

Resumo

Eu sou um estudante japonês a estudar em Portugal. Uma das primeiras experiências que tive aqui fascinou-me, intrigou-me, e continua a fazê-lo. É a experiência emocional conhecida como SAUDADE. Identifiquei-me com esse estado emocional, complexo, porque é em muitos aspectos, semelhante ao conceito japonês, Mujo-kan. Apenas algumas palavras não seriam capazes de transmitir o significado desta palavra, mas talvez possa ser traduzido como "transitoriedade" e "Vazio". No meu trabalho eu queria interpretar e expressar o significado e a experiência da Saudade.

Eu pretendi criar uma obra que falasse sobre esse sentimento, a saudade, como eu o experimentei. Este trabalho é composto por objetos separados, reunidos para formar um espaço interior. Encontrei um espaço adequado para fazer isso, utilizei objectos produzidos com sopro de vidro livre, corte e polimento a frio, sopro no maçarico, e pintura a esmaltes para criar os elementos da minha instalação. Por fim, encontrei dois cientistas cognitivos que trabalham no Instituto Gulbenkian de Ciência que me ajudaram a entender como um sentimento tão complexo como SAUDADE se forma no cérebro.

Lisboa, 28 de Outubro de 2011

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Abstract

I am a Japanese student studying in Portugal. One of the first experiences I had here fascinated me, intrigued me, and continues to do so. It is the complex emotional experience known as SAUDADE. I identified myself with that complex emotional state because it is in many ways similar to a Japanese concept, Mujo-kan. A few words would not be able to convey the meaning of the word but it could be translated as “Transience” and “Emptiness”. In my work I wanted to interpret and express the meaning and the experience of Saudade.

I intended to create a work that would speak to that feeling, SAUDADE, as I experienced it. This work was composed by separate objects that were gathered together to form a designed interior space. I found a suitable space to do this, used the processes of glass blowing, cold working, torch working, and enamelling to create elements of my installation. I found two cognitive scientists working with the Gulbenkian Institute of Science who helped me understand how such a complex feeling as SAUDADE originates in the brain.

Lisbon, 28th of October, 2011

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INDEX OF CONTENTS

Abstract	i
Index of Contents	iii
Index of Contents	iv
Introduction	1
Experimental Procedure	3
Results and Discussion	
A. Portuguese Concept	4
B. Japanese Concept	7
C. Scientific Research	11
D. Artworks	18
E. Discussion	20
Conclusion	23
Appendix	
Art Making Process	a
Figures and Tables	g
Bibliography	n
Acknowledgement	q

INDEX OF FIGURES

Figure 1. Artworks, Synapse of Memory #1 - #5	g
Figure 2. Artworks, The Optic Nerve, To the Retina #1, #2 and To the Mind #1, #2	g
Figure 3. Artworks, Communication, Memory and Brain #1	h
Figure 4. Artworks, Communication, Memory and Brain #2	i
Figure 5. Artworks, Communication, Memory and Brain #3	j
Figure 6. Artworks, Neuron Case	k
Figure 7. Annealing Kiln, Pipe Warmer, Furnace, Big Glory Hole, Small Glory Hole, Pipe Cooler and Bench	l
Figure 8. Jacks, Tweezers, Bonsai Shears, Diamond Shears, Wet Newspaper, Wood Blocks and Water in bucket	l
Figure 9. Cutting Machine	m
Figure 10. Lapping Machine	m

Introduction

I had been in Portugal twice before the Masters of Glass Art and Science started in September 2009. When I explored the city of Lisbon, I felt this strong yet inexpressible emotion, and now that almost two years have passed, the emotion stays in my mind. My life in Portugal has been filled with experiences of different emotions and thoughts. I treasured these emotions and thoughts through my study and life here. Among all the experiences I had, I was most intrigued by and interested in studying that inexpressible emotion, which I identified with the Portuguese expression SAUDADE. As a Japanese person, I could not comprehend the true meaning of the Portuguese expression, SAUDADE. The word represents the cultural memory of Portuguese people over the course of long history. However I would like to assume that the feeling that I experienced was similar to the state of SAUDADE. I think that the feeling of SAUDADE is similar to MUJO-KAN, which is a feeling specific to the Japanese language. I started being interested in exploring those two emotional states, SAUDADE in Portugal and MUJO-KAN in Japan and it inspired me to study and compare the similarities and differences between the two.

In the Masters of Glass Art and Science, we studied and created art by focusing on the material of glass itself and art from both a scientific and an artistic perspective. In addition, I chose to study the mechanism of our mind and SAUDADE from the point of view of neuroscience. In my previous works, I have never applied a scientific approach. Therefore, I was sure that this new opportunity and challenge would be very helpful in discovering new possibilities in my work, understanding my thought and emotion processes, and also discovering myself. For those reasons, I chose the theme of my thesis to be SAUDADE.

Fortunately, I had the opportunity to meet two Japanese neuroscientists, who live in Lisbon

and were interested in my research project. I would like to credit them for significantly influencing my project with their collaboration.

Firstly, I am going to define the concepts of SAUDADE and MUJO-KAN. Both concepts represent people's perspectives on life, human nature and their mentalities by looking at underlying historical backgrounds and the use of these concepts in literatures and poems. Secondly, from a scientific perspective, I focused on the question, "How are emotions elicited in one's mind and expressed in one's body?" Specifically, I studied vision, memory and their relationship to emotions in the brain mechanism. In the section of art-making, I will elaborate on the process of the creation of the artwork in relation to the aforementioned research. I will also describe the art pieces by explaining how each of them embodies my understanding of Saudade. Each piece represents different aspects such as one's visual perception of the external world, emotional experiences and also fragments of events' memories.

