Introduction to cognitive action theory

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Abstract. Incorporating a conscious 1st person observer in scientific theories has been hampered by the lack of physically viable mind/body models. I will present a Cognitive Action Theory (CAT) model of an integrated mind/body system and identify the process of creating conscious experience as the basic building block of reality. This building block is a cyclic process in time, connecting the 1st-person experience with its 3rd-person physical models so that conscious phenomena are possible. We therefore propose a fundamental shift to consider what we do to be conscious as an a-priory activity that must be happening for us to be able to ask the question, “How can conscious beings exist in our physical world?” This activity contains both qualia and an explanation to produce what Archibald Wheeler described as a self measuring explanatory cycle. At this level of definition such a cycle of activity can accommodate any belief system defining physical reality as an explanation for personal experience and therefore provides a framework which accommodates most scientific and spiritual traditions. However visualizing abstract activity as the motion of masses and charges that together compose matter allows us to couple what we do to the formalism of classic physics thus describing a Reality of interacting events. Such a theory integrates the subjective and objective aspect of our experience in a single physical framework, reducing to the linear quantum formalism when the motions involved are small enough to be reversible.

1. Philosophic grounding

In western traditions there are two fundamental approaches to the nature of reality. Plato thought that we experience our daily lives as the shadows on a cave wall projected from an ideal reality outside. His student Aristotle believed we are looking directly at that external reality through the windows of our senses. Aristotle’s belief that reality is composed of the objective world we see in front of our nose is shown on the right side of figure 1. This view has been the basis of classic physics which describes the behavior of objects we can see. Plato’s view shown on the left of figure 1 introduces a processing mechanism between reality and the things we see. To emphasize this difference the 1st person left eye perspective drawn by Ernest Mach \cite{1}, showing his nose on the right side and his legs stretched out on a couch in front of his nose. Such a 1st person every day experience is thereby identified as our mental display resulting from brain processing of sensor interactions.

Our subjective selves held fast inside our skull are shown as the prisoners of a modern version of Plato’s Cave in figure 2. They cannot get out to experience reality directly and are therefore limited to speculate on the nature of reality by building symbolic theories. The symbols of these theories are visualized and projected onto the sensations experienced.
For example, the entity causing the sensation of the cat in figure 2 is, according to quantum theory, a wave function that is visualized on the pad as an oscillating squiggle. This probability wave is actually what has been measured by our optical sensors to produce the cat’s image in our mind. Knowing that the sensation of our every day experience is, like the cat, first and foremost a mental image that is processed into the symbols of an explanatory theory requires us to recognize that we ourselves produce our every day world including our nose and body parts. We are therefore a larger processing system producing the objects we perceive rather than simply a world of objects themselves.

Such a realization changes our concept of reality from an object-oriented to an event-oriented world view. Objects are not as fundamental as the processing events in which they are incorporated. It is elementary events rather than elementary particles that are the building blocks of the universe and it is a physics of interacting events that must be developed to replace the classic physics of things, if we are to make progress toward our next stage of evolution.

2. The fundamentals of cognitive action theory
The development of Cognitive Action Theory (CAT) was inspired by a desire to incorporate the
subjective experience into a physical theory which could include the self and its feelings as an active participating element. By observing the activities of a human observer who produces and explains sensations using a symbolic model, a fundamental processing cycle has been identified which achieves the goal of incorporating the subjective aspect of human experience in a physical model. It turns out that Rather than extend the complexity of quantum theory, the integration with human experience is best served by returning to the pre-quantum age at the beginning of the 20th Century. Here we find the material objective world had been adequately described by two fundamental force categories. These consisted of gravity and inertial forces “Fgi” formulated by Newton’s laws and the electric magnetic forces “Fem” formulated by Maxwell’s equations. The challenge confronting the physicists around the year 1900 was the nature of the inside of material. Experiments with black body radiation and spectroscopy forced a rethink of the classic physics assumptions. Starting with the discovery of Plank's quantum of action the notion of an infinitesimal small division of material had to be abandoned. Instead new ideas of what was inside material needed to be developed.

