Epistemology of Imagination: knowledge through imagination and its epistemic uses in physics

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Abstract

Rodríguez-Salazar cognitive triad of his epistemology of imagination: sensory motor actions, symbolic-imaginative representations, and formal reasoning, in this article are compared and enriched with the Embodied Cognition proposal "think with the body" and co-evolution of brain and language proposal which highlight visceral motor system. Both, as dyad are reaching to electromagnetism case as new scientific knowledge. My approach is that current of electricity and electromagnetism was not a discovery, but subject structuration of reality, structuring his cognitive structures by means of cognitive triad of epistemology of imagination working together. Rodríguez-Salazar proposal is compared too, and strengthened whit the Amy Kind "Knowledge through imagination", proposal coordinated with Peter Kung, and other with Christopher Bandura entitled: "Epistemic uses of imagination" as second dyad. Results and conclusions of these two dyads proposed as tetrad working together are applied to Hans Christian Ørsted experiments in the search of the relationship between electricity and magnetism, resulting in electromagnetic and field theory in physics.

Keywords: Epistemology, imagination, embodied knowledge.

Resumen

La tríada cognitiva de Rodríguez-Salazar de su epistemología de la imaginación: acciones sensomotoras, representaciones simbólico-imaginativas y razonamiento formal, en este artículo se comparan y enriquecen con la propuesta de Cognición Embodied "pensar con el cuerpo" y la coevolución del cerebro y el lenguaje. Propuesta donde se destaca el sistema motor visceral. Ambos, como pareja, están llegando al caso del electromagnetismo como nuevo conocimiento científico. Mi enfoque es que la corriente de electricidad y electromagnetismo no fue un descubrimiento, sino una estructuración subjetiva de la realidad, estructurando sus estructuras cognitivas mediante la tríada cognitiva de la epistemología de la imaginación trabajando en conjunto. También se compara la propuesta de Rodríguez-Salazar, fortalecida con la propuesta de Amy Kind "Conocimiento a través de la imaginación", coordinada con Peter Kung, y otra con Christopher Bandura titulada: "Usos epistémicos de la imaginación" como segunda díada. Resultados y conclusiones de estas dos díadas propuestas como tétrada trabajando en conjunto se aplican a los experimentos de Hans Christian Ørsted en la búsqueda de la relación entre electricidad y magnetismo, dando como resultado el electromagnetismo y la teoría de campos en física.

Palabras clave: Epistemología, imaginación, conocimiento encarnado.

I. INTRODUCTION

The epistemology of the imagination was proposed more than a decade ago by Rodríguez-Salazar [1, 2, 3], based on Piaget's approach without exhausting itself in it, but rather, Rodríguez-Salazar goes beyond Piaget's proposal. From this point, epistemology is understood as scientist's reflection of his own work, not in its traditional conceptualization as philosophical speculation. This indicates its autonomy as science field with own identity, different from philosophy of science epistemology based in reason and mathematics.

In the scientist's reflection framework, mathematical reasoning ability both appears today as a prior capacity to strengthen mathematical creativity in children [4, 5, 6]. Stolte, Kroesbergen & Van Luit [5], argue that mathematical creativity "is commonly operationalized as divergent thinking" composed by fluency, flexibility and originality. While mathematical ability is an essential prerequisite for mathematical creativity. Therefore, new strategies are needed to link both.

This mathematical reasoning approach is conceptualized in this paper as neo monism, but at contrariwise of traditional monism, that is, a reason without matter. Monism is centered in matter without soul or spirit, as well as mind or reason. Cartesian dualism proposal is not the separation of mind to body, or mind to brain, but, as I assert here, add brain and mind to matter. In this framework, embodied cognition is an option, mind embodied in brain and body, at the contrariwise to my proposal: mind emerges from brain and body, as we will see under.

Neo-Piagetian theory could help to understand cognitive processes in mathematical creativity and giftedness [7, 8], but is necessary to propose other actor added to mind and body or cognition and body: imagination.

Some authors of cognitive embodied [9, 10, 11], propose reach cognition to sense and motor action, inversely to Piaget´s proposal from sensory-motor action to concrete and formal operations. Nevertheless, there are some proposals that reach the relation conversely to which to proposing the role of sensory-motor information to semantics [12], or, more radical, fundamental for epistemology of imagination: thinking with the body, towards cognition [13].

Between cognition and body, Piaget proposes a bridge, the symbolic actions named for him pre-operatory stage, which is subsumed in the stage of concrete operations [14, 15]. For it, I need to illustrate relations and differences between the proposals of Cognitive Triad with Cognitive Embodied.

Contrary to commonly thought, for Piaget, there are only two, not four, developmental stages of cognitive process: sensory-motor and a very long stage which divided in three sub stages: pre-operatory, concrete and formal operations.

Epistemology of imagination proposal is to create a *Tertium Quid* between them (a middle course or an intermediate component), transforming the bridge of pre-operatory stage into an intermediate component between sensory motor and concrete and formal operations: symbolic imaginative stage which is not subsumed. It is proposed as Cognitive Triad [16].

Therefore, I want to enrich epistemology of imagination with current epistemological approach to imagination [17, 18], to put in actual context the proposed of epistemology of imagination a decade ago. Thus, as is proposed in the title of this paper, epistemology of imagination is linked to the knowledge through imagination and its epistemic use [17, 18], which proposed a transcendent uses of imagination, opposed to instructive uses of it, linking both by puzzle imagination use and with its epistemic uses transforming beliefs in knowledge [17, 18].

Based on the aforementioned, the paper starts with a brief description of epistemology of imagination proposal, an author's own proposal of this paper. Later, I present mathematical reasoning as neo monism that is, as reason separated to the body in a conversely of the original monism of matter without conscious.

Subsequently, I present the cognitive embodied proposal that study the role of sensory motor actions, compared and enriched with epistemology of imagination cognitive triad. This is followed by comparative analysis of epistemology of imagination with knowledge through imagination proposal and too the epistemic uses of imagination. My objective is the strengthening of epistemology of imagination with tis two proposals, analyzing the origin of electromagnetism.

The most important results of two dyads enrichment (embodied cognition and brain-language co-evolution (first dyad) and Knowledge through imagination and its epistemic uses (second dyad) proposed as tetrad, working together with epistemology of imagination, are applied, in four acts, to Ørsted experiments.

Finally present my conclusions in the roll of imagination in Ørsted search of the relationship between electricity and magnetism, as origin of electromagnetic and field theory in physics.

II. EPISTEMOLOGY OF THE IMAGINATION

The innovative epistemological Piaget´s proposal is to shift the traditional subject-object relationship in which the origin of the knowledge starts in object, like in the *empirism*, or in subject like *innatism* or *apriorism*. In Piaget´s proposal the origin of knowledge is not in experience or in reason, but in action into an expanded notion of experience as we will see.

Then, its proposal is an non aprioristic alternative to *empirism* throughout three sets of actions: 1) materials actions, referring to the acts of the subject onto the objects of reality; 2) evoked actions: mental prolongations of the material actions like symbolic reality representations; and, 3) operative actions, by means of which the subject organize external reality through formal representations.

This proposal assumes an extended notion of experience to integrate the symbolic sphere in this relation, therefore it sustains "that the three sets of actions coexist in every subject and continue to function coordinated throughout life, forming a general structure of cognitive behavior, that is, a cognitive-behavioral structure" [1: 164].

This new form of relationship can be expressed in the following equation:

$$\frac{MOA}{MMA} MEA \leftrightarrow \frac{A}{R} \leftrightarrow ICPR \frac{ICFE}{IPR} \quad (1)$$

Subject-Object relationship. Expanded notion of experience. The abbreviations are: MOA = Mechanism of Operative Actions; MMA = Mechanisms of Material Actions; MEA = Mechanisms of Evoked Action; A = Actions; R = Reality; ICPR = Imaginary Configurations of Possible Realities; ICFE = Image Configurations of Formal Structures; IPR = Intrinsic Properties of Reality. Source: Adaptation of the figure presented in Rodríguez-Salazar [1: 165].

