

On Probability and Knowability in Language: A Physics Perspective

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Abstract—Since the 20th century, science development follows a trend, characterized with high degrees of divergence, as well as convergence, shaking the traditional system of science disciplines. Linguistic studies follow a similar pattern, which highlights on social disciplines, but few of them take the advantage of nature sciences. In the case, this article attempts to explore two long-lasting issues in language studies from a physics perspective. Since, on the one hand, physics is a much well-developed science than linguistics, the troubles and problems the latter faces may be like those of the former. Also, the great similarities shared by the two sciences may shed light on the latter. To be more specific, in reviewing the transition from classical mechanics to quantum physics, the importance of probability is explored, and thus the concept can be used in language research. A second point is about two epistemologies in physics, namely, the Copernican principle and the anthropic principle, which proposes totally different sets of hypotheses on whether the nature of universe could be known and understood by humans. Inspired by two theories, the puzzle about the nature of language is discussed. The article concludes that, the research in physics can guide and stimulate linguistic studies.

Index Terms—linguistics, physics, probability, knowability

I. INTRODUCTION

Michael Halliday (2014) stated, in his *An Introduction to Functional Grammar*, “language as particle, wave and field” (p.387). A Chinese scholar also criticized, “the development of linguistics today is much more like that of physics in 17th century” (Zhang, 2008). Very few researchers discuss language studies under physics theories. This, however, does not mean the two sciences has an unbridgeable gap, and does not cover the works of forerunners. Albert Bastardas-Boada (2014) argued that the concept of observer effect in quantum physics could enlighten us to study linguistics. Noam Chomsky proposed language studies should follow Galilean-Newtonian style in nature science, which insisted that due to human’s limitations in science and technology, the world was unknown to us, and, in a specific field, what we should do was to try to build the known part (Feng, 2011). With the rapidly growing researches, linguistic achievements are used in some nature and social sciences, such as voice recognition, artificial intelligence, and machine translation. Meanwhile, linguistics makes use of other disciplines, and a number of new paradigms begin to emerge, computational linguistics, neurolinguistics, cognitive linguistics and corpus linguistics, to cite only a few (Wu, 1994). The studies tend to be one focuses on two or more disciplines, and an inter-disciplinary or super-disciplinary study is likely to be dominant, just as Hu (2007) said, “the situation in which one single theory dominate linguistic studies has gone with the wind since there is no perfect theory”.

There is, however, an obvious shortage in current language studies that the inter-disciplinary ways are constrained mainly in social sciences, without much work being done in nature science, and with just a few exception, computational linguistics, ecolinguistics, etc.. Based on the situation, this article attempts to explore two linguistic issues from a physics perspective, i.e., the probability and the knowability.

II. PROBABILITY

A. Research in Classical Mechanics

In 1687, drawing on the predecessors’ work, Isaac Newton’s *Mathematical Principles of Natural Philosophy* was published, a milestone that classical mechanics as a complete system was established, and the first integration of human’s nature sciences. Newton’s work affected directly, both in theory and method, physicists’ mind, research, and practice in the following 200 years and beyond. It is a fundamental revolution in nature sciences that greatly changes people’s point of views on the world and the way of thinking, and its achievements accelerates the development of chemistry, biology, astronomy, etc.. Newton, so to speak, stimulated the process of sciences in modern times (Qing, 2007, p.13). Led by Newton and other physicists, the mansion of classical physics was built so splendid that many believed all physics laws were already discovered, and its development had already reached the summit, and what was left for the coming generations of scientists was to find more details under the framework. “The future physics has to look for truth and facts after six digits after the decimal point” (Li, 2009, p.9).

The perfection and practicability of classical mechanics made the physicists believed all things and motions could be

described and predicted, both for their past and future. Under Newtonian regime “all scientists are driven by a mania of mechanical motion” (Li, 2009). After *Principles*’ publishment mechanics laws were applied to acoustics, optics, electromagnetism, and thermology and other paradigms, and even the universe was running in the way a clock swings, just as Einstein commented, “there is no complete system before Newton that can reflect the fundamental features of the experiential world” (Li, 2009, p.4). In a long time, people had a blind faith in Newton and his theories, and it lasted to the end of the 19th century.

