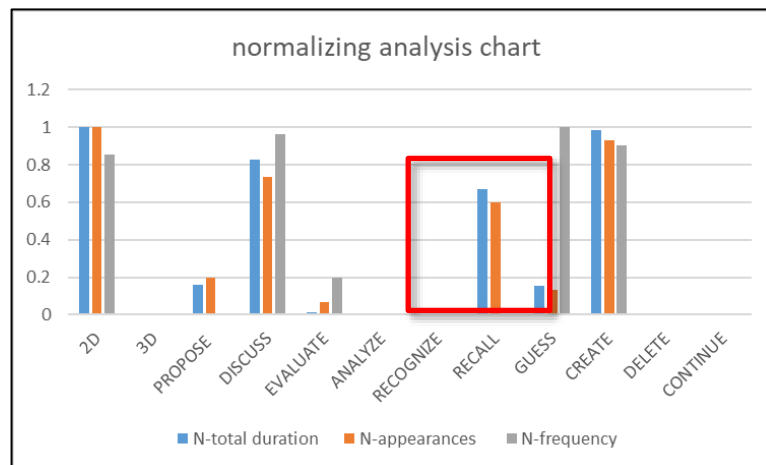


Figure 4.32: Normalizing Analysis Chart for Experiment 16.

In this figure (4.32) the architect did not commit to the instructions or miss understood how to run the experiment.

First the time limits was under the average (only five minutes).

Second: as it shown in the chart there is no recognizing activities at all, while there is only retrieve and guess activities, which indicates that the architect might miss understood how to run or use the three terms to describe his work.

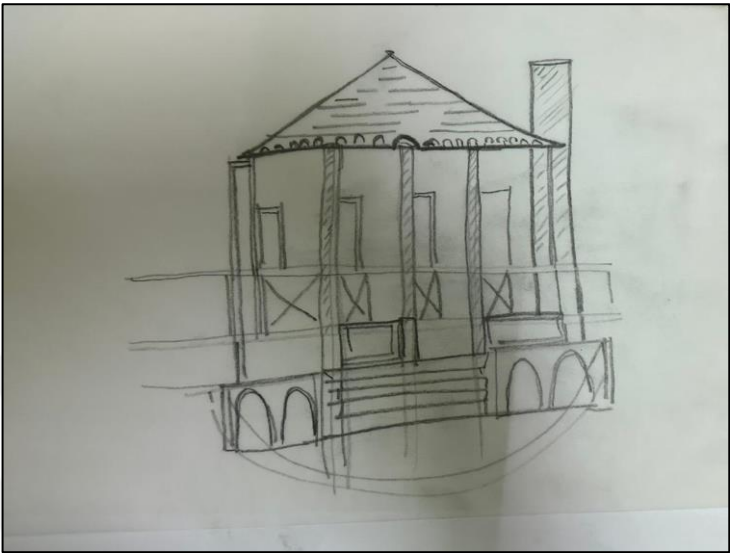


Figure 4.33: Result of Experiment 17.

Table 4.17: Excel Sheet Analysis for Experiment 17.

DURATION (SECONDS)		###	29	7	24	24	17	26	21	32	16	16	30	25	31	32	20	34	46	39	35	66
DESIGN SPACE	2D																					
	3D																					
DESIGN PROCESS	STUDY-MEMORIZE																					
	PROPOSE																					
	DISCUSS																					
	EVALUATE																					
	ANALYZE																					
MENTAL PROCESS	RECOGNIZE																					
	RECALL																					
	GUESS																					
ALIZATION ACTION	CREATE																					
	DELETE																					
	CONTINUE																					

The same problem of timing the architect spent most of the time explaining things that are not related to the core of the experiment, like discussing the history of architecture and the architect’s personal memories.