Therefore, the Equation 1 represents an extended subject-object relationship model, where the actions mechanisms of the subject, impact on reality producing a set of cognitive configurations of this structured reality. Thus, when subject deal with some problem, he produce some cognitive configurations as some possible realities to solve it. Hence, those imaginary scenarios address the actions mechanisms of subject to test them on reality to restructure reality. This produces a new set of cognitive configurations and this process goes on.

That is the core of epistemology of imagination proposal centered in symbolic-imaginative representations joined both sensory motor actions and formal representations.

In short, the evoked actions have special epistemological value that consists in "creating the imaginary configurations of materially possible realities" [1: 167]. Therefore, it is interpreted in this work that imagination is the connection between sensory motor actions and formal representations, extending this mental subject processes to social spheres when individual subject arrives at the social world.

Through these mental collective configurations, the social subject organizes socially reality, which implies that subjectivity is objectified through this organization. In this sense, epistemology of the imagination offers a model to understand social reality through the actions with which the subject structures its reality.

I argue [2] that this structuring of the subject "Taken to the social field and within the framework of genetic epistemology, Piaget establishes a parallelism between the structures of practical intelligence and formal operations, with the structures of social groups." [2: 89].

In this way, a neo-Piagetian position is that the nature form and function of thought are social while the content of thought is individual [19]. Therefore, according to Piaget, the psychogenic explanation oscillates between individual and social subject: physiological and logical given rice to epistemic subject. The challenge consisting in explaining how it is possible and in what way the construction social operational stages are carried out by the epistemic subject through imagination.

Subject Cognitive Triad is grounded in Piaget proposal [20] of two general stages of cognitive development. The first is the sensory-motor, based on the satisfaction of needs. The second, operative, is composed of three moments:

1) Pre-operative, considered as a link between first and second stages, consisting of the acquisition of language and in the first configurations of intentional actions without being fully structured;
2) Concrete operations, where the subject establishes the direct relationship with the environment and regulates this relationship based on mental schemes of action; and
3) Formal operations, where the subject can achieve the abstraction of reality by developing a hypothetical-deductive thought.

These two general cognitive stages, generally knotweed as four by the decomposition of the three moments in which is composed operative stage, are linked to psychological fact consisting of three inseparable aspects: 1) Structure of behavior (normative-cognitive aspect); 2) Economy or energy (affective aspect [values]); and, 3) Symbol systems (signifiers of the operative structures).

Therefore, it is observed that the psychological facts can be studied from the structuring aspects of reality, structured by and throughout the cognitive stages, leading to determine what the values of the subject are. In this framework, those things that cause pleasure or displeasure, the meanings that subject assigns to objects structured by him, are embedded for these psychological facts.

On Piaget's lessons of the psychology of intelligence, argues that there is much work to be done "between preverbal intelligence and operative thinking so that reflexive groupings are constituted, and if there is functional continuity between the extremes, it is indispensable to construct a series of intermediate structures in multiple and heterogeneous levels" [21: 156]. Derived from the semiotic function [22: 64] that appears at the end of the sensory-motor stage, the subject configures a set of operations that are divided into two kinds of instruments: the symbol and the sign.

Piaget [21: 160-161] establishes that all kinds of motor or cognitive activity is symbolic insofar as it consists of relating a signifier to a signified reality, whereas the sign consists of arbitrary conventions about reality; that is, the signs, as their conceptual unity, are social while the symbol is individual. However, any symbol can be collective as it is socialized with a group, so it is configured as half symbol and half sign. In this way, the mathematical language corresponds to the signs while mathematical reasoning constitutes a kind of collective symbolic configurations.

When subject acquires language the symbolic schemes or actions schemes that evoke absent situations begin; these schemes appear in the child's game, and they contribute to the understanding of signs through language, which can be defined as a general symbolic function.

The child in his early years and during the development of language can strengthen what Piaget calls as egocentric assimilation of reality to structure reality to his own interests. In other words, as long as the child strengthens the symbolic game at this stage to model the images of reality by the self, his structures will have greater capacity to decentralize and, therefore, to formalize those images.

Nevertheless, in its Genetic Epistemology [20], Piaget not include the epistemic roll of psychogenetic child's game, and its contribution to understand signs through scientific language applied to epistemic subject, that I want to enrich with actual use of imagination [17, 18] applying it to my proposal of epistemology of imagination [19].

According to the epistemology of the imagination [19], there is a Social Cognitive Triad in which Sensory Motor Actions became in Practical Reasoning (PR), not sensory, but now intellectual, conforming intellectual motor actions giving the status of practical, not only formal reasoning. Symbolic-imaginative Representations became in Symbolic-imaginative Reasoning (SIR), giving an epistemic use to imagination. Finally Formal Representations became in traditional Formal Reasoning (FR).

In this way, both the PR and the FR converge and communicate through the SIR, applied to electromagnetism phenomenon in which, as we will see, scientific cognitive

mental game expressed in experimental design, contribute to understand signs and symbols to new scientific language.

III. MATH REASONING AS NEO MONISM

The American philosopher specializing in metaphysics, epistemology, mind, and language Jonathan Schaffer, in the beginning of his article "Monism", published in The Stanford Encyclopedia of Philosophy, suggests that "There are many monisms. What they share is that they attribute oneness. Where they differ is in what they target and how they count", giving entry to his article and immediately add:

> This entry focuses on two of the more historically important monisms: existence monism and priority monism. Existence monism targets concrete objects and counts by tokens. This is the doctrine that exactly one concrete object token exists. Priority monism also targets concrete objects but counts by basic tokens. This is the doctrine that exactly one concrete object token is basic, and is equivalent to the classical doctrine that the whole is prior to its (proper) parts [23: 1].

About mathematical reasoning [24], the argument is that mathematical creativity "is commonly operationalized as divergent thinking" composed by fluency, flexibility and originality. While mathematical ability is an essential prerequisite for mathematical creativity. In their paper they argue that one factor of mathematical creativity base could be inhibition. If inhibition is reducing, the relation between mathematical ability and originality could be strengthened. However, the paper approach is based on cognitive sphere, as monism, not embodied cognition as dualism.

To broke this monism, is necessary to go deeper and include the symbolic and social sphere in order to elaborate new strategies that link mathematical creativity and ability. In dualism, Howard Robinson, in his article for *The Stanford Encyclopedia of Philosophy* pointed:

> In dualism, 'mind' is contrasted with 'body', but at different times, different aspects of the mind have been the center of attention. In the classical and mediaeval periods, it was the intellect that was thought to be most obviously resistant to a materialistic account: from Descartes on, the main stumbling block to materialist monism was supposed to be 'consciousness', of which phenomenal consciousness or sensation came to be considered as the paradigm instance [25: 3].

Without being dualism as cognitive embodied, today's strategies to develop the mathematical reasoning have been addressed to involve all the children social spheres (family, friends, educators, etc.) [26-27]. Also, it is known that "children do not possess a true concept of number until they are able to reason on numerical quantity" [28]. Therefore, it is considered in this work the construction games are vital for the reasoning development in general and mathematical reasoning in particular.

Thus, through activities at classroom and home dedicated to strength the reality images configuration in response to the emotional and intellectual needs of the child, it can contribute to constitute a solid base that will later be developed by the socialization in the rules games.

Cognitive or motor action involves a symbolic component, so the child needs to adapt to in the world of adults to find an emotional balance. As Piaget says:

> Obliged to adapt incessantly to a social world of elders [...] It is, therefore, indispensable to its affective and intellectual equilibrium that may have a sector of activity whose motivation is not adaptation to the real, but, on the contrary, the assimilation of the real to the self, without coercion or sanctions [22: 65].

In this way, the symbolic game appears as a way to transform the real in terms of the needs of the self. In other words, through this kind of play, the child, in his egocentric sphere, assimilates his environment to his own interests. Then, to accommodate these assimilations according to what is presented as external. Finally, in its decentralization process, the child achieves a balance between both processes.

Language has an important role in achieving such a process. Therefore, it is essential that the children have their own means of expression that allows them to build a system of signifiers according to their interests. This is how a symbolic language forms and can be modified according to their needs.