B. *The Turn of Research in Physics*

Though some scientists, such as Gottfried Wilhelm Leibniz and George Berkeley, were skeptics and criticized Newton’s theory, those voices were buried up in his glory until a new revolution once again changed people’s mind and overturned their views about the world and the universe. In 1901, Baron Kelvin, in one address, represented two “dark clouds” in physics, which turned science direction in 20th century, and brought two pillars of the modern physics mansion: the theory of relativity and the quantum physics. One is the theory of macrocosm, and the other microcosm.

In 1905, based on relevant studies Albert Einstein’s paper *On the Electrodynamics of Moving Bodies* was published, a landmark of the establishment of the theory of special relativity. He continued to explore and discovered general relativity in 1915. Given by his theory, the explanation for the anomalous perihelion advance of the planet Mercury being proved in 1919 shocked the whole world. The theory of relativity is a key foundation of modern physics and high technology. Its establishment is the greatest achievement of nature science in the 20th century, giving far-reaching impacts to physics, astronomy and philosophy.

In 1925, inspired by Niels Bohr’s atomic framework, Werner Heisenberg and Max Born discarded the concept of atomic “path”, and laid the foundation for matrix formulation of quantum mechanics from two observables, the frequency and intensity of radiation. In 1926, drawing on Max Planck’s quantum hypothesis, Einstein’s quantum theory of light, and Louis de Broglie’s theory of matter wave, Erwin Schrodinger originated wave mechanics. Later then, he proved, mathematically, his theory and Heisenberg’s were equivalences. Paul Dirac and Pascual Jordan soon respectively represented transformational equations for the two systems, and proposed a concise and perfect mathematical expression of quantum physics.

C. *The Significance of Quantum Physics*

Quantum physics is the first theory human built with logic completeness at macroscopic scales. Not only it explains phenomena traditional theories fail, but it also provides us insights on secrets of the tiny world. A lot of new technologies come from it, with direct examples being information technology, nuclear energy uses, aerospace exploration, and nano technologies, and indirect instances ranging from life science, geoscience, and chemistry to materials science. Its application in the study of semiconductors led to the invention of the diode and the transistor, which are indispensable parts of modern electronic systems and devices (He, 2001). Thus it can be stated that without quantum physics there would be no modern computers, let alone the economic globalization and information revolution, which are the bases of the third industrial revolution. Therefore quantum physics together with relativity theory and the double helix structure are three greatest discoveries in the 20th century, which changed human concepts on time, space, motion, matter, and life.

The Copenhagen school proposed the classical explanation for quantum physics, which was composed of the probability interpretation, the uncertainty principle, and the complementarity principle. Just as American physicist and science historian Abraham Pais commented on the probability interpretation, “the introduction of probability into quantum physics is likely to be the most dramatic change in science. Meanwhile, its discovery marks the end, not the beginning, of a revolution” (Li, 2009, p.314). In Pais’ view (favored by most physicists today) the probability interpretation proposed by Born provides a perfect completion for the establishment of quantum physics.

Born’s probability interpretation has much far reaching effects and significances. Nancy Greenspan named her Born’s biography *the End of the Certain World*, because the probability interpretation he originated became a truly fundamental scientific method, and he was the one who shattered the certain world defined by classical physics. Born’s interpretation broke the classical determinism in Newtonian physics world. Also, it denied what believed by Immanuel Kant the efficacy of determined necessity, and created the new paradigm of the world (Hou, 2013).

