Using spiral waves of the little brain on the heart for designing new neuronal circuits in brain

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Recently, some authors have considered the spiral waves in neuronal systems and proposed a model for it. We generalize their consideration to radiated waves from the little brain on the heart of birds to design new neuranal circuits in brain. First, we put two chick embryos in an inductor and send a current by a generator. Radiated waves of chick embryos change the initial current and produce an oscillating current which can be observed by an scope. Using this system, we consider the exchanged spiral waves between two little brains on the hearts of two chick embryos and show that they have direct effects on the life, death and other activities of each other. We put two chick embryos of two different types in this inductor and control the process of formation of neuronal circuits. Each type has it's own circuits and thus, exchanged spiral waves between two chick embryos may change shape of neuronal circuits in each type. Comparing radiated signals of a chick embryo which was under radiation in this inductor with a normal chick embryo without experiencing external wave, we can consider differences between neuronal circuits.

Keywords: Spiral waves, neuronal circuit, Little brain, Heart, Chick embryo

I. INTRODUCTION

Recently, some authors have simmulated the formation of spiral waves in neuranal systems and confirmed that spiral wave could be induced by the defects even if no specific initial values are used [1]. Also, they have argued about the process of formation of these spiral waves in some neural circuits like Chua circuit [2]. This type of waves could be observed

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in systems of initial DNAs so [3]. Because DNAs have been constructed of hexagonal and pentagonal base-pairs. In these structures, there are some deffects or coilings that lead to the production of spiral waves. Using the concepts of this model, we can explore many facts about radiated waves from little brain of the heart and their role in controlling body.

Several years ago, some investigators have proved the existence a little brain on the heart which acts like a real brain in the head [4]. This little brain on the heart is comprised of spatially distributed sensory (afferent), interconnecting (local circuit) and motor (adrenergic and cholinergic efferent) neurones that communicate with others in intrathoracic extracardiac ganglia, all under the tonic influence of central neuronal command and circulating catecholamines. Neurones residing from the level of the heart to the insular cortex form temporally dependent reflexes that control overlapping, spatially determined cardiac indices [5]. Until now, less discussions have been done on brain-heart connections [6–9]. For example, some researchers have argued that cardiac function is under the control of the autonomic nervous system, composed by the parasympathetic and sympathetic divisions, which are finely tuned at different hierarchical levels. They have shown that while a complex regulation occurs in the central nervous system involving the insular cortex, the amygdala and the hypothalamus, a local cardiac regulation also takes place within the heart, driven by an intracardiac nervous system. This complex system consists of a network of ganglionic plexuses and interconnecting ganglions and axons [10]. Now, the question arises that what happen for this little brain during heart transplantation? Recent investigations show that patients who gave hearts from donors, obtain some characteristics of them. One of them was Sylvia who declared that soon after her operation, she felt like drinking beer, something she hadn't particularly been fond of before. Later, she observed an uncontrollable urge to eat chicken nuggets and found herself drawn to visiting the popular chicken restaurant chain, et al [11]. This means that the little brain could be transformed from one body to another during heart transplantation. To consider the process of formation of the little brain, one can use of spiral waves which are produced by neuronal systems [12]. These waves are emerged because of the existence of some deffects in neural systems [13, 14] and also their special structures [15, 16]. Various types and evolutions of spiral waves have been considered in many papers. For example, in one paper, instability and death of spiral wave in a two-dimensional array of HindmarshRose neurons have been considered [17]. Or in another research, transition from spiral wave to target wave and other coherent structures in the networks of HodgkinHuxley neurons has been investigated [18]. Also, in another work, the effect of small-world connection and noise on the formation and transition of spiral wave in the networks of HodgkinHuxley neurons have been investigated in detail [19].

In this paper, using radiated spiral waves of the little brain on the heart, we control the process of formation of neuronal circuits in chick embryos. To this aim, we produce two chick embryos in shell less cuture vessels. We put these vessels interior of an inductor and send an initial wave to it. Two chick embryos interact with each other and this wave. If two chick embryos be of two different types, their exchanged waves have direct effects on the formation of neuronal system. In these conditions, radiated waves of each of these chick embryos are different respect to radiated wavesofnormal chick embryo.

The outline of the paper is as follows. In section II, we propose a mathod for providing chick embryo out of shell and designing a circuit of inductor, a generator and an scope for considering exchanged wavesbetween little brains. In section III, we showresults. In section IV, we discuss about results and new circuits which may be produced due to external spiral waves. In section V, we propose some conclusions.