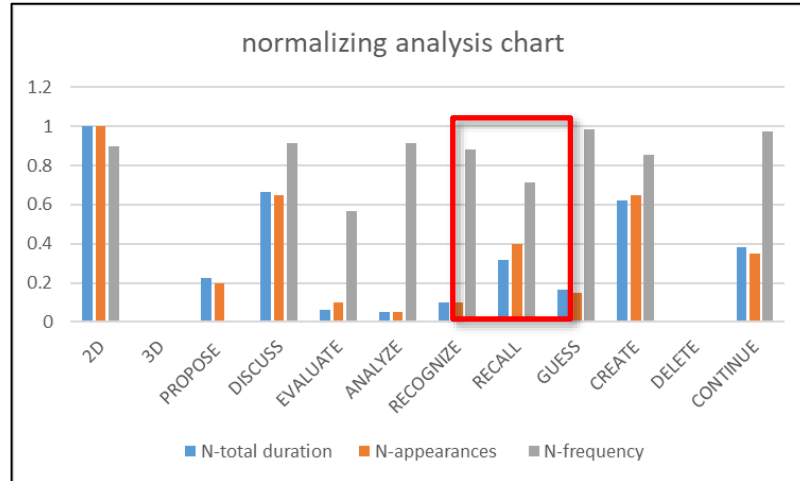


Figure 4.34: Normalizing Analysis Chart For Experiment 17.

In this experiment the architect spent most of the time explaining his childhood memories and how it affected his career in architecture, it is noticed also that the architect depends on what is retrieved more than what is recognized as shown in the chart.

Architect in this sketch prefers to sketch in 2D which is obviously has the maximum values of total duration and appearances in the chart, and that also explain why the create action and discuss action have high values also in most of the charts because the architects keep sketching and explaining the whole process.

There is no 3D or delete values as the participant prefer to use 2D space to complete the task.

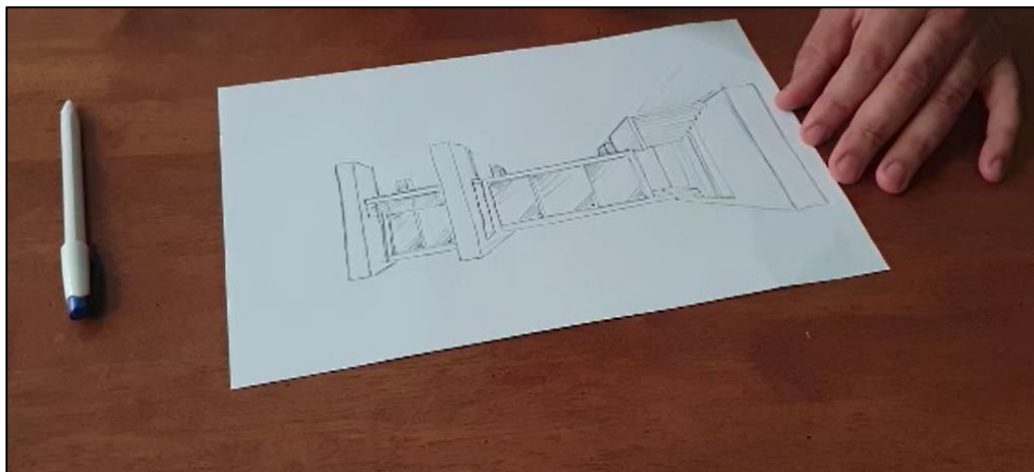


Figure 4.35: Result of Experiment 18.

Table 4.18: Excel Sheet Analysis for Experiment 18.

DURATION (SECONDS)		###	51	27	24	24	7	23	23	23	31	14	17	13	7	23	18	9	25	25	40	23	50	28	26	50	14	12	16	4	24	12	12	27	52	16		
DESIGN SPACE	2D																																					
	3D																																					
DESIGN PROCESS	STUDY-MEMORIZE																																					
	PROPOSE																																					
	DISCUSS																																					
	EVALUATE																																					
	ANALYZE																																					
MENTAL PROCESS	RECOGNIZE																																					
	RECALL																																					
	GUESS																																					
REALIZATION ACTION	CREATE																																					
	DELETE																																					
	CONTINUE																																					

In this experiment the architect did not use the main three terms (remember, know or guess) properly, that did not help to analyzing the codes:

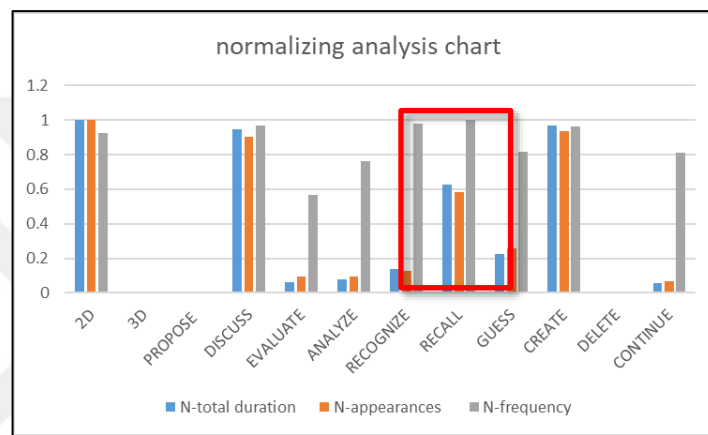


Figure 4.36: Normalizing Analysis Chart for Experiment 18.

In this experiment the architect misunderstood the main idea of this experiment, the architect only copied one of the images he saw as it is without any addition or changes, which is obvious from the recalling activity's values, and the architect prefer to use 2D space to accomplish the task while applying the think loud method as shown in the values of the two actions in the chart.

There are no values for the 3D and propose actions as the architect prefer the 2D space and not proposing new ideas to create the new façade, he just copied on of the facades shown in the images.

5. CONCLUSION

Memory plays a role in architecture, as shown in some of the examples in chapter three, it can be the main concept of the design, as Daniel Libeskind expressed his personal experiences within his design, combining his own memories with the artist Felix Nussbaum's memories to create a museum that tells a personal story.

Memory can be used to create new designs out of combining what the architect can remember as shown in the experiments done above.

Out of (18), ten architects as shown in the charts depend equally on what they remember and what they recognize from the same images shown to the other architects, with a very slight differences in values.

While one architect as also shown in the charts they depend on what he/she could recognize more on what it is remembered from the images shown to the others.

Four architects show that they depend on their memory more than recognition while analyzing the charts above, three more architects miss understood the experiment therefore the results are not reliable since the instructions have not been taken into consideration.

It can be understood that (10) architects out of (15) not including three participant whom could not follow the experiment properly, are able to utilize what they remember and what they know and recognize in to a new design, creating new architecture, indicating that these two actions completing each other to provide fully understood designs, as shown in table:5.1 What the architects remember help them to have a new concept for new designs expressing their vision about architecture, some architects focus on the modern houses in the images and their new sketches are affected by the details related to those images.

Table 5.1: Results

NUMBER PF EXPERIMENTS	NUMBER OF PARTICIPANTS	ACTIONS		
		RECALL	RECOGNITION	RECALL&RECOGNITION
10	10			
1	1			
4	4			

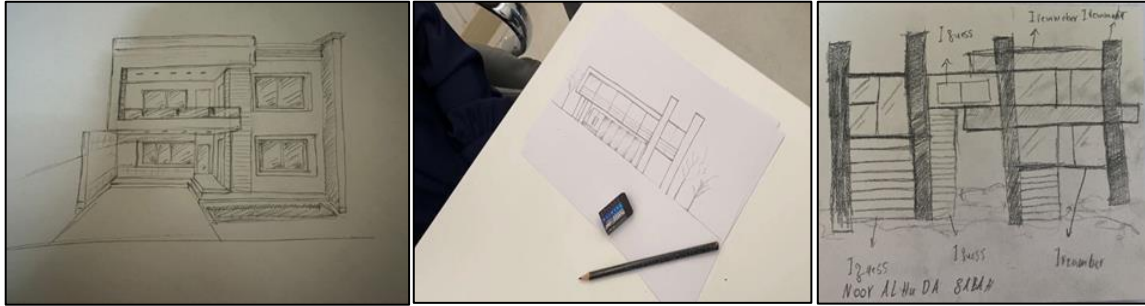


Figure 5.1: Experiments' Results.