Mathematical reasoning can be addressed in this sense. As long as math is symbolic conceived its teaching strategies must involve the children symbolic sphere. According to Piaget & Inhelder [22: 66] there are four types of games that are involved in the development of the subject: 1) Exercise game, which consists in repeating an activity for pleasure; 2) The symbolic game, which is based on evoked actions; 3) Games of rules, which is the social expression of the child; and, 4) construction games, which is a link between the second and the third, whose main function is to offer a base for adaptation or problem solutions.

For this paper nature, there is not space to get deeper in the explanation of those statements. However, the thesis of construction games as strategy to link the social and symbolic components to strengthen the mathematical reasoning and creativity is presented.

IV. NEO DUALISM: EMBODIED COGNITION

My approach to this issue is the same approach to monism and dualism debate, in which like I proposed above, math reasoning is a monism centered in reason, in a inversely to the original monism centered in matter. Now, I propose that philosophy of mind and philosophy of cognition are a neo monism in this same sense. In this framework, like the Cartesians proposal is not a division of mind and body, but the addition of mind to body as matter, embodied cognition is the addition of body to mind and cognition proposed by both philosophies.

Therefore, I propose in this paper that embodied cognition is a neo dualism, but beyond the addition of mind to body as different entities linked each other, but the incorporation of mind to sensory motor actions of body, behavior or motor behavior.

Other monism can be memory, language or perception in cognitive psychology, by which "Movement is often quite secondary in such accounts, and is considered to be a somewhat "low-level" activation of organisms" [29]. This psychological monism is added with active organism, which, by the researcher of the *Institut für Neuroinformatik, Ruhr-Universität*, Bochum, Germany, Sebastian Schneegans and Gregor Schöner, all behavior of an organism is ultimately motor behavior.

> Embodied cognition is an approach to cognition that has roots in motor behavior. This approach emphasizes that cognition typically involves acting with a physical body on an environment in which that body is immersed. […].The roots in motor behavior of the embodiment stance manifest themselves also in the emphasis on the real-time autonomy of cognitive processes […].
>
> In relation to the environment, this context sensitivity of cognition is sometimes referred to as "situatedness" a concept we subsume here under embodiment. Finally, for some (and for us), the embodiment stance also postulates that an understanding of cognition must be based on concepts that are consistent with the fundamental principles of neuronal organization that govern our nervous systems [29: 241-242].

For Schneegans and Schöner, the radical stance within the approach of embodied cognition are the constraints imposed to the neuronal substrate of sensory and motor surfaces in which neural control systems is grounded in biomechanics and physiology of the physical body and the structured environment in which is immersed. For them, in this radical view, all cognition is hypothesized to be of this kind.

In a similar sense but since a more radical stance, Ricardo Sanz, Jaime Gómez, Carlos Hernández and Idoia Alarcón, researchers of Autonomous Systems Laboratory, at the Technical University of Madrid, propose thinking with the body, scaling to cognition. They assert is that "The reflection on the nature of mind has a long history. "In our western tradition, this reflection has mostly taken place along the so-called dualist approach, where mind and body completely have different characteristics and even natures" [13: 395].

Like I pointed above, Cartesians dualist, of course, propose that mind and body have completely different characteristics and even natures, but in response to matter monism adding mind or consciousness to this matter. My propose in this article is that embodied cognition is a neo dualism opposed to cognitive philosophy and psychology or philosophy of mind as neo monism.

To for coming Symposium Enseñanza, epistemología, cognición y representaciones encarnadas, which to be held January 23-25, 2024 in México City, I made a radical stance: brain is an appendage of the spinal cord [30]. Clarifying, according to Webster Dictionary, appendage is usually defined as projected part of body, "typically smaller and of less functional importance than the main part to which it is attached" [31].

Continuing with this clarification, I want to emphasize that the brain (parietal lobe, temporal lobe and occipital lobe) is only a small part of the whole encephalic mass (forebrain, midbrain, brain stem, etc.). Sanz, Gómez, Hernández and Alarcón proposal is the reconciliation of the duality by means of unity "There are no minds without bodies and there are no bodies without minds" [13: 396]. Terrence Deacon proposal [32] is: The midbrain is the transition zone between the brain stem and the forebrain. It is the first point, ascending form the spinal cord [32: 230].

My proposal is that is not necessary the unity of duality or dualism, By virtue of the fact that it is a continuity of the same structure, in which mind and consciousness are the product of the physiological process of this anatomical structure. As emergence, in further work, Deacon [33] proposed: "Consciousness is an emergent property of the cellular and molecular processes within a brain in the same sense as surface tension is an emergent property of the interactions of water molecules" [33: 278-279].

Before he was reference [32] to the origin of brain and language as co-evolution process grounded in that he call visceral motor system transformed animal call in human speak [32] In further work [34], about the visceral motor system and eat and breath behavior give origin to anatomical changes, "included the descent of the larynx, the addition of Broca's language area to the brain, symmetry of the planum temporale, enlargement of the hypoglossal nerve" [34: 84].

The comparison and enrichment of first element of the cognitive triad of the epistemology of imagination (sensory motor actions) with both "think with the body" proposal of the embodied cognition, and the proposal of co-evolution of

mind and language highlighting visceral motor system can give complementary issues.

> Obviously the autonomy of heart pacing is limited because the heart must also respond to the needs of other parts of the body (muscles, viscera, etc.) that are transmitted by different kinds of signals coming from different control levels— including the cortex-level mind. Indeed, the core system-integrated control of heart rate originates in the circulatory centers of the medulla oblongata and pons, in the brainstem [13. 396.
>
> At one end is the skeletal motor column (controlling voluntary muscles of the mouth and face), at the other end the visceral motor column (controlling automatic muscle system for swallowing, breathing, and heart rate) [32: 234].

About the second element of cognitive triad, that is the symbolic-imaginative representations, is related with the proposal of Deacon *Homo Symbolicus*, who points out that with heuristic prose, is applied to all hominid symbols users [32]. After, with other editors coordinate the book The Symbolic Species Evolved, adopting so-called Baldwinian evolution [35]. Another book by other authors and editors, but adopting Darwinian proposal: *Homo Symbolicus*: The dawn of language, imagination and spirituality [36]. This proposal is not embodied cognition but representations embedded in the bodies.

> We recycle symbolic used by others and give them different, possibly opposite meaning. Swastikas were important symbols in various ancient civilizations and remind widely in use in Indian regions. The adoption of the swastika by the Nazi party in Germany after 1920 led to an association of this symbol by some with fascism and white supremacist. The antithesis of its early meaning […] but our knowledge of how and when those aptitudes first emerged within our linage is imprecise speculative [36].
>
> Deacon´s proposal was fourfold –based upon the combination of an evolutionary, a semiotics, a neurological and anthropological hypothesis. The evolutionary hypothesis was based upon so-called "Baldwinian" evolution– after the American psychologist James Mark Baldwin [35].

As a heuristic proposal, Terrence Deacon invents new specie designed *Homo Symbolicus*, specie between *Homo Habilis* and *Homo Sapiens*. This phylogenetic evolutionary triad is related with the epistemology of imagination cognitive triad as ontogenetically psycho developmental cognitive process. In short, *Homo Habilis* will be related with sensory motor actions and *Homo Sapiens* with formal reasoning, linked, both, by *Homo Symbolicus* and second element of cognitive triad, that is, the symbolic-imaginative representations: phylogenetically and ontogenetic one.

This is my approach to the compaction and enrichment of epistemology of imagination with Embodied Cognition proposal, both think with the body and co-evolution of brain and language proposal as first dyad. At the same time, is the linking point with de second dyad: Amy Kind and Peter Kung proposal Knowledge through imagination and too Amy Kind and Christopher Bandura Epistemic uses of imagination as second dyad, conforming a tetrad.

V. KNOWLEDGE THROUGH IMAGINATION

In the introduction to the volume edited by them, Amy Kind and Peter Kung propose that I call the Triad of uses of Imagination. At one end is the transcendental use of the imagination, represented by daydreams, pretending, fancy and fantasy. In the other end is the instructive use of, in this case represented by decision making and to planning by meant of we can learn something about the world. At center is the mental challenge to unit both ends called by them the puzzle use of imagination, like the puzzle to solve a puzzle.

These issues were shaped al the conference Knowledge Through Imagination in the spring of 2012 at Claremont McKenna College, focused on the way imagination provide knowledge about the world.