Finally, for the discussion and conclusion part, I will describe what I learned from the Masters and this dissertation projects as well as the findings and difficulties that I encountered. I will also mention briefly some further improvements that I could make for future art works.

Experimental Procedure

The steps taken to research and create my artistic representation of SAUDADE are as follows;

- Study of the concept of SAUDADE by analyzing Portuguese literatures.
- Study of the concept of MUJO-KAN by looking at the customs and tradition in Japan and how they represent their understanding of the nature. This helped me to understand the similarity to SAUDADE and how I feel SAUDADE.
- Study of these emotions from the perspective of neuroscience by interviewing cognitive scientists.

My art piece, SAUDADE was created based on the ideas derived from these three studies together with the knowledge from the study of glass art and science in the Masters. I made the artwork to visualize my ideas and also organized the exhibition and the presentation. I mainly used the material of glass and used the standard techniques of glass making, such as blowing, torch working, enameling, and cold working (cutting, grinding, polishing, and bonding).

Results and Discussion

A. The Portuguese concept of SAUDADE

The expression, SAUDADE has been used in different contexts and interpreted in many ways. Today in Portugal, the generic understanding of the term would be the feeling of longing for things and people that are physically distant and not present at the moment (often associated with the desire to regain lost happiness). However, SAUDADE also appears to be associated with the future such as daydreaming about something unexpected. As seen in the expression of "SAUDADE of heaven", SAUDADE can be oriented towards one's future.

In the history of Portuguese literature, SAUDADE and solitude were romanticized and they often appeared in the medieval poems as SOLIDADE. SOLIDADE is an old expression used to represent the sadness of separation. The Portuguese poets of the Renaissance, Baroque, and the neo-classical writers such as Bernardim Ribeiro and Luís de Camões, associated SAUDADE with the people and places they recalled with special fondness.

As a Portuguese writer and Poet, Pascoaes, stated in 1920s, 'SAUDADE entails two dimensions; one is lustful desires and heightened expectation towards one's future and the other is a spiritual and painful memory from the past.'¹ 'SAUDADE, in terms of future, is understood as a wish or a desire, and in terms of the past, is seen as a recollection from the past. SAUDADE is creation and a perpetual combination of remembrance with desire. SAUDADE holds two elements, the action of desire on remembrance and of remembrance on desire, and it is the perfect fusion of Nature and the Spirit.'² Pascoaes defined the SAUDADE as 'the desire of being or of the loved thing, along with the pain of their absence. Desire and pain are confounded in only one's senses that combine a carnal or a material

¹ Teixeira de Pascoaes

² Teixeira de Pascoaes, *Ibid.* V

element “desire” with a spiritual element “pain”, an orientation towards the future, and the desire as a wish. The SAUDADE would be in this measure, according to Pascoaes, of contradictory feelings, usually seen as separate, such as material and spiritual, past and present.

The current definition of SAUDADE also has an historical implication and connotation. The Reconquest and the subsequent emigration to India, Brazil, and Africa forced the Portuguese to be separated from the loved ones and had to bear their absence. As phrased, ‘Love and absence are the parents of SAUDADE.’³ The meaning of SAUDADE was always interpreted differently depending on the society’s situation and context throughout the history. The most prominent example is the use of SAUDADE as a slogan to advocate nationalism by Teixeira de Pascoaes.

Portugal was at the height of prosperity in the Age of Discovery. ‘To sail is necessary, but to live is not necessary.’⁴ Portuguese sailors who led the Age of Discovery had a spirit of the heroic, and sailed out into the unknown world. In the meanwhile, their loved ones were left to wait in the country with the feeling of SAUDADE. The word SAUDADE is one of the unique expressions of the Portuguese identity even though it can be also understood as the background of nationalism in the early 20th century. Their ancestors who sailed overseas had a single-minded gallantry, with a unique sentiment, called SAUDADE.

In the late 19th century, the Age of Imperialism, Portugal was forced to retreat from imperialism competitions against the great powers. In the face of a severely weakened situation, Pascoaes endorsed national revival by embracing a positive meaning in SAUDADE and advocating it as a Portuguese spirit and tried to boost the morale of the public. In the course of time, the national identity inevitably suffered. At the beginning of the 20th century, the Saudosismo, the movement of a search for the lost national identity, brought the current definition of SAUDADE. The Portuguese identity,

³ Francisco Manuel de Melo, *Epanáforas de Vária História Portuguesa*.

⁴ Bernardo Soares, *Os Argonautas, Livro do Desassossego*

in those times, was equated to the sense of loss, caused by parting with something significant, whether it was the people they loved, things, scenes, memories or thoughts and many of emigrants identified themselves with it. In other words, SAUDADE was the answer to the pursuit of a lost identity, as a result of the movement, that was lost in sight in expanding overseas. Whether it is a place, a memory or people, it is longing for something they felt like turning to. Wherever emotions direct us, there will be a pain called SAUDADE in one's heart. Pascoaes defined the SAUDADE as the spirit of the nation and integrated everything that existed, namely body and soul, joy and sorrow, love and desire, and heaven and earth. Therefore, he tried to exert the influence of the movement SAUDADISMO into the fields of religion, philosophy, and politics.

B. Japanese concept of MUJO—KAN

'River current never fails, water flows, and moment by moment is never the same. Where the current pools, bubbles form on the surface, bursting and disappearing as others rise to replace them; none are lasting long. In this world, people and the surrounding environments are constantly changing.⁵ This is the opening sentence of the Japanese old essay, HOJOKI, written by Kamo no Chomei, in the Kamakura period, more than eight hundred years ago. The author, Kamo no Chomei, watched water flowing in the river and how the water never comes back, and began to write the opening sentence "There is no eternity in the world". In observing that, he saw the concept of Buddhism called "MUJO (EMPTINESS)". Kamo no Chomei drew a comparison of different perspectives on living things, in this case, "Even though nothing stays still in the world like the flow of water, the flow never ends".