By eliminating the objective world concept and recognizing a flow of activity as the fundamental happening of Reality we arrive at the highest summary depiction showing the major component divisions of that flow in figure 3. This deceptively simple action model retains the gravito-electric force categories of classic physics along with their charge and mass center source and sinks for those forces while adding a balancing cognitive domain of cognitive forces inside material. As in classic physics the objects seen as one’s every day experience are explained by the theoretical assumptions that actual material is composed of mass and charge. Masses interact with mass with gravito-inertial force and charges interact with charges with electro-magnetic forces. Our theoretical assumptions have here been expanded to include mental processes. The subjective experience has been allocated to happen inside material - meaning inside the objects of every day external experience. What happens inside material has been studied by quantum physicists for over 100 years. However, the ontological basis providing an interpretation of the symbols of this theory has never been established. Avoiding the complexity of the resulting instrumentalist “shut-up-and-calculate” dogma, which undoubtedly includes many practical calculation rules, our initial attempt to integrate subjective experience into physical material is based upon new foundational postulates summarized as follows:

1) charge and mass have an outside and inside aspects
2) The inside aspect is governed by “Fcm” and “Fem” forces, which to first order hold the charge and mass together.
3) The mental display of conscious experience is correlated with the inside activities (of the?) material.
By recognizing the classic world of objects as 1st person creations in the mental phase of our larger processing mechanism we also recognize ourselves, and all other approximately independent divisions of Reality, as self-contained explanatory-measurement action loops that process their experiences in their own repeating life-times of change.

3. Action theory additions to classic physical concepts
In order to incorporate the subjective aspect into physics we have substantially expanded the concept of Reality and the physics required to explain it. Though initially postulated as a model of the activities of a human observer figure 3 shows a closed path of action flow between mass and charge phases that represents a fundamental shift in our concept of Reality and all its parts whether alive or not. Many concepts of classic physics have been retained. Figure 4 shows the same loop architecture but new annotation has been added to show how additional classic physics concepts are incorporated in the CAT loop model.

A self-contained flow of action through a form of activity replaces the concept of a material particle. The material phase of the flow consists of mass-charge densities into which centers of mass and charge have been placed. In this diagram the action flows counter clock wise from the space of future interface detector/actuator arrays through mental processing elements to be presented as 1st person observables in the mental display. They appear as objects such as the apple, nose, and the observer’s arm somewhat later than when the stimulation reached the receive side of the detector arrays – the retina when the modeled system is human. From there, the action flows through the explanatory pathways into the model of physical reality. Unlike the pure representation of the interaction flow and accompanying forces shown in figure 3 the role of the physical aspect is taken by a classic material system which may have layers of sequential processing steps between its receive and send sides including a time increment to the next cycle state which then stimulates the receive side of the retina to repeat the loop. In this basic cycle the interface between the inside subjective phase and outside objective phase are the material boundaries implementing the detector-actuator arrays which play the role of the vonNeumann Cut and separate the world of probability states from the classic objective world in quantum theory. However, the CAT model goes beyond quantum theory.

Fig. 4 Concepts in an Action Cycle Architecture
By showing a classic material system playing the role of an explanatory model we have replaced the probabilities of the Copenhagen interpretation with visualizations of classic mass-charge material systems. Such a replacement provides an ontologically viable interpretation of quantum theory symbols that resembles classic concepts but differs because those classic concepts are embedded in a new context of activity cycles. What CAT has added to classic physics which allows CAT to become a superset of quantum theory is summarized as follows:

**General:**
- All systems are observers consisting of interacting self-measurement-explanatory activities.
- Classic point states “qf, pf” are replaced by dynamic states qf(t), pf(t) of activities happening.

**Time:**
- Time points name the configuration state of a system.
- The time interval has been expanded to include an objective external and subjective internal phase of the activity of matter.
- Measurement time is defined as the name of the state of the system adopted as a clock.
- Newtonian time is an abstract quantity derived from the complete dynamic state of an isolated system

**Space:**
- Space for an isolated system is the Hilbert Space of detector/actuator interface arrays between object and subject phases of action loops.
- Space is a sensation derived from an extension of material action not its container.
- Empty space is the feeling associated with an isolated event in a dynamic state of equilibrium.