> More commonly, the philosophical treatment of each uses of imagination has simply occurred in isolation from the other, with some discussion focused on imagination´s transcendent use and other discussion focused on its instructive use. The bifurcated nature of such discussion has undoubtedly been a key factor in masking the puzzle that interests us […].
>
> Such a question is inextricably tied puzzle of imagination use. Because there seems to be a little doubt that imagination can be put to transcendent use, imagination will only be able to provide us with knowledge about the world in which we live if the transcendent use of imagination is compatible with the instructive use […]
>
> Though we do not think this solution is a new one –indeed, as we will see, there are hints of it throughout both the historical and the contemporary literature– we do not think it has yet been clearly articulated and developed [17: 2]

> Such is the primary goal of this volume. In the ten chapters that follow, our contributors all explore various way in which imagination might enable us to learn about the world. Though not all of them are sanguine about what imagination can teach us, all of them address the question of whether and how we can gain knowledge of this world via imagination. [17: 3].

In their introduction, after an historic-philosophical treatment of imagination, editors give a contemporary treatment of imagination in three categories: engagement with fiction; modal epistemology (thought experiment), and that they call mindreading. For the enrichment of the my proposal of epistemology of imagination, I will present the first one about the Kendall Walton Mimesis as Make-Believe [36] and the book of Gregory Currie The Nature of Fiction [37].

The main interest refers to the analogy of both with the children game make-believe, wide discuses by Piaget in his book Play dream and imitation in childhood [38], about the play roll of children game and that Piaget´s call collective monologues in conscious symbolism, configurations and cognitive representations. Nevertheless, in Piaget´s proposal this state is only a bridge between sensory motor actions and formal reasoning, which is subsumed in it.

Therefore, the enrichment of cognitive triad second element of the epistemology of imagination proposal, about symbolic-imaginative representations as state present in all subject life, is anchored in Walton´s and Curie proposals fictional truth.

> According to Walton, "a fictional truth consists in there being a prescription or mandate in some context to imagine something" […] For Walton, then, the relationship between imagining and fictionality turns out to be analogous to the relationship between belief and truth: "imagining aims at the fictional as belief aims at the true. What is true is to be believed: what is fictional is to be imagined" [36: 39, 41. 17: 15]. Currie, for example, notes explicitly that "make-believe allows us to achieve in imagination what we are denied in reality" [37: 19. 17: 15].

As we will see Ørsted experimental work, his believes in the Electric Conflict [39] published as Latin facsimile [Appendix 1], translated to English by the editors of his scientific works [40] soon will become in Current of Electricity as scientific truth [42, 43] when its work was published in English journal [Appendix 2], and in French one [Appendix 3], translated by Ørsted himself. It is relevant this translations by Ørsted, because in then he eliminated the first paragraph about his twenty years previous experiments as we will see below.

He achieved in imagination what was denied in reality, since at that time the concept of electric current did not exist. Likewise, my approach about current electricity and later electromagnetism was not a discovery, but the structuration of reality, structuring cognitive structures, can be anchored in the Kind and Kung Resolving Puzzle proposal [17:20] can be illustrated in the following way:

> Our discussion has highlighted two primary classes of constraints. First, the constraints may be *architectural*; that is, they may results from our cognitive psychological architecture. Our psychological architecture prevents us from imagining certain things or using the imagination in particular ways. Second, the constraints may derive from a non-architectural source, such as from *our will*. This latter class of constraints is of the sort that we can (perhaps only when properly disciplined) voluntarily impose upon our imaginative projects [17: 21].

As we will see latter, in its first twenty years experiments, his cognitive architectural not constrained his imagination, but it was encouraged by his will, leading him to create new cognitive architectural which were reified in the instruments created by Ørsted himself together with the artisans of his time. His believe about electricity could have a magnetic effect, as he imagined this possibility, was transformed in scientific knowledge of electric current and electromagnetic theory give epistemic value to imagination, his imagination.

VI. EPISTEMIC USES OF IMAGINATION

Though imagination, such as thought experiments have been studied, by philosophers, in philosophical work of ancient philosophers since the middle of last century. Recently philosophers, like contributors in the book edited by Bandura and Kind [18] explore if imagination can play an epistemic role from the studies in: modality and modal knowledge; as reasoning; of course thought experiments and understanding self and others.

In the collection Epistemic Uses of Imagination [18], contributors particularly "take up the way in which our imagination must be constrained so as to justify beliefs and give rice to knowledge" [18: 1]. Constraint, claim Bandura and Kind is the way in which imagination can be epistemic use, comparing perception as world-sensitive which, by its nature is constrained by the world. In contrast, imagination its nature is not world-sensitive.

> It´s this lack of world-sensitivity that, traditionally, led many philosophers to dismiss imagination as epistemically irrelevant. But many recent discussions have suggested that imaginers can be,

> and often are, governed by constraints –even is these constraints are not provided by the world in the same way as they are in the case of perception. It´s precisely in virtue of these constraints –some architectural and some set by the imaginer– that imagining can be epistemologically useful [18: 2].

It is the kind that Any Kind, Russel K. Pitzer Professor of Philosophy at Claremont McKenna College, also serves as Director of the Gould Center to Humanities Studies, who with PhD student at the Ruhr University Bochum Germany Christopher Bandura, are explorer this questions in this volume that enrich epistemology of imagination.

VII. ØRSTED'S EXPERIMENTS IN FOUR ACTS

In this section I assert that all experiments are thought, some only thought, but there are others in which the thought is reified in the experimental design. Therefore, the dichotomy thought and real experiments is artificial in embodiment framework, since, for my, both are real in different contexts of reality.

First one is carried into the laboratory of the mind; mind embodied in the brain, embodied at the same time in the body who thought the experiment. Second are carried out by the experimenter with his body, guided by design designed previously imagined mentally (thought), doing, seeing what he does and its results creating imaginary representations of the external world.

Nevertheless, there are some kinds of thought experiments merely hypothetical not executable, which are used to explain real possibilities which can be better defined as imaginary experiments, not thought or mental experiments. But that is not their particularity, rather, over time; they can be materialized and even technologically developed. Such is the case of the Vienna Circle physicist, Rudolf Carnap who proposed an imaginary experiment to observe a live brain by meant of a mirror:

> This consists of applying the mirror to a person's brain, to observe the processes that develop in it, and also, to listen to the information that this person gave us about the processes that simultaneously occur in their consciousness; Finally, we would observe their expressive movements [With this, there are] two series of parallel physical processes, namely: the series of visual observations of the brain that we make in the mirror and the series of audible observations of the spoken words of the person in the experiment, perhaps combined with visual observations of their expressive movements [41].

The language in which person´s brain spoke was the fourth language called by Carnap fiction operational language, the language of computational subject. Joined this fourth is the third; realism language, second; natural language and finally first logistic symbolic language. The imaginary experiment about language of imaginary observer throughout the mirror was materialized by Generative Artificial Intelligence Long Language Model using Artificial Neural Networks with their three architectures:

1. Convolutional Neural Networks;
2. Recurrent Neural Networks, and
3. Generative Pre-trained Transformer (ChatGPT).

Thus, Carnap´s Imaginary Observer can be expressed in technological development as Computational Subject, giving reality to his imaginary experiment. Having this framework in mind, I explored experimental work of Hans Christian Ørsted in is innovative imaginary design, the creation of instruments to carry them out and imagining throughout his intellectual motor actions creating symbolic-Imaginative representations of new realities produced by it.

A. Reality, imaginative design and real experiments

The starting point of Ørsted's experimental work was in 1800, with the creation, by Alejandro Volta, of an instrument with which electricity, for the first time, could be produced continuously. In honor of his creator, the instrument was named voltaic, and the electricity produced in it was called galvanic, in honor to Luigi Galvani, his discoverer. This discovery and creation of new instrument gave rise to three of his lines of research carried out by Ørsted. The first was aimed at studying the chemical reactions generated by the internal circuit of the voltaic pile, derived from the continuous series of copper and zinc plates joined by meant of a humid medium, which produced electricity continuously.