II. THE METHOD

We do our experiments in three stages:

1. In this research, using non-linear electromagnetics, we investigate the origin and process of formation of the neuronal circuits and little brain on the heart. To this aim, we will consider the process of formation of a chick embryo out of shell and egg in a container (See figure 1). This helps us to observe all stages and details without needing to imagine or using MRI. To obtain this shell-less culture system, we will use of the method which has been proposed in [20, 21]. Similar to [20, 21], a 450 ml polystylene plastic cup was applied as the pod for the culture vessel. A 1-1.5 cm diameter hole was made in the side of the cup approximately 2 cm from the bottom, and the hole was plugged with a cotton pledget as a filter. A 2mm diameter plastic tube was inserted through the space between the pledget and the hole to provide an oxygen supply. An aqueous solution (40ml) of benzalkonium chloride was then added to the cup. A polymethylpentene film was formed into a concave shape, carefully avoiding wrinkles and installed as an artificial culture vessel in the pod. A polystylene plastic cover was placed on top of the culture vessel. For ex-ovo mechanism

FIG. 1: Emergence of a heart in early stages of formation of a chick embryo.

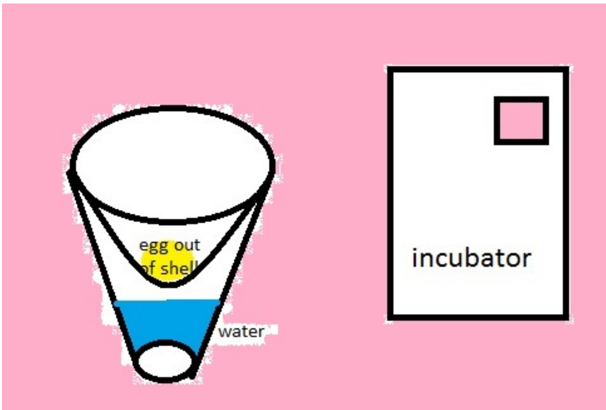

FIG. 2: The method for producing shell-less culture system (chick embryo out of shell).

(Shell-less culture method), fertilized chicken eggs were not incubated before transferring to the culture vessels. Their eggshell was wiped and cracked and the whole egg contents were transferred to the culture vessel without pre-incubating period. The culture vessels were maintained at 38^0C and rotated with 120 clockwise twice a day. After 54 h, in most of vessels, chick embryo is emerged (See figure 2).

In figure 1, we show that the heart of a chick embryo is one of first organs that form. This is because that heart send blood molecules to other cells and contributes in transmission of food and oxygen. However, heart could have another main role in trasmission of information to other cells. Before formation of brain, the little brain on the hear controlls evolutions of body and send some signals to other cells. These signals could be carried by blood molecules.

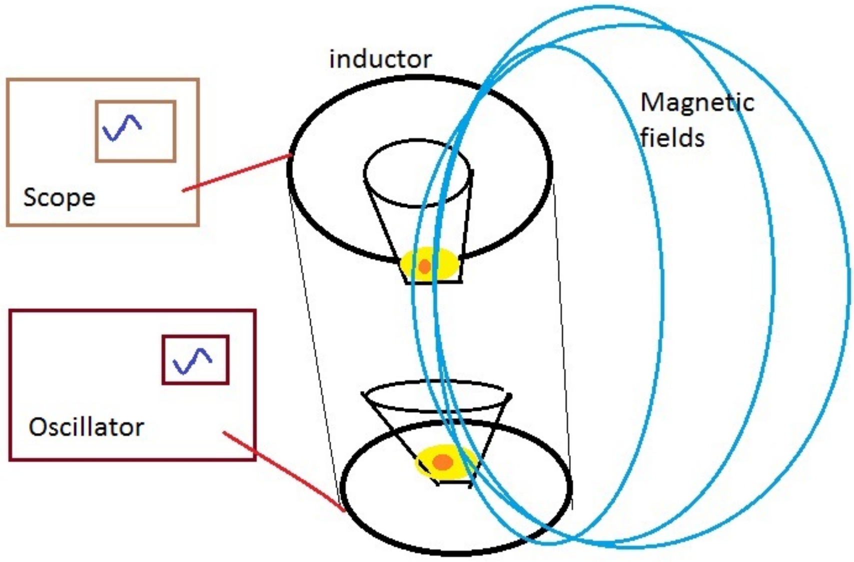

FIG. 3: A circuit of two chick embryos, inductor, oscillator and scope

2. Then, we show that two little brains can exchange information with each other and external magnetic fields. To this aim, we connect one end of an inductor to an oscillator and another end to an scope. We put two shell-less cultures of two different types of embryos interior of inductor and send an input current (See figure 3). This current produces a magnetic field interior of inductor. We take output current and compare with initial current. We observe that little brains interact with external magnetic field and produce some changes in it. These changes lead to the difference between input and output currents.

3. We connect a chick embryo which was under radiation of external wave of inductor and another embryo to an scope and take it's signals. Then, we connect a chick embryo which wasn't under any radiation to another scope and compare with first one (See figure 4). We observe that their radiated signals are different.