I stated that SAUDADE could correspond to "Mujo-kan" in Japanese. "Mujo-kan" can be translated as EMPTINESS in English. The concept of Mujo-kan and the Japanese mentality in general originated from their adaptation into the geological nature of the country and consequential natural disasters for thousands of years. Instead of avoiding risks, they accepted natural disasters with the attitude of "c'est la vie." This might have influenced our aesthetic sense. Although the worldview of MUJO originates in Buddhism, we inherited it in a different context and created the Japanese tradition and culture. The Japanese learned to appreciate the natural course of life and have even adapted it into their lifestyle.

MUJO implies that everything born into this world will vanish sooner or later, never staying in one state, and is constantly changing its form. There is neither eternal stability nor immortality. The idea of MUJO is engraved into the Japanese mentality from ancient times to today. The way of thinking such

⁵ HOJOKI, Kamo no Chōmei, written in 1212, Kamakura period.

as “Everything will be gone” or “Human beings are powerless in the face of nature“ resembles desperation or surrender. However, the Japanese found an alternative way of seeing the instability and mortality and found beauty in it.

Their perspective on humans and nature is expressed in Japanese popular culture, for instance, Teatism. The tea ceremony is a mere act of drinking a cup of tea. However, the attitude, behaviour, and hospitality seen in the occasion reflect Japanese humanity and humbleness, in another word, the pursuit of perfect (eternal) beauty. The philosophy of tea-ism does not only lie in its aesthetic sense. It also expresses ethics, religion and our perspective about the human nature. The concept of Tea-ism is essentially a worship of the Imperfect, as it is a tender attempt to accomplish something possible in this impossible thing we know as life.

There are other Japanese customs that reflect their mentality and appreciation of beauty. For instance, we gather and picnic under cherry trees when they blossom in spring. On summer nights, we take a walk to watch fireflies and enjoy their bright yet gentle lights, and in autumn we find fallen coloured leaves and make arts with them or cook steamed sweet potatoes with gathered leaves. We do it collectively and habitually. The reason why we do these activities is that we try to witness and celebrate the moment of glory, which will fade away and eventually be lost, just as all cherry blossoms, fireflies, and colored leaves will lose their beauty in a short time. Not only do we celebrate its prime beauty but also appreciate the falling of those beings. We see fireflies losing their small lights, and we see the vivid color of the leaves disappear. We seem to find a relief when we see this; we find a peace in the prime time of beauty passing and vanishing.

This attitude appears to be the opposite of Western thought that pursues eternal (perfect) things and finds virtue in it. Although Mujo-kan has been adapted and interpreted into our life style and morale, they have a strong connection to religion as well. The central idea was influenced by Buddhism,

Taoism, and Confucianism in the middle of the eighth century. The pantheistic symbolism of the time was urging one to mirror the Universal in the Particular. The Taoist conception that immortality exists in the eternal change permeated all their modes of thought. It was the process, not the deed, which was interesting. It was the completing, not the completion, which was really vital. Man came thus at once face-to-face with nature.

Lao-tzu⁶, Taoism master spoke of it thus: "There is a thing which is all-containing. I do not know its name and so call it the Path. With reluctance I call it the Infinite. Infinity is the Fleeting, the Fleeting is the Vanishing, and the Vanishing is the Reverting." The Tao is in the Passage rather than the Path. It is the spirit of Cosmic Change, the eternal growth that returns upon itself to produce new forms. Subjectively it is the Mood of the Universe. Its Absoluteness is the Relative. The art of life lies in a constant readjustment to one's surroundings. We accept the mundane as it is and try to find beauty in our world of woe and worry. If now we turn our attention to Zennism we shall find that it emphasizes the teachings of Taoism.

A special contribution of Zen to Eastern thought was its recognition of the mundane as of equal importance to the spiritual. It held the idea that in the great relationship of things there was no distinction between small and great, an atom possessing equal possibilities with the universe. The seeker for perfection must discover, in his life, the reflection of the inner light. The whole ideal of Teism is a result of this Zen conception of greatness in the smallest incidents of life. Taoism furnished the basis for aesthetic ideals, Zennism made them practical.

Lao-tzu said "Heaven and earth are pitiless." And also Kobodaishi⁷ said "Flow, flow, flow, flow, the current of life is ever onward. Die, die, die, die, death comes to all." Destruction faces us wherever we turn; destruction below and above, destruction behind and before. Change is the only

⁶ A mystic philosopher of ancient China.

⁷ 774–835, a Japanese monk, scholar, poet, and artist, founder of the Shingon.

Eternal. They are nothing but counterparts to one another. Through the disintegration of the old, re-creation becomes possible.

C. Scientific research

When I feel SAUDADE, what is happening to my body?

When I feel emotions, I feel as though my heart feels it rather than the brain. Then, what is the HEART (or MIND)? I cannot feel or see the physical presence of the mind. But it seems that the heart and the mind have close proximity. Sometimes I feel my heart moving. For example, the heart skips a beat and pounds when I feel happy to see someone that I like. The heart hurts and I feel broken-hearted in sadness in times of difficulty. Those experiences make me think that my mind is in my heart. Indeed, the word MIND in Japanese includes so-called emotional representations such as FEELING and MOOD. In addition, MIND and THOUGHT are defined as representations of the HEART in dictionaries. In this scientific research part, I took an approach of studying SAUDADE with an emphasis on the relation between HEART and mechanisms of visual memory.