The second line was aimed to investigating the reactions produced by the discharge of the galvanic electricity produced inside the voltaic pile by closing its circuit in external conductive means, one connected to the positive pole and the other to the negative pole. Therefore, the discharge was a function of the external circuit constituted by the wires connected to said poles, positive and negative, of the voltaic pile, by putting them in contact with an external conductive medium that joined them, like when was placed in water, producing hydrolysis phenomenon.

We have then a closed internal circuit and an open external one in these two lines of research. Both were

closely related, since to verify the improvements in the chemical reaction in the internal circuit, verification of the chemical reaction produced by the discharge in the external conductive medium that brought the poles into contact was required, positive and negative.

The third research line was to seek the magnetic effect through galvanic electricity by mean of the convergence of the two previous lines. Particularly, Ørsted investigated the transmission of galvanic electricity imagining its transmission as alternating positive and negative undulations.

These undulations were mutually attracted and repelled by the resistance opposed of the bodies to their transmission, called electrical conflict: the resistance of the bodies to the passage of electricity produced in the internal circuit of the galvanic pile through its external circuit open when it is closed.

Ørsted's research into galvanic electricity with the voltaic pile was carried out from 1801 to 1806 modifying both, construction materials and its internal conductive medium with different variants [43, 44, 45, and 46].

The galvanic electricity production improvement of flow charges from positive and negative poles was tested through their transmission inside the metal wires [47]. The transmission of electricity was carried out from 1812 to 1820 [48, 49], creating a reciprocal process: the chemical reaction due to the discharge in the conductive medium external and the improvement of the chemical reaction in the internal circuit of the voltaic pile to increase the flow of charges.

It is not an interaction, but the evolution of both research lines with common origin. In it convergence, converging as only single line, in which reality was prolonged in imagination, as well as the creation of new experimental processes, imagining and creating new instruments to carry out new experiments.

B. Imagining what does not exist founded in reality

In the framework of knowledge throughout imagination, philosophical treatment of imagination, transcendent and instructive use occurred in isolation from the other. In my approach, instructive use can detonate a transcendent use not implying a mental challenge their union: a puzzle in words of Kind and Kung asserts [17].

Focusing in its instructive use, taking as a fact that electricity, through lightning bolts during storms, produced a momentary magnetic effect in the compasses of ships, Ørsted imagined that was due to the incandescence of the lightning bolt. If now we focused in the transcendent use, or imaginary configuration to the epistemology of imagination, Ørsted imagined that through the incandescence of a metal wire, produced by discharges of positive and negative poles of the voltaic pile, called by him galvanic apparatus, search a magnetic effect on compass magnetic needle by meant of its incandescence.

> Starting from the fact that Ørsted put his galvanic apparatus to act on a magnetic needle through the incandescence of a metal wire. Ørsted did not seek to close the circuit on itself, but rather to transform electricity into magnetism by neutralizing positive and negative electricity produced through the incandescence of the wire that served as an external conductive medium [1: 62].

> To achieve the incandescence of the metal wire, Ørsted created his own galvanic apparatus, and even though he did not achieve the magnetic effect through its incandescence, the metal wire was integrated into the galvanic apparatus as a new scientific instrument [1: 160].

History shows us that neither the incandescence of lightning during storms nor the incandescence of metal wire produced the imagined magnetic effect, which does not mean that their beliefs had not become in truth. What Ørsted was looking for was the magnetic effect of galvanic electricity, and he achieved it. He also managed to transform the electrical conflict into electric current, since the wires did not produce incandescence, due to the resistance of the passage of positive and negative electricity inside them. Quite the contrary, it was his unresisting passage that achieved the imagined and sought effect following his imaginary configuration, not his transcendental imagination.

C. Thinking with de body and imagining new realities

Ørsted report his experimental work publishing it in Latin as facsimile, not in a journal, despite the fact that, as we know, there were many scientific journals in this time, as is evident from having published his own report in them a few months later [Appendices B and C]. Regarding his experiments carried out during the previous two decades follow:

> *In experimentis recensendis omina præteribo, quæ ad rationem rei inveniendam quidem conduxerunt, hac autem inventa rem amplius illustrare nequeunt; in eis igitur, quæ rei rationem perspicue demostrant, acquiescamus* [39: 1, 1: 66. Appendix A]

> In reporting these experiments, I shall omit all those which have undoub tedly led to the discovery of the nature of the matter, but which,

> once this had been discovered, could not further illuminate the subject; we shall the refore content ourselves with those things which clearly demonstrate the nature of the matter [40: 414, 1: 67].

Immediately afterwards he noted:

> A magnetic needle can be moved from its position by means of a galvanic apparatus, but by a closed galvanic circuit, not an open one [*idque circulo galvanico cluso, non aperto*], as several very famous physicists attempted in vain some years ago [40: 413, 1: 65].

About closed galvanic circuit, not an open one, my reconstruction, in de framework of the epistemology of imagination was:

> My reconstruction is that in Ørsted's new galvanic apparatus, the wire used to study the conduction of galvanic electricity was joined to the wires connected to the positive and negative poles of the apparatus, which formed a single "junction conductor" wire, *conductorem conjungentem* as Ørsted called it in his original work in Latin, or simply "union wire", *filum conjungens*. This connecting wire, while closing the circuit on itself, created a new phenomenon around it [1: 67].

To exploring this new phenomenon Ørsted, as I assert [1] go back to his sensory motor actions, He moved metallic wire around the magnetic needle continuously through the four cardinal points, staring at the front, towards the back and from up to down as follow:

> The opposite ends of the galvanic apparatus are connected by a metallic wire, which, for the sake of brevity, we shall henceforth call the connecting conductor or the connecting wire. However, the effect which take place in this conductor end on the surrounding space we shall call the electric conflict.
>
> A straight portion of this wire is placed in a horizontal position above and parallel to a magnetic needle which has been properly suspended. If necessary, the connecting wire can be bent so that that suitable part of it assumes the position required for the experiment. When this has been achieved, the magnetic needle will move, and it will deviate to the west under that part of the connecting wire which receives electricity most closely from the negative end of the galvanic apparatus [40: 414].

Thinking with the body by meant of its sensory motor experimental movements, led Ørsted to break with the established theory of effect at a distance through attractions and repulsions. Regarding the latter, he points out:

> The connecting wire can be moved, either towards the east or towards the west, provided that it maintains its orientation parallel to the needle, with any change in the effect other than with respect to is magnitude. Hence, the effect cannot possibly be ascribed to an attraction; for the sane pole of the magnetic needle which a approaches the connecting wire when the latter is placed on its east side should move away from it when the wire occupies a position on the west side if this deviation were dependent on attractions or repulsions [40: 414].

Regarding the distance effect, he states that:

> It is sufficiently evident from the presiding observations that the electric conflict is not confined to the conductor both, as mentioned above, is dispersed quite widely in their circumjacent space. [40: 416].

The thinking with the body is explicitly expressed by Ørsted, at the final of his facsimile report: "The agreement of this law with nature will be better understood by a repeating of the experiment than by a long explanation" [40: 416].

D. Images into experiment of unimaginable realities

My approach is that he thinking with the body searching the structure of new phenomenon following his movements, prolonging their material actions into imaginary actions. In other words, their represent-actions moving the wire were prolonged as imaging-actions as circle, but to as spiral:

> From was have been observed we may likewise conclude that this conflict moves in circles; for without this condition it seems impossible that the same part of their connecting wire moves the magnetic needle towards the east when placed below the magnetic pole, but towards the west when placed above it: for it is the nature of circles the motion in opposite parts most have opposite direction [40: 416].

According to colleagues, Ricardo Sanz. Jaime Gómez, Carlos Hernández and Idoia Alarcón, of the Technical University of Madrid, the mind–body relation is due to an

informational–physical relation between mind, as controller, is necessarily physical implementation in which "cognition is the closed dynamical process of sense–think–act–behave" [13: 418] as systemic—emergent—phenomenon, enrich my proposal of movements prolong material actions converting them in imaginary actions.

Nevertheless, colleagues proposal get very rich to may proposal about represent-actions moving toward imaging-actions as cognitive loops which are organized hierarchical but too heterarchically. In this framework:

a) Sensing is mapping physical states into informational states; b) Actuating is mapping informational states into physical states; c) Perception is model-integration of sensed information, and d) Knowledge is executable dynamic models.