**Material:**
- Material is fundamentally composed of mass and charge densities
- The degrees of freedom of classical systems has been doubled by separating mass and charge.
- Internal material forces between mass and describe the physics in the inside of matter, which is not directly observable and has been the domain of quantum theory.
- Force and reaction-force happen when action flows between two degrees of freedom
- Action flows when material deviates from its equilibrium dynamic state.
- Mach’s principle and the connection between gravitation and inertia field is introduced so that the gravito-inertial and electromagnetic force domains are connected through internal forces between mass and charge in the internal subjective phase of matter,

This list of features along with the architectural diagram shown in figures 3 and 4 provides a basis of characteristics which are used to define a context for objective classic and quantum experiences. The physical formalism that has been built to implement these older theories can largely be adapted to CAT models provided they are properly interpreted to reflect their role in an action flow architecture. Several examples of such reinterpretation will be presented in the next section.

4. **Traditional physics formalism in CAT models**
Physical formalism of both classic and quantum physics rests upon the assumption that the out-their-beyond-and-including-ones-body’s world is an independent thing having an existence beyond and independent of one’s feelings and subjective experience. By giving that world view a role in a self-refreshing cycle we can salvage the utility of our current physical theories by applying them to the physics describing an integrated event-oriented world view. In this world view objects no longer have an independent existence because they are observable explanations of interactions in self-contained events. We are not promoting solipsism but rather replacing Kant’s “Things-onto-themselves” with “Events-onto-themselves” and thereby proposing a Reality of interacting events in which You, I, and the Universe are recognizable parts.

Of course, only Reality as a whole would be completely isolated by definition of the word “whole”, but parts can be approximated as isolated repeating systems if the bulk of their internal
activity is much, much, larger than their interactions with external events. An isolated system, I mean a completely isolated system, runs at its own time and therefore the entire dynamics of traditional physics must be revised to account for the absence of a God-given external Newtonian time.

4.1 Physics of an Isolated System

In classic physics the evolution of an isolated the system is defined by the functions

\[ q_1(t), q_2(t) \ldots q_f(t) \ldots, p_1(t), p_f(t) \ldots p_f(t) \ldots \] (1)

Where: \( q_f(t) \) = the generalized coordinate or position at a time \( t \)
\( p_f(t) \) = the generalized momentum or desire to change at a time \( t \)
\( t \) = an external time parameter
\( f \) = the degrees of freedom of change available to the system

We have “2f” equations for “2f” unknowns. The evolution of the system is completely defined by the value of time “t” and to the extent this parameter increases relentlessly the system is causal and deterministic. In classic physics the physical basis for the connection between time and the simultaneous evolution of all its components is simply assumed.

The physics of a truly isolated system would need to include the clock in the system. Mathematically we can add the motion of a clock as a zeroth degree of freedom

\[ q_0, p_0(q_0), q_1(q_0), q_2(q_0) \ldots q_f(q_0) \ldots p_1(q_0), p_f(q_0) \ldots p_f(q_0) \ldots \] (2)

Where: \( p_f(q_0) \) = the clock momentum, i.e. desire of the clock change at a time \( q_0 \), \( q_0 \) = the position of the clock pointer.

Now the motion of the clock, defined by \( q_0 \), is physically connected to the rest of the degrees of freedom. We have added one additional condition “\( p_0(q_0) \)”, which defines a clock as a system running at constant energy. However, \( q_0 \) is not known a priori. One condition is missing. An outside observer who is isolated from the system under consideration cannot determine its state until at least one measurement is made.

The entire random nature of quantum theory is explained in CAT by the fact that quantum systems are electromagnetically isolated from outside observers until a measurement is made. If external observer’s clock says the time is “t” then a measurement of “\( q_0 \)” will in general produce a random result because the clocks of truly isolated systems are not synchronized. The foundations of quantum theory have a logical explanation if we recognizing ourselves as systems which can be approximated as self contained isolated events.