BRAIN and HEART seem to point towards the same place. And whether one call it BRAIN or HEART would depend on the level of abstraction people apply. More specifically, it is called HEART in lay terms and BRAIN in science. Current brain science regards the “heart” as grown by brain. In other words, the heart is an internal phenomenon of the brain. The term HEART mentioned here refers to mental activities such as cognition, emotion, decision-making, language manifestations, memory and learning. Those mental activities are held by carefully organised activities of billions of cells in the brain. The brain as an entity is created in the embryonic stage, and grows further after birth. The formation of the brain depends on the interaction of genetic programs and the social environment and also on the development of other body parts. The core component of the brain, the neurons⁸ are constantly active in the grown-brain as well. Their activities are also affected by genes and learning.

Then, how does the brain have such a structure? And, what are its mechanisms?

⁸ An electrically excitable cell that processes and transmits information by electrical and chemical signalling.

Specifically, I would like to focus on the way the brain processes and organises external stimuli. First of all, the basis is the working of the nervous system and the advanced brain system. The brain and spinal cord⁹, grouped as the central nervous system, consist of the neurons and the glia cell¹⁰. Their shape and function vary greatly between brain areas, and their cell to cell association is very complex compared to other organs. When we see something, the visual information of the external world is projected two-dimensionally onto the retina of the eyes at first. It is then converted into wave-like electrical signals by the neurons that exist in the retina and it is transmitted to the central nervous system. Here again, the several types of neurons work between those areas. Eventually, the information is transmitted into the area called the visual cortex¹¹ in the occipital lobe¹² of the brain and is recognized as a three-dimensional image. However, to recognize the image of the external world in a true sense is a complex function of a more significant central nervous system. A part of those recognised information is stored as a memory in a part of the brain called the hippocampus. Then, those memories would help us understand the meaning of the visual information.

From human observations and experimental studies of animals, the formation of memories related to facts and events are closely connected with a part of the brain called the hippocampus¹³,

⁹ A long, thin, tubular bundle of nervous tissue and support cells that extends from the brain (the medulla oblongata specifically).

¹⁰ Non-neuronal cells that maintain homeostasis, form myelin, and provide support and protection for the brain's neurons.

¹¹ A part of the cerebral cortex responsible for processing visual information. It is located in the occipital lobe, in the back of the brain.

¹² Located at the back of the brain, behind the parietal lobe and temporal lobe. Concerned with many aspects of vision.

¹³ A major component of the brains of humans and other mammals. It belongs to the limbic system and plays important roles in the consolidation of information from short-term memory to long-term memory and spatial navigation.

which is one of the oldest cortex in evolutionary history. The aforementioned type of memory is technically called declarative memory or explicit memory because its contents are easy to explain in words. On the contrary, the memory that is hard to explain in words such as remembering (by successive learning) how to ride a bicycle is called non-declarative memory or implicit memory.

Then, how is the declarative memory formed? The hippocampus receives visual and auditory sensory information, as noted before, through the cerebral cortex¹⁴, and necessary information is stored in the hippocampus for a period of time. In the case of humans, generally it is stored for two years, and when judged unnecessary, it is saved to be dispersed in part of the cerebral cortex. How then does the hippocampus accumulate the information? There is a specialized part, called the synapse¹⁵, existing between neurons in the hippocampus area. The synapses have the ability to accumulate information. Information in the nervous system is transmitted by digital signals as previously mentioned. But the synapse replaces it with a chemical signals, called neurotransmitters¹⁶. To modify electrical signals in vivo¹⁷ is very difficult, but chemical signals can be modified relatively easily. In the formation of memory in hippocampus, it proved that the modification of chemical signals at synapse is a fundamental change. This modification facilitates transmission of the information in the synapse and it is important in the formation of the memory.

Synaptic bonding connects neurons by transmitting signals, which differs itself from mechanical and passive objects such as an electrical junction or a computer element. The brain is a

¹⁴ A sheet of neural tissue that is outermost to the cerebrum of the mammalian brain. It plays a key role in memory, attention, perceptual awareness, thought, language, and consciousness.

¹⁵ A synapse is a junction that permits a neuron to pass an electrical or chemical signal to another cell (neural or otherwise) in the nervous system.

¹⁶ Endogenous chemicals that transmit signals from a neuron to a target cell across a synapse.

¹⁷ Experimentation using a whole, living organism as opposed to a partial or dead organism.

highly dynamic device that evolved to adapt itself, corresponding with new input or experience. The brain is an organ that evolved over the years, which uses the hardware named neurons, and was built to mobilize a variety of genes. Therefore, I considered that those differences in genetic traits between Portuguese and Japanese and their cultural differences might have had an impact on their perception (the result of seeing), emotion and memory.

Here I am going to describe the anatomy and function of the brain mechanism related to emotional experience and emotional expression. The cerebrum¹⁸ is at the central position, and the interbrain¹⁹, midbrain²⁰, cerebellum²¹, brainstem²² and spinal cord, that are contiguous to it, run an instruction smoothly from the cerebrum. On the other hand, it communicates appropriately to the cerebrum, the information about the environment around us, and determines how we react. The frontal lobe²³ is developed in the primate. It is the source of thought, which in some ways defines humans as human, social behaviour based on decisions, creativity and will. However, the workings of the mind as emotional expression such as pleasure, displeasure and feelings (joy, anger, pathos, and humours) and also instinctive behaviour such as an appetite and a sexual desire, is involved in the

¹⁸ The most anterior or, especially in humans, most superior region of the vertebrate central nervous system.

¹⁹ The region of the brain that includes the thalamus, metathalamus, hypothalamus, epithalamus, prethalamus or subthalamus and pretectum.