Other enactment to epistemology of imagination is Lotte Meteyard and Gabriella Vigliocco proposal about semantic representations engaged with sensory and motor action into experience is their statement:

> The necessity condition states that without the support of sensory and motor systems, semantic representation for concrete objects and events is impaired. The directness condition states that sensory and motor systems are engaged during semantic access without being mediated by other cognitive processes [11: 306].

The circle can understand in this process to seeing the movements was doing, but the spiral it was inexplicable to him.

CONCLUSIONS

This is my proposal about cognitive triad of epistemology of imagination: sensory motor actions, symbolic-imaginative representations, and formal reasoning, are enriched with the Embodied Cognition proposal, especially think with the body with brain language proposal changing visceral motor system by sensory motor actions, both, as dyad. Likewise is enriched whit dyad knowledge through imagination and its epistemic uses applied to Ørsted experiments in the search of the relationship between electricity and magnetism, resulting in electromagnetic and field theory in physics

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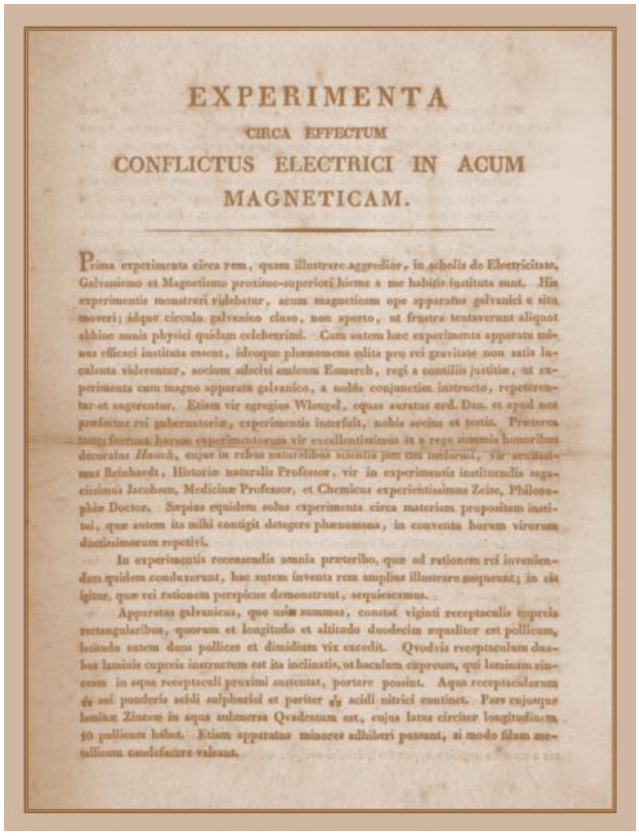
APPENDIX A



EXPERIMENTA

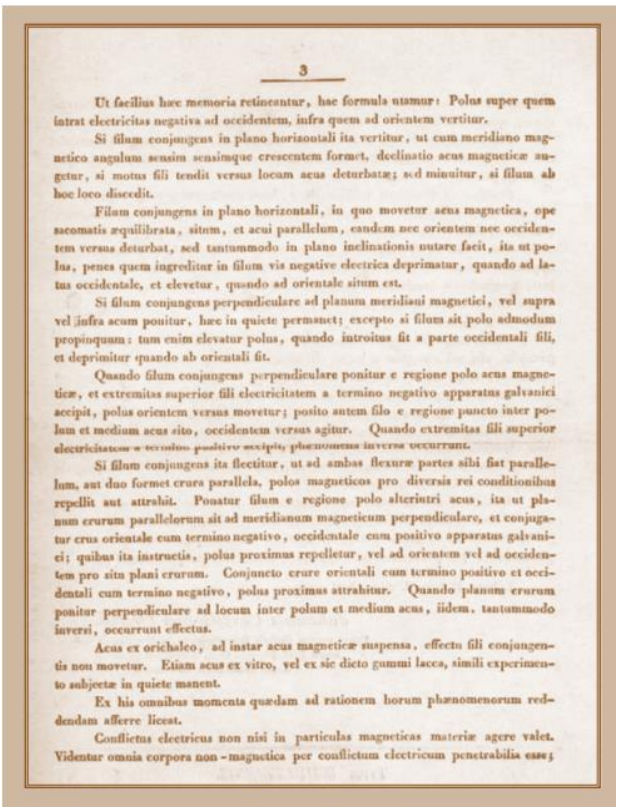
CIRCA EFFECTUM

CONFLICTUS ELECTRICI IN ACUM MAGNETICAM.

Prima experimenta circa rem, quam illustrare aggrediar, in scholis de Electricitate, Galvanismo et Magnetismo proximo-superiori hieme a me habitis instituta sunt. His experimentis monstrari videbatur, acum magneticam ope apparatus galvanici e situ moveri; idque circulo galvanico cluso, non aperto, ut frustra tentaverunt aliquot abhinc annis physici quidam celeberrimi. Cum autem hæc experimenta apparatu minus efficaci instituta essent, ideoque phænomena edita pro rei gravitate non satis luculenta viderentur, socium adscivi amicum Esmarch, regi a consiliis justitiæ, ut experimenta cum magno apparatu galvanico, a nobis conjunctim instructo, repeteremur et augerentur. Etiam vir egregius Wiengel, eques auratus ord. Dan. et apud nos perfectus rei gubernatoriæ, experimentis interfuit, nobis accima et potis. Præterea tertia fortuna horum experimentorum vir excellentissimus et a rege summis honoribus decoratus *Hauch*, cujus in rebus naturalibus scientia jam din mirantur, vir acutissimus *Reinhardt*, Historiæ naturalis Professor, vir in experimentis instituendis sagacissimus *Jacobsen*, Medicinæ Professor, et Chemicus experientissimus *Zeise*, Philosophiæ Doctor. Serpius equidem solus experimenta circa materiam propositam instituí, quæ autem ita mihi contigit detegere phænomena, in conventu horum virorum doctissimorum repetivi.

In experimentis recensendis omnia prætribo, quæ ad rationem rei inveniendæ quidem conduxerunt, hæc autem inventa rem amplius illustrare nequeunt; in eis igitur, quæ rei rationem perspicue demonstrant, acquiescamus.

Apparatus galvanicus, quo usus summus, constat viginti receptaculis cupreis rectangularibus, quorum et longitudo et altitudo duodecim æqualiter est pollicum, latitudo autem duos pollices et dimidium vix excedit. Quodvis receptaculum duabus laminis cupreis instructum est ita inclinatis, ut baculum cupreum, qui laminam sinistram in aqua receptaculi proximi sustentat, portare possint. Aqua receptaculorum $\frac{1}{24}$ sui ponderis acidi sulphurici et pariter $\frac{1}{24}$ acidi nitrici continet. Pars cujusque laminæ Zinceæ in aqua submersa Quadratum est, cujus latus circiter longitudinem 16 pollicum habet. Etiam apparatus minores adhiberi possunt, si modo filum metallicum candefacere valeant.



Ut facilius hæc memoria retineantur, hæc formula utamur: Polus super quem intrat electricitas negativa ad occidentem, infra quem ad orientem vertitur.

Si filum conjungens in plano horizontali ita vertitur, ut cum meridiano magnetico angulum sensim sensimque crescentem formet, declinatio acus magneticæ augetur, si motus fili tendit versus locum acus deturbatæ; sed minuitur, si filum ab hoc loco discedit.

Filum conjungens in plano horizontali, in quo movetur acus magnetica, ope acomatis æquilibrata, situm, et acui parallelum, eandem nec orientem nec occidentem versus deturbat, sed tantummodo in plano inclinationis nutare facit, ita ut polus, penes quem ingreditur in filum vis negative electrica deprimatur, quando ad latus occidentale, et elevetur, quando ad orientale situm est.

Si filum conjungens perpendiculare ad planum meridiani magnetici, vel supra vel infra acum ponitur, hæc in quiete permanet; excepto si filum sit polo admodum propinquum: tum enim elevatur polus, quando introitus fit a parte occidentali fili, et deprimitur quando ab orientali fit.