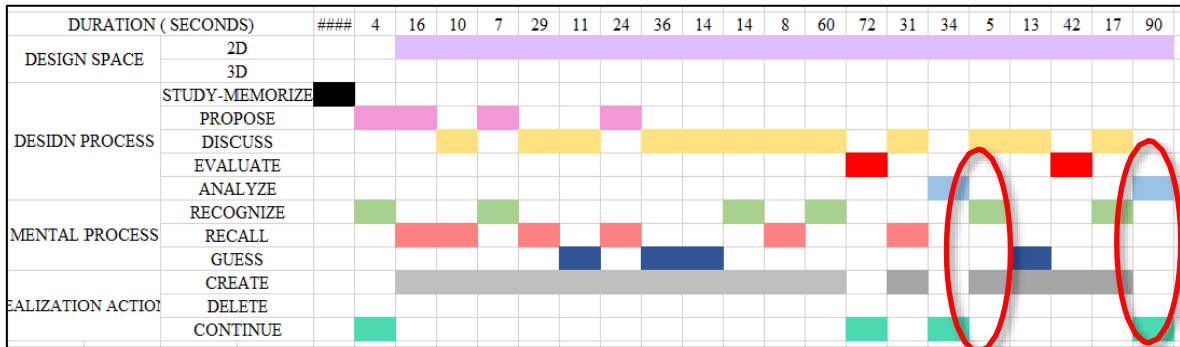
Figure 5.2: In the Left Farns Worth House in the Middle Douglas House and in the Right the Water Falls House.

Some other architects focus on the historical mansions and castles and again their new sketches are obviously affected by the details of those castles.



Figure 5.3: Experiments' Results.

Table 5.5: Excel Sheet Analysis for Experiment 6.



Analyzing action seems to show together in the charts along with the continuing action, indicating that when the participant pauses to think about the current step, then the procedure continues, the participant back to complete the design after that pause.

Another relation show in the tables below:

Table 5.6: Excel Sheet Analysis for Experiment 7.

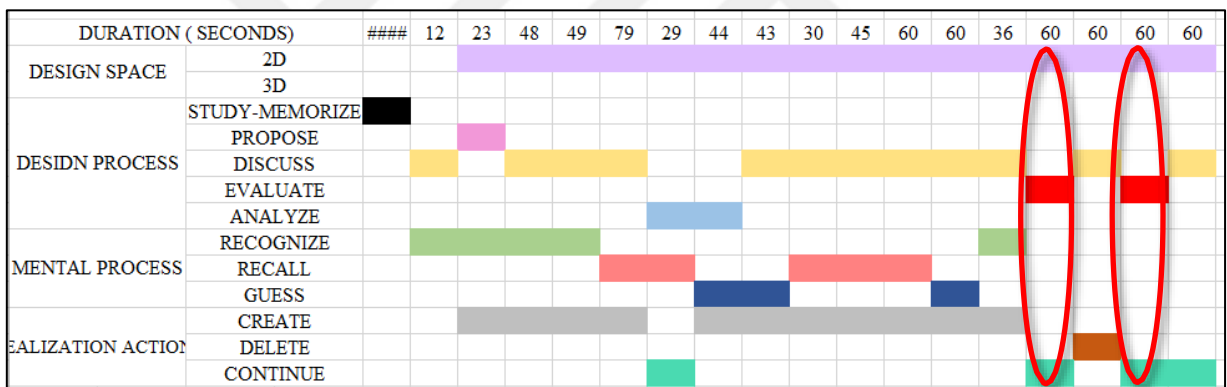


Table 5.7: Excel Sheet Analysis for Experiment 14.