²⁰ A portion of the central nervous system associated with vision, hearing, motor control, sleep/wake, arousal (alertness), and temperature regulation.

²¹ A region of the brain that plays an important role in motor control. It is also involved in some cognitive functions such as attention and language, and probably in some emotional functions such as regulating fear and pleasure responses.

²² The posterior part of the brain, adjoining and structurally continuous with the spinal cord. The brain stem provides the main motor and sensory innervation

²³ Concerned with reasoning, planning, parts of speech and movement (motor cortex), emotions, and problem-solving

phylogenetically older areas in the cerebrum, primarily called the limbic system²⁴. This limbic system is anatomically placed around the lateral ventricle²⁵, and the hippocampus and the amygdala²⁶, arranged to surround the diencephalons²⁷, are a major component. The cerebrum cortex, such as the cingulate gyrus²⁸ and the piriform lobes²⁹, is an additional part of the limbic system. It can be roughly divided into the hippocampus of the limbic system, mainly involved in memory, and the amygdala being involved in emotion. However, the amygdala plays an important role in the memory that is strongly associated with the emotion. The amygdala is also responsible for determining what memories are stored and where the memories are stored in the brain. It is thought that this determination is based on how huge an emotional response an event invokes. There is a strong relationship between visual cortex, hippocampus and amygdale.

I am going to look further into the brain mechanism of perceiving emotional stimuli and the bodily reaction to these stimuli. When the conditioned stimulus springs up, this information reaches to the thalamus³⁰, or we could say the gate of the process that sensory stimuli transmitted to the

²⁴ A set of brain structures including the hippocampus, amygdala, anterior thalamic nuclei, septum, limbic cortex and fornix, which seemingly support a variety of functions including emotion, behaviour, long term memory, and olfaction.

²⁵ A part of the ventricular system of the brain. Classified as part of the telencephalon, they are the largest of the ventricles.

²⁶ Almond-shaped groups of nuclei located deep within the medial temporal lobes of the brain in complex vertebrates, including humans.

²⁷ The region of the brain that includes the thalamus, metathalamus, hypothalamus, epithalamus, prethalamus or subthalamus and pretectum.

²⁸ A part of the brain situated in the medial aspect of the cortex.

²⁹ A part of the rhinencephalon that is a part of the brain involved with olfaction, situated in the cerebrum.

³⁰ A midline paired symmetrical structure within the brains of vertebrates, including humans. Its function includes relaying sensation, spatial sense, and motor signals to the cerebral cortex, along with the regulation of consciousness, sleep, and alertness.

neocortex³¹. The thalamus is large group of neurons, located deep within the ventral area of the cerebrum, and the emotional information is divided into two here. One pathway transmits information to the cerebral cortex, where after being analysed in detail is transmitted to the hippocampus, and finally it is saved in the long term memory. In the other pathway, the information is immediately transmitted to the amygdala, which is a large group of neurons next to the thalamic. The amygdala does a value judgement and evaluates the sensory information, whether it is beneficial for our survival in a broad sense. This processed result of the information related with emotions in the amygdala is first transmitted to the hypothalamus³², the centre of autonomic nervous function and hormone. It is led to autonomic nervous response, causing the heart to beat faster, or changing the stomach movement. When encountering fear-producing stimulus, the information is transmitted from midbrain to amygdala at the same time, and gives rise to actions such as a cringing with fear. In addition, the stimulation is transmitted from the amygdala to the limbic system, such as the hippocampus and the cingulate gyrus in the cerebrum. It is also greatly influences long-term memory. Thus, the amygdala accumulates the memory associated with primitive emotions, and it elicits the memory when input with emotional stimuli related to this memory, leading to strong emotional or physical reactions.

So far, I looked at the information processing related to fear and disgust. How are pleasant emotions elicited? And how are they controlled? The emotional stimuli pass through the amygdala and hypothalamus. The stimulus that causes a feeling of satisfaction and pleasure pass through a specific area in midbrain, called ventral tegmental area³³, to release the dopamine, one of the neurotransmitter³⁴,

³¹ Part of the cerebral cortex that is involved in higher functions such as sensory perception, generation of motor commands, spatial reasoning, conscious thought and language.

³² A portion of the brain that contains a number of small nuclei with a variety of functions. One of the most important functions of the hypothalamus is to link the nervous system to the endocrine system via the pituitary gland.

³³ A group of neurons located close to the midline on the floor of the midbrain that is important in cognition, motivation,

in the nucleus accumbens³⁵, the group of neurons, located in deep ventral in the cerebrum. When the dopamine is released, it gives one pleasant feelings or satisfactions. As described so far, there are multiple systems, which situate feelings in the brain. Specifically, the amygdala is directly related to discomfort, and the nucleus accumbens is related to pleasant emotion and they are the major components of emotional mechanism.

drug addiction, intense emotions relating to love, and several psychiatric disorders.

³⁴ Endogenous chemicals that transmit signals from a neuron to a target cell across a synapse.

³⁵ A collection of neurons within the striatum that is thought to play an important role in reward, pleasure, laughter, addiction, aggression, fear, and the placebo effect.

D. Artworks

I organized the exhibition "SAUDADE" at Galeria Diferença in Lisbon and it was open to public from the 28th of May to the 2nd of July. I made the artworks that were inspired by my study of the concept of SAUDADE and MUJO-KAN, and the brain mechanism related to those senses. In the exhibition I took the installation style to demonstrate my understanding of SAUDADE in the form of glass art. In addition, I asked a Japanese film producer, Takashi Sugimoto, to make a short film about the creative process of my artworks because I would like to have made the distance between audience and my works closer.