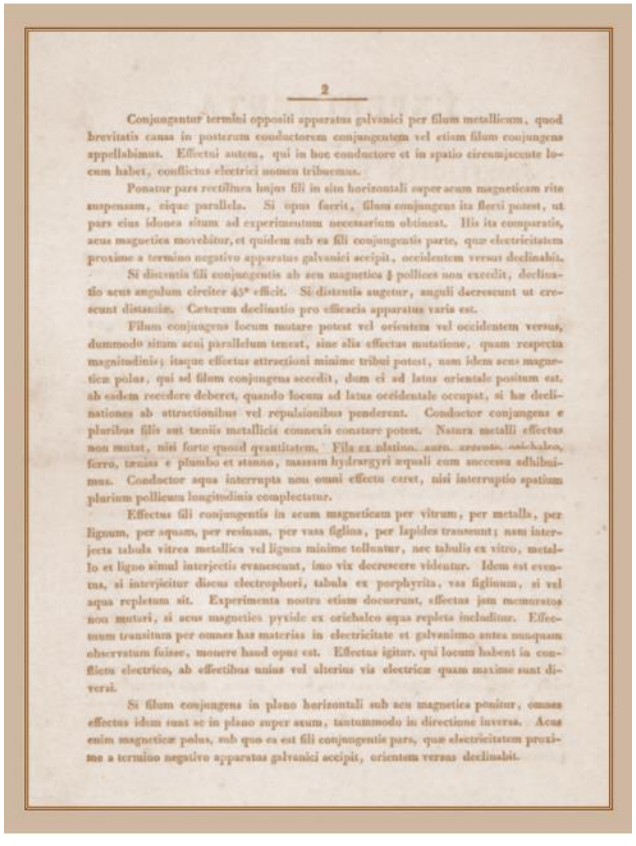
Quando filum conjungens perpendiculare ponitur e regione polo acus magneticæ, et extremitas superior fili electricitatem a termino negativo apparatus galvanici accipit, polus orientem versus movetur; posito autem filo e regione puncto inter polum et medium acus sito, occidentem versus agitur. Quando extremitas fili superior electricitatem a termino positivo accipit, phænomena inverse occurrunt.

Si filum conjungens ita flectitur, ut ad ambas flexuræ partes sibi fiat parallelum, aut duo formet crura parallela, polos magneticos pro diversis rei conditionibus repellit aut attrahit. Ponatur filum e regione polo alterintri acus, ita ut planum crurum parallelorum sit ad meridianum magneticum perpendiculare, et conjugatur crus orientale cum termino negativo, occidentale cum positivo apparatus galvanici; quibus ita instructis, polus proximus repelletur, vel ad orientem vel ad occidentem pro situ plani cruum. Conjuncto crure orientali cum termino positivo et occidentali cum termino negativo, polus proximus attrahitur. Quando planum crurum ponitur perpendiculare ad locum inter polum et medium acus, iidem, tantummodo inversi, occurrunt effectus.

Acus ex orichalco, ad instar acus magneticæ suspensa, effectu fili conjungentis non movetur. Etiam acus ex vitro, vel ex sic dicto gummi lacca, simili experimento subjectæ in quiete manent.

Ex his omnibus momenta quædam ad rationem horum phænomenorum reddendam afferre licest.

Conflictus electricus non nisi in particulas magneticas materiæ agere valet. Videntur omnia corpora non-magnetica per conflictum electricum penetrabilia esse;



Conjungantur termini oppositi apparatus galvanici per filum metallicum, quod brevitatis causa in posterum conductorem conjungentem vel etiam filum conjungens appellabimus. Effectui autem, qui in hoc conductore et in spatio circumjacente locum habet, conflictus electrici nomen tribuemus.

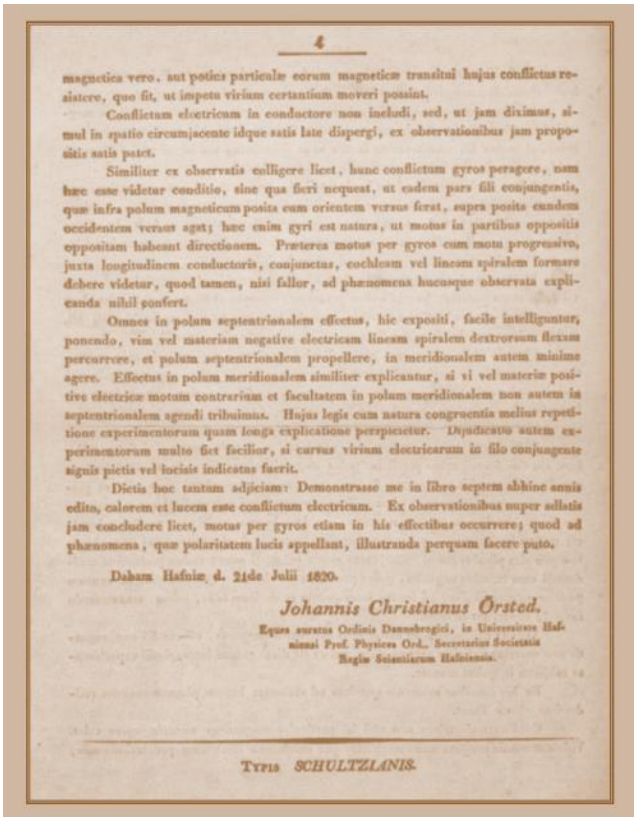
Ponatur pars rectilinea hujus fili in situ horizontali super acum magneticam rite suspensam, eique parallela. Si opus fuerit, filum conjungens ita flecti potest, ut pars eius idonea situm ad experimentum necessarium obtineat. His ita comparatis, acus magnetica movebitur, et quidem sub ea fili conjungentis parte, quæ electricitatem proxime a termino negativo apparatus galvanici accipit, occidentem versus declinabit.

Si distantia fili conjungentis ab acu magnetica $\frac{1}{2}$ pollices non excedit, declinatio acus angulum circiter 45° efficit. Si distantia augetur, anguli decrescunt ut crescunt distantiæ. Ceterum declinatio pro efficacia apparatus varia est.

Filum conjungens locum mutare potest vel orientem vel occidentem versus, dummodo situm acui parallelum teneat, sine ulla effectus mutatione, quam respectu magnitudinis; itaque effectus attractioni minime tribui potest, nam idem acus magneticæ polus, qui ad filum conjungens accedit, dum ei ad latus orientale positum est, ab eadem recedere deberet, quando locum ad latus occidentale occupat, si hæ declinationes ab attractionibus vel repulsionibus penderent. Conductor conjungens e pluribus filis aut taeniis metallicis connexis constare potest. Natura metalli effectus non mutat, nisi forte quoad quantitatem. Fila ex platina, auro, argento, orichalco, ferro, taeniis e plumbo et stanno, massam hydrargyri æquali cum successu adhibuimus. Conductor aqua interrupta non omni effectu caret, nisi interruptio spatium plurium pollicum longitudinis complectatur.

Effectus fili conjungentis in acum magneticam per vitrum, per metalla, per lignum, per aquam, per resinam, per vasa figlina, per lapides transeunt; nam interjecta tabula vitrea metallica vel ligna minime tollantur, nec tabulis ex vitro, metallo et ligno simul interjectis evanescunt, imo vix decrescere videntur. Idem est eventus, si interjicitur discus electrophori, tabula ex porphyrita, vas figlinum, si vel aqua repletum sit. Experimenta nostra etiam docuerunt, effectus jam memoratos non mutari, si acus magnetica pyxide ex orichalco aqua repleta includitur. Effectuum transitum per omnes has materias in electricitate et galvanismo antea nunquam observatum fuisse, monere haud opus est. Effectus igitur, qui locum habent in conflictu electrico, ab effectibus unius vel alterius vis electricæ quam maxime sunt diversi.

Si filum conjungens in plano horizontali sub acu magnetica ponitur, omnes effectus idem sunt ac in plano super acum, tantummodo in directione inversa. Acus enim magneticæ polus, sub quo ea est fili conjungentis pars, quæ electricitatem proxime a termino negativo apparatus galvanici accipit, orientem versus declinabit.



magnetica vero, aut potius particulæ eorum magneticæ transitui hujus conflictus resistere, quo fit, ut impetu virium certantium moveri possint.