Consider the dogma that the position and momentum of a particle can only be determined to the accuracy of Planks constant. The logic of Heisenberg’s microscope thought experiment depends upon our old habit of assuming particles are where they interact. An event is a dynamic happening. Its interactions do not determine its location. We interpret interaction events as objects which give a location in our mental display. Then we assume the display along with the objects in it are, or at least represent, Reality. By eliminating this assumption, we can sidestep many of quantum mysteries and return to a classical treatment of reality [2] by substituting events for the objects. In fact, once we assume events are primary the formalism of classic physics can be recognized as simply describing one activity from two different points of view.

4.2 Two coordinate frames specifying a single event

Let’s consider a system assumed to be isolated with degrees of freedom “\( q_f, p_f \)”. We can make a list of the different values of these variables as the system passes through its states. We then have a sequence of rows with many columns of values. Each row represents a state. We then label the states
with a parameter “Tw” and define a state function $Tw = Tw(...pf,qf...)$ that assigns the single state value to each row. We then calculate the amount of action required to change the values from one row to the next as $Aw(\Delta Tw)$ and thin the rows so that rate of action change is a constant $Ew = \frac{A(\Delta Tw)}{\Delta Tw}$ which is called energy. Since $\Delta Tw$ equals the difference between two functions of two rows of the “p1f, q1f” and “p2f, q2f” parameters we now have two functions of all the degrees of freedom which give two parameters that can be used to index the individual degrees of freedom. We therefore recognize the time and energy expressions as one way to specify a system and the individual position and momentum as an alternative way to specify the same system. Figure 4 provides a comparison between the two ways of looking at such systems.

These equations implement a type of Contact Transformation between two coordinate frames in which the system is specified. Here “Tw” defines the motion of a system point moving with constant velocity along a trajectory marked off by intervals of constant action through a multi-dimensional coordinate frame composed of all degrees of freedom. The critical difference from classic physics is that the clock state “q0, p0” used to measure time is included as the zeroth degree of freedom and therefore progress in the evolution of such a system can again be parameterized by an abstract Newtonian like time parameter “Tw” however the meaning of the time parameter is no longer of a “god-given” external nature, but rather a property of the isolated system Whole which includes its own time. To emphasize this point we have added the “w” to the energy and time parameters, although these additional designations are often left out when it is obvious that the state and energy of a Whole system is implied.

The recognizing the possibility that self-contained isolated systems exist in Reality we can reinterpret classic physics formalism within a new event-oriented context. A list of applicable reinterpretations of classic equations follows:

1) Equations in figure 4 are no longer deterministically dependent on time, but become eigen-value equations giving them the stature of non-linear formulations of quantum theory.

2) A change in time $\Delta Tw$ is calculated from and in turn projects into coordinated changes in the “qf, pf” states in all degrees of freedom. If $\Delta Tw=0$ nothing changes in the system configuration, the clock “q0, p0” stands still and no time has passed.

3) A change in time $\Delta Tw$ will generally imply interactions between the clock and the remaining “f-1” degrees of freedom. Using clock measurements instead of the Newtonian-like “Tw” parameter to parameterize experiments will require corrections reminiscent of special relativity and the Lorentz transformations.

A detailed exposition of the mechanics of interacting events, is in press with Routledge Press [3]. A sample of the implications will show the significance of this development.

4.3 Example of the least action principle in CAT
Since equations in figure 4 are two ways of specifying the same phenomena the action calculated in both coordinate frames must be identical.
Ew \cdot \Delta Tw = Aw = \sum_{all-f} pf \cdot \Delta qf  
\text{(3)}

Subtracting gives

Aw = 0 = \sum_{all-f} pf \cdot \Delta qf - Ew \cdot \Delta Tw  
\text{(4)}

Rearranging the time variable gives,

Aw = 0 = \left( \sum_{all-f} pf \cdot \Delta qf / \Delta Tw - Ew \right) \cdot \Delta Tw = \left( \sum_{all-f} pf \cdot uf - Ew \right) \cdot \Delta Tw = \int Lw() \cdot dTw  
\text{(5)}

Where: uf = the velocity of the "fth" degree of freedom using whole system time. Lw = the Lagrangian for the whole system.