First, the works "Synapse of Memory #1 - #5 (Fig.5)", placed at the middle of the space are based on the study of the sense of vision. I considered that most of our thoughts are associated with visual images, and as a result, I set the mechanism responsible for "seeing" as fundamental for the making of this piece. The tremendous amounts of things that I saw are recorded in the brain. I made this work by thinking about how my experiences or some parts of them are memorized in the brain as embodied images, elicited and transmitted by neurons. I made this artwork with full of such idea.

Then, the work "The Optic Nerve, To the Retina and To the Mind (Fig.6)" are also based on the study of the sense of vision. This piece was inspired by the study of the optic nerve that connects between the brain and retina. The important nerve related to "seeing" that one side is connected directly to the brain and to the other side of the retina, and the various nerves around it. Understanding the mechanism brought me a thought and I tried to make my interpretation of that study in this artwork.

Next, the piece, "Communication, Memory and Brain #1, #2, #3 (Fig.7 - 9)" are a representation of the movement of my heart when I feel SAUDADE or MUJO-KAN; the heart is guarded in a safe place, the pain is welling up like a fountain from the bottom of my heart to the top of the head with the sensation of SAUDADE. It is exactly like a spring of water, which indicates the path of emotion

experience leading up to the top of the body from deep in the heart.

Lastly, the work, "Neuron Case (Fig.10)" was inspired by "remembering". Something comes to my mind from deep inside the heart, protected by many layers. It might be a thought or a memory. I tried to represent such mind's activity of "remembering" of my past experience with a chain reaction of neurons.

E. Discussion

I described the concepts of Portuguese SAUDADE and Japanese MUJO-KAN by looking at the underlying background and their use today. Secondly, I focused on the brain mechanisms related to the whole experience of those two emotions (i.e. visual perception, emotion and memory).

First, both emotional expressions have their own historical backgrounds and related to their attitudes/mentality towards life and living things. SAUDADE is the feeling that entails a pain from the past and hope for the unknown future. In contrast, MUJO-KAN is the feeling of relief that result from recognition and acceptance of instability in life and appreciation of changes in life. SAUDADE is greatly related to parting with loved ones and their loss of national identity throughout the Portuguese history, and MUJO-KAN is recognized as the result of the natural environment in Japan and consequential life perspective.

Referring to the scientific opinion, before starting this research, I considered the working parts of the brain would be same for both SAUDADE and MUJO-KAN, because I assumed that those two emotions were similar. However, over the course of research, I found those two emotions are based on different concepts, and therefore I conclude that the working parts of the brain could be also different.

Moreover, those researches had a significant influence on my idea of making artworks. Above all, before this research, experiences of thoughts and emotions were vague and inexpressible, but neuroscience explained it in the visible form, which made it clearer to me. Making art with scientific understanding of the mind was a continuous journey into the unknown and of new discoveries. Through this study, I realized there was a similarity between art and science in terms of challenge of making invisible visible.

My understanding is that we humans have had different emotional experiences and

expressions due to the differences in history, geography, or even due to race. It might be possible that social memory could be embedded in the Portuguese genes over the course of history, and Japanese genes for the Japanese. However, in order to carry out such a study, it should not be a simple comparison between Japan and Portugal, and I would need to gather several statistics that include other countries with the same systematic trend. Moreover, I would have to examine not only genetic differences, but also examine its relationship with education and other environmental influences.

Everything changes. That was one of the first and most important things I learned in the chemistry class of the Masters. On the atomic level, all things that exist in this world, whether they are solid or liquid, consist of numerous elements, nucleus and electrons that move around freely. And those will die out eventually regardless of their life expectancies. This fact echoes with the uncertainty and emptiness HOJOKI described in the example of a running river. Similarly, even though my memories from the past do not change, cells, neurons and synapses are constantly being reproduced. Even when I recall the same event many times, electric currents that propagate on the neurons and synapses in the brain are never the same ones. Those seemingly contradictory elements represent our world. The concept of instability in scientific research reassured my research interest and art making. The scientific knowledge of glass not only made me see the potential of glass as a material but also changed my perspective about objects and living things.

I considered the objective of this Master course to be the study of how glass art interacts with Science, but for me, it was also the process of exploring and expressing "who I am" through glass art. Just as the disordered movement of glass molecules found its form, I discovered myself and a new world in my artwork. This was achieved by encountering and fighting contradictions within me during

my time in Portugal and through the 28 years of my life in Japan. After that journey of discovering myself and a new perspective on art, I believe what I feel now is SAUDADE.

Conclusion

The emotional feeling, SAUDADE, I experienced in Portugal left me with a strong impression. The sentiment seemed similar to the Japanese MUJO-KAN and I wanted to represent my interpretation of those emotions in my work, with the scientific understanding of mechanisms.

I conclude what made me feel SAUDADE in Portugal was linked to the environment around me such as the colours, sounds, and the smells in Portugal. All these stimulated my sensation and perception and created memory. The sensation that I felt when I came to Portugal for the first time was the emotion of MUJO-KAN embedded in my genetic memories as Japanese, and it reacted to the feeling equivalent to Mujo-kan, which was SAUDADE.

Appendix

Art Making Process

A. Glass Blowing Technique

Most of my works applied glass blowing technique (Fig.7). Soda-lime glass, provided by Atlantis, the Portuguese crystal producer, was melted in our glass furnace at temperatures up to 1150°C. The pipes for glass blowing were made by stainless steel, and tip of the blowpipe was preheated in the pipe warmer before dipping in the molten glass in the furnace. In the making process, we primarily worked on the bench, using various tools, such as a jack, paddles, tweezers, bonsai shears, diamond shears, wet newspaper, and wood blocks (Fig.8). When the glass was cooled and hardened, it was reheated in the other furnace, called glory hole, until re-moldable temperature. The finished work was stored in the annealing kiln set to 515 °C, and cooled down to room temperature overnight for removing any stress.