Conflictum electricum in conductore non includi, sed, ut jam diximus, simul in spatio circumjacente idque satis late dispergi, ex observationibus jam propositis satis patet.

Similiter ex observatis colligere licet, hunc conflictum gyros peragere, nam hæc esse videtur conditio, sine qua fieri nequeat, ut eadem pars fili conjungentis, quæ infra polum magneticum posita eum orientem versus ferat, supra posita eandem occidentem versus agat; hæc enim gyri est natura, ut motus in partibus oppositis oppositam habeant directionem. Præterea motus per gyros cum motu progressivo, juxta longitudinem conductoris, conjunctus, cochleam vel lineam spiralem formare debere videtur, quod tamen, nisi fallor, ad phænomena hucusque observata explicanda nihil confert.

Omnes in polum septentrionalem effectus, hic expositi, facile intelliguntur, ponendo, vim vel materiam negative electricam lineam spiralem dextrorsum flexam percurrere, et polum septentrionalem propellere, in meridionalem autem minime agere. Effectus in polum meridionalem similiter explicantur, si vi vel materiæ positive electricæ motum contrarium et facultatem in polum meridionalem non autem in septentrionalem agendi tribuimus. Hujus legis cum natura congruentia melius repetitione experimentorum quam longa explicatione perspicietur. Dispicuisse autem experimentorum multo fiet facilior, si cursus virium electricarum in filo conjungente signis pictis vel lucisis indicatus fuerit.

Dictis hoc tantum adjicam: Demonstrasse me in libro septem abhinc annis edito, calorem et lucem esse conflictum electricum. Ex observationibus super adlatis jam concludere licet, motus per gyros etiam in his effectibus occurrere; quod ad phænomena, quæ polaritatem lucis appellant, illustranda perquam facere puto.

Dabam Hafniæ d. 21de Julii 1820.

Johannis Christianus Örsted.

Eques auratus Ordinis Dannebrogici, in Universitate Hafniensi Prof. Physices Ord., Secretarius Societatis Regiæ Scientiarum Hafniensis.

TYPIS SCHULTZIANIS.

APPENDIX B

ANNALS OF PHILOSOPHY;

OR, MAGAZINE OF

CHEMISTRY, MINERALOGY, MECHANICS,

NATURAL HISTORY,

AGRICULTURE, AND THE ARTS.

BY THOMAS THOMSON, M.D. F.R.S. L. & E. F.L.S.

REGIUS PROFESSOR OF CHEMISTRY IN THE UNIVERSITY OF GLASGOW, MEMBER OF THE GEOLOGICAL SOCIETY, OF THE WERNERIAN SOCIETY, AND OF THE IMPERIAL MEDICO-CHIRURGICAL ACADEMY OF PETERSBURGH.

VOL. XVI.

JULY TO DECEMBER, 1820.

London:

Printed by C. Baldwin, New Bridge-street;

FOR BALDWIN, CRADOCK, AND JOY,

47, PATERNOSTER-ROW.

1820.

1820.] *Bonaparte's Fly Bridge at Antwerp.* 273

The above estimate amounting to the sum of 3,922*l.* 10*s.* is of course to be considered as a very general statement, for every estimate of this kind must vary according to the position of things. This, however, appears but small, compared with what would be necessary for the erection of a bridge either of iron or stone of 500 yards in length; while such a mode of crossing a large river is not only expeditious, but is safe and commodious. Horses and carriages can also be conveyed by this means without unyoking, and passengers may either remain upon deck, or retire into cabins below. For cattle ferries this would be an improvement of much consequence, as almost any number of cattle may be carried across at one operation.

But establishments of this kind may be required upon a still larger scale than is necessary for crossing the Scheldt, the Rhine, and the Po; and as it is believed that such an idea has not been put in practice in this country, it will be an easy matter to make the trial on any river, or ferry, at a small expense, it being only necessary to apply the ordinary tackle and materials of shipping for making the experiment.

I am, dear Sir, yours truly,

ROBERT STEVENSON.

ARTICLE IV.

*Experiments on the Effect of a Current of Electricity on the Magnetic Needle.** By John Christian Oersted, Knight of the Order of Danneborg, Professor of Natural Philosophy, and Secretary to the Royal Society of Copenhagen.

THE first experiments respecting the subject which I mean at present to explain, were made by me last winter, while lecturing on electricity, galvanism, and magnetism, in the University. It seemed demonstrated by these experiments that the magnetic needle was moved from its position by the galvanic apparatus, but that the galvanic circle must be complete, and not open, which last method was tried in vain some years ago by very celebrated philosophers. But as these experiments were made with a feeble apparatus, and were not, therefore, sufficiently conclusive, considering the importance of the subject, I associated myself with my friend Esmarck to repeat and extend them by means of a very powerful galvanic battery, provided by us in common. Mr. Wleugel, a Knight of the Order of Danneborg, and at the head of the Pilots, was present at, and assisted in, the experiments. There were present likewise Mr. Hauch, a man very well skilled in the Natural Sciences, Mr. Reinhardt,

* Translated from a printed account drawn up in Latin by the author, and communicated by him to the Editor of the *Annals of Philosophy*.

APPENDIX C

JOURNAL

DE PHYSIQUE,

DE CHIMIE,

D'HISTOIRE NATURELLE

ET DES ARTS,

AVEC DES PLANCHES EN TAILLE-DOUCE;

PAR M. H.-M. DUCROTAY DE BLAINVILLE,

Docteur en Médecine de la Faculté de Paris, Professeur de Zoologie, d'Anatomie et de Physiologie comparées, à la Faculté des Sciences et à l'Ecole normale; ex-Suppléant de M. Cuvier au Jardin du Roi et au Collége de France, Membre et Secrétaire de la Société Philomatique, Membre de la Société Wernérienne d'Edimbourg et de la Société d'Histoire naturelle de Dublin, etc.

JUILLET AN 1820.

TOME XCI.

A PARIS,

CHEZ Mme Ve COURCIER, LIBRAIRE,

rue du Jardinet, quartier St.-André-des-Arcs.

72 JOURNAL DE PHYSIQUE, DE CHIMIE

du G. *jeffersonia*, que je viens de remarquer. Les étamines y sont opposées aux pétales; et les anthères ont 2 loges dorsales, s'ouvrant chacune par une valve roulée du bas en haut. Ces caractères transportent ce genre dans la famille des *berbéridées*, à côté du G. *epimedium*, et l'éloignent totalement des G. *macrotrys*, *podophyllum* et *actea*, qui forment la famille des *actéacées*, et qui ont les étamines indéterminées, nullement isopétales ni opposées, et les anthères sans valves roulées.

5. Le *Trillium sessile* diffère de tous ses congénères par sa fleur sessile, et je viens de découvrir qu'il possède un autre caractère exclusif dans la forme de ses anthères, qui sont foliacées, lancéolées, sessiles, et à deux loges latérales marginales totalement séparées. Il pourra former un sous-genre, sous le nom de *phyllantherum*. Il offre beaucoup de variétés, et il paraît qu'il y a déjà trois espèces de ce sous-genre, savoir, les *T. sessile*, *T. petiolatum* et *T. tinctorium*.

EXPÉRIENCES

Sur un effet que le courant de la Pile excite dans l'Aiguille aimantée;

PAR M. J. C. ŒRSTED.

LE fait que je vais essayer de mettre en évidence n'est pas absolument nouveau; c'est l'hiver dernier, dans mes Cours d'Electricité, de Galvanisme et de Magnétisme, que j'en fis les premières expériences.

Déjà il sembloit en résulter que l'aiguille magnétique est déviée par l'influence de l'appareil galvanique, et cela sous une condition, c'est qu'on expose l'aiguille au fil qui joint les pôles, et non pas entre les fils de chaque pôle, comme de célèbres physiciens tentoient de le faire il y a quelques années.

Cependant, mon premier appareil étoit foible et les effets produits ne sembloient pas assez décisifs pour constater une action nouvelle et si importante, c'est pourquoi je me suis associé mon ami Esmarch, conseiller du roi, pour faire avec lui une pile plus forte, capable de reproduire et d'agrandir le phénomène.

LE