If we separate out the clock in the system, we get a standard classic formulation in which the clock is treated separately from the degrees of freedom specifying the rest of the system

\[ 0 = \left\{ p0 \cdot u0 + \sum_{all-(f-1)} pf \cdot uf - Ew \right\} \]
\text{(6)}

Subtracting the clock energy from both sides we get,

\[ \sum_{all-(f-1)} pf \cdot uf - Ew = - p0 \cdot u0 \]
\text{(7)}

The definition of the velocities in this equation used the whole system time Tw. To get actual measurement parameterization we need to use clock time units "\Delta q0\) which are usually given the symbol of a measured coordinate time "t". Multiplying equation 7 by the ratio (\Delta Tw/\Delta t) gives

\[ \sum_{all-(f-1)} pf \cdot uf \cdot (\Delta Tw/\Delta t) - Ew \cdot (\Delta Tw/\Delta t) = - p0 \cdot u0 \cdot (\Delta Tw/\Delta t) \]
\text{(8)}

Which reduces in conventional notation to

\[ \sum_{all-(f-1)} pf \cdot vf - H(pf, qf) = -p0 \cdot v0 \]
\text{(9)}

Where: vf, v0 are velocities of the measured in measured clock time. H(pf, qf) is the classic Hamiltonian, \Delta Tw/\Delta t is identified with the relativistic gamma parameter, v0 = \Delta q0/\Delta t is the constant ratio between the special displacement of the clock dial and the chosen time unit measured by that clock. This parameter is often associated with Einstein’s constant speed of light when electromagnetic clocks are used.

The form of equation 9 points out that the classic Lagrangian (left side) which is often written as the kinetic minus the potential energy of a system of interest is actually equated to the energy of the clock. In other words, the evolution of a classic system, which is usually given by state functions of time “q(t), pf(t)”, has always hidden the actual interaction with the clock. By defining time as a god given external parameter systems were also given intrinsic properties of inertia, since the clock in classic physics was the gravitational movement of the distant masses. The connection with inertia was not moved from an intrinsic property to a gravitational velocity field effect till Mach’s Principle was coined by Einstein [4]. The derivation above also shows that when the observer can be approximated as an isolated system, relativistic corrections are required because the measured clock time “t” is usually used rather than the whole isolated system time “Tw”.
For an isolated system the action difference must be zero as shown by equations 4 and 5. When a system is not isolated this restriction no longer applies. In this case “Aw” is non-zero and the non-zero value can be equated to an interaction. If we draw an interaction between a system named “I” and a universe name “U” and label the interaction arcs by the amount of action flowing from “U” to “I” is designated by “AUI,” then we can see in figure 5 that the action perceived in the 1st person subjective aspect of “I” action cycle will include the action in the 3rd person – theoretical not directly experienced – plus the action “AUI” flowing from “U” to “I.” If we subtract the unobserved action from the observed action and include I’s clock, we get the form for Hamilton’s Principle Function, traditionally given the letter “S”,

\[
S = \int \left\{ \sum_{\text{all}} p_u q_u - H(q, p) \right\} \text{d}t.
\] (10)

By substituting the momentum-coordinate definitions of actions the formula for Hamilton’s Principle Function is identified as the

\[
S = A_I^I - (A_I^I + A_{UI}) = A_{UI}.
\] (11)

Unlike the isolated case the Hamiltonian is now dependent on the coordinate and momentum variables in both systems. Typically, this is due to a potential energy dependent upon the distance between the two coordinate sets. Though A_{UI} is no longer zero its value is restricted to be a minimum as required by the least action principle.

\[
\delta A_{UI} = \delta S = 0
\] (12)

The variation of coordinates and momentums changes around the actual interactions; activities are zero when the interaction is a minimum.

This physical principle can now be given an anthropomorphic interpretation because in CAT the systems involved are interacting action loops that include subjective elements. The subjective may or may not want to participate in an interaction. An exchange of action will only happen if each partner in the exchange can transition from one stable self-contained state to another which benefits both. The absorption of an action quantity resulting in a non-equilibrium state will require more action since equilibrium occurs when all motion occurs along a minimum energy trajectory.