B. Lampworking Technique

Some of my works applied lampworking technique. We used the borosilicate glass rods and tubes of various diameters from Schott AG in Germany. And our torch burns propane gas for the fuel gas with pure oxygen as the oxidizer. In the making process, we used various tools, such as tweezers, graphite paddles and rods, and tungsten picks. This technique was used to make more delicate or finer parts compared to glass blowing technique. The finished works were placed in the kiln, firing at 560 °C, and cooled down to room temperature for removing any stress.

C. Enamelling

The parts made by lampworking were given colour by enamel paint. I used the low-fire

enamel; firing temperature was 500 to 600 °C. First, mixing the enamel powder with a medium on a sheet of window glass to obtain a paint-like consistency, and adding water drop by drop until the desired consistency was achieved. Any brush may be used for painting. Once application is complete, the enamels should be allowed to dry prior to being kiln-fired. Then put into the kiln, and fires at 550 °C for 15 minutes.

D. Cold Working

Cold Working refers to methods, includes Sandblasting, Engraving, Cutting, Grinding, Polishing, and Bonding.

- Cutting

Glass can be cut with a specialized cutting machine as required (Fig.9). This machine can be cut the glass in a straight line by vertically rotating diamond-impregnated wheel. While glass cutting process, it requires water to cool its wheel to prevent a breaking glass by frictional heat.

- Grinding and Polishing

The cut glass can be grinded to make a flat surface with a specialized lapping machine as required (Fig.10). This machine can grind the glass into a flat surface by horizontally rotating diamond-impregnated metal disc. Then it is followed by a series of gradually thinning finer grits to prepare the glass for a shiny finish. In the final polishing process, I used cerium oxide and water slurry to polish glass to a smooth or clear shine with a felt disc after grinding steps. While glass lapping process, it requires water to cool its disc to prevent a breaking glass by frictional heat.

- Bonding

Parts of polished glass can be glued to each other especially using UV glue, VERIFIX UV Adhesive B682-T, Bohle in Germany as required. This type of adhesive is reacted to cure by irradiating of UV light that I used the UV lump, H135 Labino AB in Sweden, and to enable bonding with very thin adhesive layer, clear, and strong. However, it can be used only to parts of glasses, which fit together exactly.

- Synapse of Memory (Fig.1)

It was shaped with blowing technique. For example, it was used to create the shape of the witch's hat so that one of the brims is concave and the other one is convex. And I cut and polished those tips to be same diameter. For the bottom part of this art piece, first I made a sphere, heated up half of bottom side, then blew to make the bottom, and cut and polished to the tip. Each of the top parts had different shapes. In addition, I made glass balls that contain keys, escudo coins, and parts of a clock. They were bonded to the bottom and to the hat, put in the glass balls and very thin glass flakes made by blown up glass. Then, I bonded the other hat in the opposite way and continued the same process a few times. The clearance greater than 1 mm was filled with silicon. Finally, I made the "Nerve" part by lampworking, painted red colour enamel, fired, and bonding it.

- The Optic Nerve, To the Retina and To the Mind (Fig.2)

I made a glass sphere with blowing technique, and made some small holes on the surface with the graphite rod, partially heated with gas-oxygen torch. After annealing, polished a lip, painted black colour enamel on those holes, and fired it. Then, put in it the small "Nerve" parts that made by lampworking, and enameled black and white colours, and also very thin glass flakes made by blown up the glass.

I made a glass ball by blowing that sprinkled colour powder, Kugler 2095 Opal black, and fired for reduction reaction in the glory hole. After annealing, I polished a lip. I made the "Nerve" part by lampworking, painted red colour enamel, and fired it. Similarly, I painted black enamel on the inside of a half of borosilicate glass tubes, and fired them. After firing, I cut those black and cleared tubes to proper length, glued so that the cross section become a circle, and glued "Nerve" parts to the centre. Finally, I glued those three parts together.

- Communication, Memory and Brain #1 (Fig.3)

I made a big glass sphere by blowing technique. After annealing it, I cut, grinded, and polished the lip and the bottom of it. I cut two sheet glasses that 1cm thickness, to proper shape, hit down on the edge with a hammer to make organic shape, and bonded each other. I blew an egg-shaped ball, in the making process, opened a tip little bit, attached preheated glass canes inside the ball, and closed the tip. Then, an assistant brought me some glass bit coloured with Kugler 2016 Copper ruby light powder, fused on surface, and made it pointed shape with diamond shears. I made a small cup with the same colour powder. Finally, I glued those four parts together. I blew four glass parts like a fig that also coloured the same colour only the tip, and hung from ceiling with nylon string.

- Communication, Memory and Brain #2 (Fig.4)

In the Crisform, Marinha Grande in Portugal, I made big glass sphere using mold-blown technique with their original ruby colour rod. Then, I cut, grinded, and polished the lip and the bottom of it. I cut two sheet glasses that 1cm thickness, to proper shape, hit down on the edge with a hammer to make organic shape, and bonded each other. I blew an egg-shaped ball, in the making process, opened a tip little bit, attached preheated glass canes inside the ball, and closed the tip. Then, an

assistant brought me some glass bit coloured with Kugler 2016 Copper ruby light powder, fused on surface, and made it pointed shape with diamond shears. I blew a foundation part to support the egg-shaped ball that aforementioned, and I fixed a semi-transparent texture on its surface by grinding with the blade of cutting machine. Finally, I glued those four parts together, and put in it the very thin glass flakes made by blown up the glass. Then, I blew parts for lighting, coloured with Kugler 2172 Opal light grey powder and Kugler 2016 Copper ruby light K0 frit, and hung from the ceiling as a lamp.