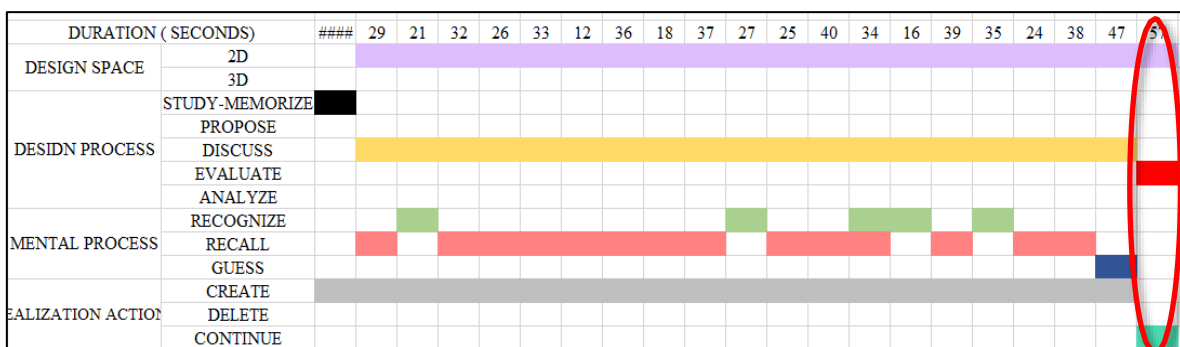


Table 5.8: Excel Sheet Analysis for Experiment 15.

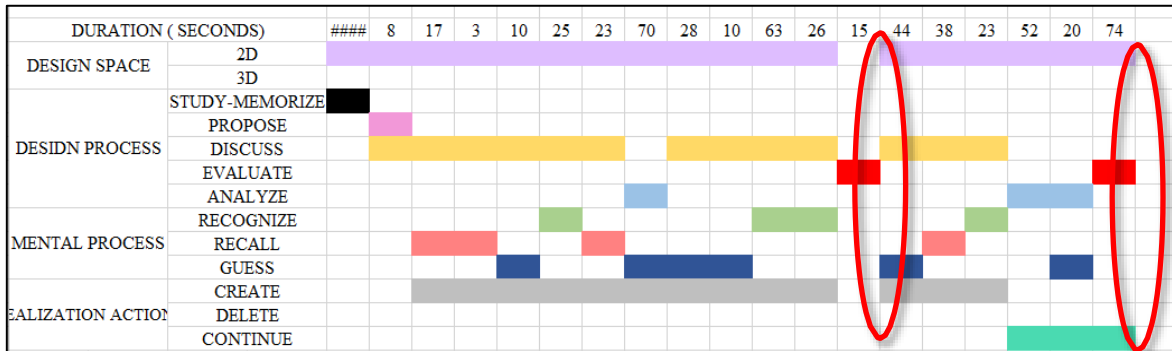
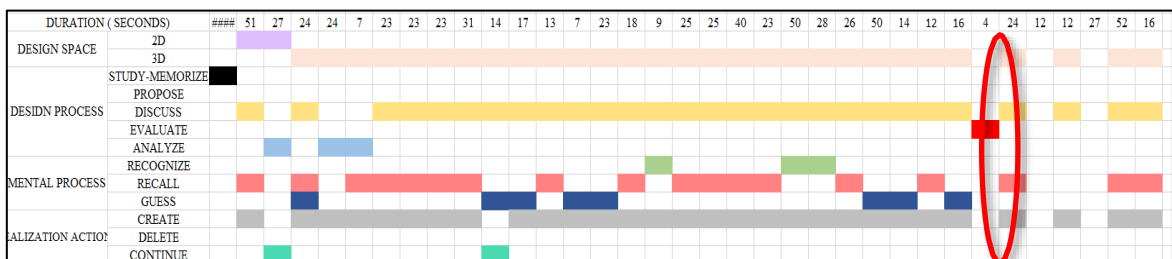


Table 5.9: Excel Sheet Analysis for Experiment 18.



In the tables above, the evaluating action indicate that the architect either stops all other actions to assess the design for a while before continuing the designing task.

5.1 RECOMMENDATIONS AND FUTURE WORK

We can suggest the memory and recognition actions are equally important for a design process. But to investigate more and to get objective results we should increase the number of experiments, since the number of experiments in this thesis is the limitation of the thesis.

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