5. Conclusion
By recognizing that Classic Physics was developed to predict the behavior of objects that are produced
as mental displays within a larger activity. Section 3 provided a partial list of how an event-oriented world view changes the causal explanations of why things behave the way they do. Metaphysical concepts have been debated throughout the ages. Cognitive Action Theory reduces such concepts to a mathematical formalism that can be used as an engineering level calculation tool. This formalism is applicable both to the subjective and objective aspect of material.

Section 4 has provided an example of how the classic physics formalism can be adapted to a reality conceived of interacting events rather then objects. The example emphasized how god given Newtonian time can be replaced by a system time, which is calculated from all the motions present in an isolated event that includes a clock. When no longer coupled to an external clock, self-contained isolated systems are invisible and propagate within their own eigen-states of dynamic equilibrium until interactions transitions such systems to new equilibrium states. By coupling the formalism of an event-oriented world view to classic physics we expand our theories to address subjective phenomena while retaining their proven usefulness for every day practical situations.

The full and useful development of an event-oriented physics is still in its infancy. Many contemporary researchers have contributed toward the movement. A short list of contemporary pioneers from Kafatos to Walker is attached below as an Appendix. Most of these works approach the subject by attempting to expand quantum theory into non-linear formulations but still ground their lives within the current objective world view represented by what is directly seen in figure 2 above. Only the author of this paper provides a body of work [5-9] that basis our own existence on the foundational premise that we are a physical event containing its own self, and attempts to develop the physics of interacting events from there. A book documenting this development, “Cognitive Action Theory of Reality”, is to be published in 2019 [3].

Appendix - Short list of contemporary event-oriented pioneers

[A] Kafatos M. and Nadeau R., (1990) *The Conscious Universe*, Springer Verlag ISBN 0-387-97262-5

[B] Rovelli, C., (2016) *Reality Is Not What It Seems: The Journey to Quantum Gravity*, Penguin Random House

[C] Stapp, H. P. (1993) *Mind, Matter, and Quantum Mechanics*. Springer-Verlag: Berlin

[D] Tegmark M., (2014) “Our Mathematical Universe ”, Random House LLC , ISBN 978-0-307-59980-3, Chapter 10, p243

[E] Vitiello G (2001). *My Double Unveiled: The Dissipative Quantum Model of the Brain*. Amsterdam: John Benjamins.

[F] Walker, H., (2000) *The physics of Consciousness*, Perseus Publishing ISBN 0-7382-0436-6

References

[1] Mach Ernst 1867 *Contributions to the Analysis of the Sensations* (tr. C M Williams), Chicago: Open Court, (see Merker's chap for original drawing)

[2] Goldstein, H 1965b *Classical Mechanics*, Addison-Wesley (see chap 10 for theory of small oscillations)

[3] Baer W 2019 *Cognitive Action Theory of Reality*, Taylor & Francis Ltd, Routledge

[4] Sciama D W 1953 On the Origin of Inertia, M.N.R.A.S. 113, p.34

URL: http://exvacuo.free.fr/div/Sciences/Dossiers/Gravite-Inertie-Mass/Inertie/Sciama/ D%20W%20Sciama%20-%20%20Origin%20Inertie.pdf

[5] Baer W 2010a Introduction to the Physics of Consciousness *Journal of Consciousness Studies* 17 3–4 165–91

[6] Baer W 2013 Chap 4 A conceptual framework to embed conscious experience in physical processes from *The Unity of Mind, Brain and World: Current Perspectives on a Science of Consciousness*, Eds. Alfredo Periera Jr. and Dietrich Lehmann, Cambridge University Press, ISBN 978-1-107-02629-2 p.113

[7] Baer W 2014a Chap 1 The physical foundation of consciousness *Mind, Brain, and Cosmos*, ed
Deepak Chopra, First Nook Edition, (Kindle Edition 2014)

[8] Baer W 2014b Force of consciousness in mass charge interactions Cosmos and History: The Journal of Natural and Social Philosophy 10 1 (URL: http://www.cosmosandhistory.org/index.php/journal/article/view/421)

[9] Baer W 2017 Does the rose-tinted glassed effect in contemporary physics prevent us from explaining consciousness? Journal of Consciousness Studies 24 7-8