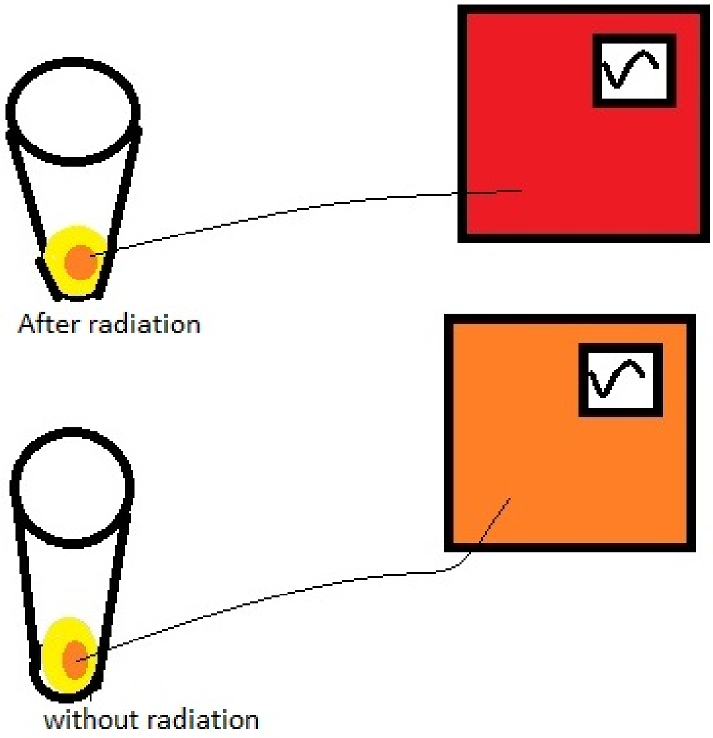

FIG. 4: Connecting two chick embryos to scopes, one after interaction with another embryo and magnetic field and one without experiencing any radiation

III. RESULTS

In this section, we will show that radiated waves of a chick embryo after interaction with other embryo is different from radiations of a normal chick embryo. This is because that some neuronal circuits are changed as due to exchanged waves with other embryos. In figure 5, we show radiated signals of a chick embryo after exchanging wave with other embryo in an inductor. These waves are more intense and stronger than radiated signals of a normal chick embryo in figure 6. This means that neuronal circuits of first embryo change and able to receive or send more signals. Figures 7 and 8 confirm this result again. In figure 7, we present the probability for producing currents for a chick embryo after interaction with other embryo in an inductor. It is clear that this probability is more for higher currents and less for smaller currents. However, figure 8 shows that the probability for producing current by a normal chick embryo is more for lower currents and less for higher currents. This means that neuronal circuits of a chick embryo change under external fields and interaction of two embryos in an inductor.

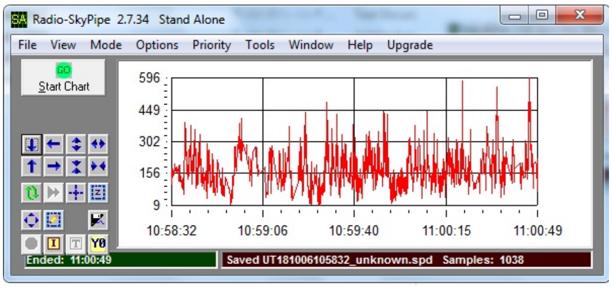

FIG. 5: Radiated signals of a chick embryo after exchanging wave with other embryo in an inductor.

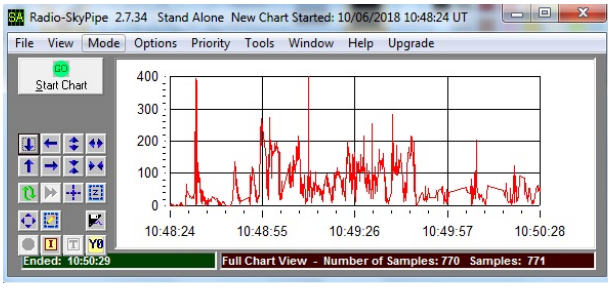

FIG. 6: Radiated signals of a normal chick embryo.

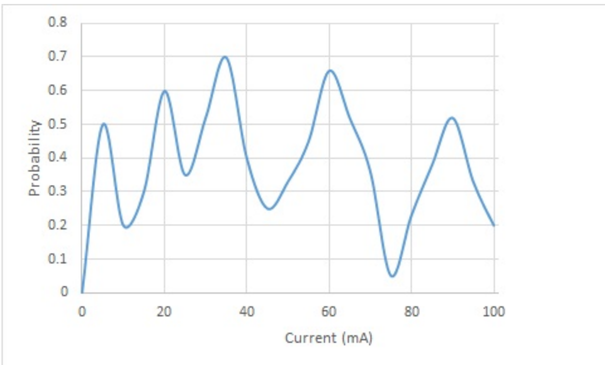

FIG. 7: The probability for producing currents for a chick embryo after interaction with other embryo in an inductor.