- Communication, Memory and Brain #3 (Fig.5)

I made a big glass sphere by blowing technique. After annealing, I cut, grinded, and polished its lip and bottom. I cut two sheet glasses that had 1cm thickness, to make it proper shape, hit the edge with a hammer to make organic shape, and bonded each other. I blew an egg-shaped ball, in the making process, an assistant brought me some glass bit coloured with Kugler 2095 Opal black powder, fused on surface, and made it pointed shape with diamond shears. I made the "Nerve" part by lampworking, painted red colour enamel, and fired it. Finally, I glued those parts together. Moreover, I blew nine egg-shaped glass balls. After annealing, I cut them in half lengthwise, and fixed a semi-transparent texture on its surface by grinding with the blade of cutting machine. Then, I glued them each three pieces, and hung from ceiling with nylon string.

- Neuron Case (Fig.6)

I blew three different size spheres of same shape, coloured with Crisform's Olive green rod, Kugler 2021 Lime Yellow powder, and Clear. After annealing, I cut, grinded, and polished the lip and the bottom of them. Each piece is fixed a semi-transparent texture on its surface by grinding with the blade of cutting machine, and painted silicon over heavily. I made a form like an elongated storage

container by blowing. I made two "Nerve" parts by lampworking, painted one of them is red and the other is white colour enamel, and fired. I cut two sheet glasses that 1cm thickness, to proper shape, hit down on the edge with a hammer to make organic shape, and bonded each other. Finally, I glued those parts together. In addition, I blew two different size balls, coloured with Kugler 2141 Cherry red powder and clear. After annealing, I cut, grinded, and polished the lip and the bottom of them. Each piece has semi-transparent texture being grinded with the blade of cutting machine, and was painted silicon over heavily. Each of top parts were glued together with silicon, and hung from the ceiling as a lamp.

Figures and Tables



Figure 1. Artworks, Synapse of Memory #1 - #5



Figure 2. Artworks, The Optic Nerve, To the Retina #1, #2 and To the Mind #1, #2



Figure 3. Artworks, Communication, Memory and Brain #1



Figure 4. Artworks, Communication, Memory and Brain #2



Figure 5. Artworks, Communication, Memory and Brain #3



Figure 6. Artworks, Neuron Case

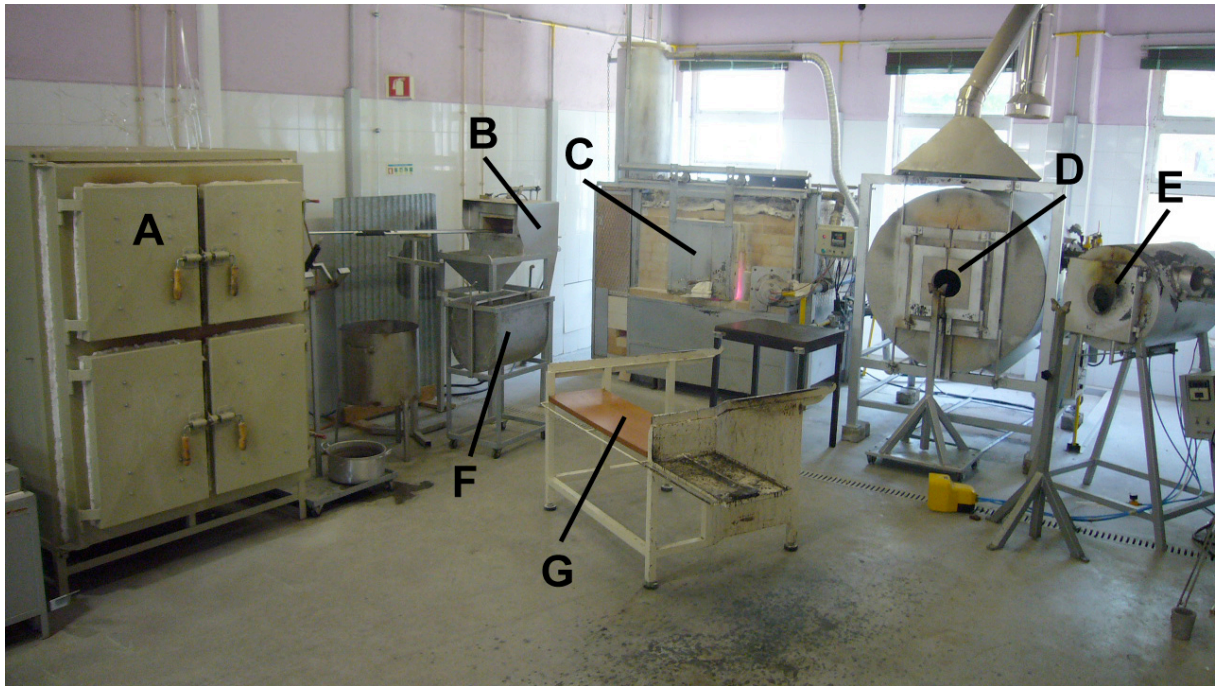


Figure 7. (A) Annealing Kiln, (B) Pipe Warmer, (C) Furnace, (D) Big Glory Hole, (E) Small Glory Hole, (F) Pipe Cooler, (G) Bench.



Figure 8. (A) Jacks, (B) Tweezers, (C) Bonsai Shears, (D) Diamond Shears, (E) Wet Newspaper, (F) Wood Blocks, (G) Water in bucket.



Figure 9. Cutting Machine



Figure 10. Lapping Machine

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