IV. DISCUSSION

Our results show that radiated waves of a chick embryo after exchanging wave with other embryo in an inductor is different respect to a normal chick embryo which has no

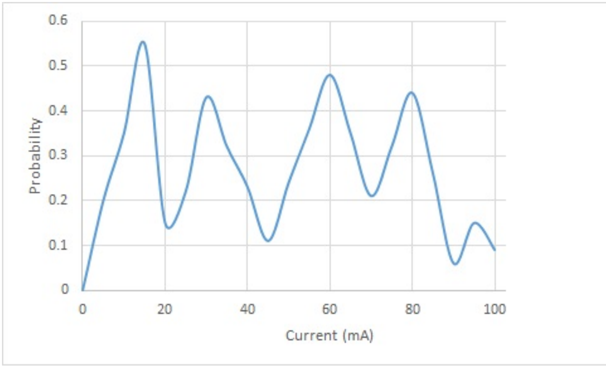

FIG. 8: The probability for producing current for a normal chick embryo.

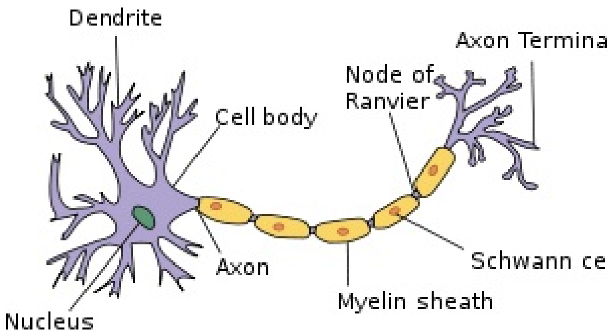

FIG. 9: The structure of a neuron.

any experience of external field. This means that neuronal system of first chick embryo is changed during it's interaction with waves of other embryo. In figure 9, we show the structure of a neuron. It is clear that there are several receiver for each neuron in it's dendrite and several sender in it's axon terminal. When, neurons join to each other form some neuronal circuits. Also, a collection of circuits form the little brain on the hear. After a period time, another collections of neuronal circuits are emerged interior of brain. These two types of circuits could interact with each other and control behaviour of a body. Each embryo has an special neuronal system which may be different of neuronal system of other embryo. If we put a chick embryo in an inductor near another embryo of different type and send an external field, neuronal systems change to be able exchange spiral and other types of waves (See figure 10). For example, in figure 10, neuronal circuits change to receive external fields. This gives us this opportunity to change neuronal circuits of embryos and design new ones which be more suitable for receiving or sending signals.

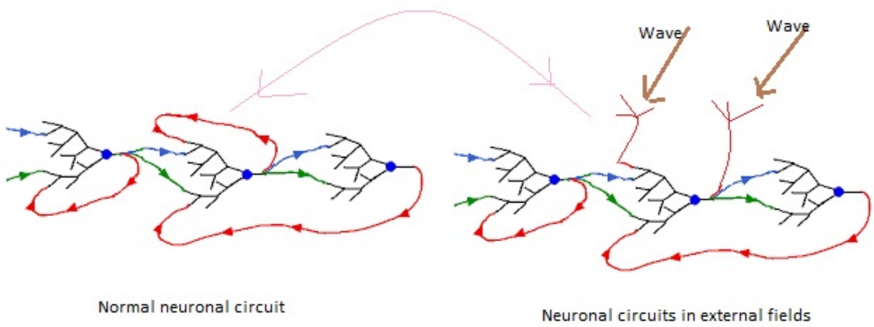

FIG. 10: Comparing a neuronal circuits with and without existence of an external wave of another embryo.

V. SUMMARY AND DISCUSSION

Newly, the process of the emergence and evolutions of spiral waves in some neuronal systems have been considered in [1, 2]. We have shown that little brains on the heart of chick embryos produce these type of waves to communicate with cells and design neuronal circuits. We have argued that by radiating some extra spiral waves from a chick embryo of different type , the shape of neuronal circuits could be changed. To this aim, we put two chick embryos in an inductor, connect one ends of it to a generator and another end to an scope. We sent a current by this generator to the inductor and produce a magnetic field. This field interacts with little brains of two chick embryos and help them to communicate with each other. Interaction between little brains change the magnetic field and different current was observed on the scope. We have put two chick embryos of different type in the inductore and under magnetic field during formation of neuronal circuits. Then, we took signals of each embryo and compare with a normal chick embryo of that type. We have observed that their radiated signals are different. This means that exchanged waves between two chick embryos of two different types change their neuronal circuits and radiated waves.

VI. COMPETING INTERESTS

The authors declare that they have no competing interests.

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