Classical mechanics also frequently refers to probability, however its basic rules are determined. Starting from the micro structures and interaction of matters, the tasks of statistical mechanics are to represent and predict the macro physical system, composed of large quantities of particles. If the amount of substance reaches at the same level of Avogadro’s constant, the quantity of particles is so large that its mechanics equations cannot be solved, and it has to be dealt with statistical analysis. According to Copenhagen school, however, probability in quantum physics is a fundamental principle. Even a simple system like hydrogen atom has to be described by probability. On nanoscopic scales, probability is related to the uncertainty principle which asserts a moving particle’s path is undefined, either its position or momentum that can be defined, but not the both at a given time. According to this principle, a particle may be at any point in the space, and travel at any speed, and may even be various places at the same time. Its speed and position are certain at the instant of measurement as if it “knows” someone is measuring it and, accordingly, its path becomes clear. This is called observer effect, a perspective claims that the measurement introduced brings the deviation to the system, which collapses from superposition states, in which many states of the system are co-existing, to a

particular state that is prominent and observable.

Though the certainty on micro scales is excluded by quantum physics, the theory based on the probability interpretation is a precise one for the physical world, in which the theory is tested repeatedly and is applicable. A typical example is the innovation and development of quantum computers, a computation system that makes direct use of quantum-mechanical phenomena, such as superposition and entanglement, to perform operations on data. The field of quantum computing was first introduced by Yuri Manin in 1980 and Richard Feynman in 1982, and David Deutsch designed its first blueprint in 1985, which combined quantum mechanics and information processing (Zhang & Zhang, 2004). In principle, quantum computers are much faster than the classical ones, and have the potential to be an effective way to lead new innovations in other branches of science.

D. *Implications to Linguistic Study*

From above discussion, we can see that linguistics and quantum physics share a similarity, that is, both have a high degree of indeterminacy. The property in language is reflected at least in two ways. First of all, language does not only links the physical world with mental activities, but also it is a biological activity, which is initiated from a body of great uncertainties. Taking language production for example, a point is formulated, and then expressed by words. In the process, even though an idea in mind can be conveyed by different tongues, some expression is eventually chosen and emerge. The question here, however, would be that before we speak it out or write it down we cannot make sure the exact language we may use, and it seems that the expression is determined at the very moment we produce it, to the extreme that we may not realize what our words are even when we speak. Taking language context into consideration, some words are more common and regular than others, but it is not absolutely so. Here, it may be more appropriate to use probability to explain language, a much more convincing description than the way of certainty.

Secondly, western linguistics circle has been sharing the recognition of uncertainty, regarding the relationship between language signs and meaning. Saussure saw language as an arbitrary system of signs, which was composed of the signifier and the signified. He believed that the relationship between the two elements was arbitrary, or to simply put it, “languages are arbitrary” (Saussure, 1972, p.113). Such arbitrariness is randomly produced. Though some scholars proposed theoretical frameworks for it, such as minimalist program, they were not universal principles. Similarly, ancient Chinese argued the issue of “Ming” (representing for the appearance or the form) and “Shi” (representing for the nature or the reality), and in a sense “Ming” is identical with the signifier and “Shi” the signified in Saussure’s theory.

Linguistic studies focus on certainty over time. In systemic functional linguistics there is the concept of proximity and probability, but it is not the main point. Functionalism pays much more attention to language description, being especially more prominent in syntactic analysis. Structuralism takes a step further, abandoning the closely related factors of semantics, i.e., context, society, and infrequent language usage, etc., and tries to propose a language generating theory, following a mechanism fashion. There attempts seek to study uncertainties in language, with the starting point in certainties, a much similar pattern with classical physics. Is there any possibility to study language based on its uncertainties, and to follow a quantum physics way?

Through the transition from classical physics to quantum physics discussed above, we can find that the development of linguistic studies goes an amazingly similar route. Shall we still be confined to the conception of certainty, and, taking the other way round, study certainty starting from its uncertainty? Language is not static in nature, and has quantum superposition states: people have various choices of expressions at certain moments for the same meaning, and the specific choice is not settled, also the various potentials share the same probability. However, the intrusion of some background information, both personally and impersonally, breaks the balance in the moment, interfering language system and leading to a regular expression under the context.

III. KNOWABILITY

A. *The Copernican Principle and Language*

The second discussion concerns with the knowability of language, i.e., whether humans have the ability to understand the nature of language in final analysis. Likewise, there has long been a heated debate in physics on the nature of the world.

It has a long history for the argument in physics and philosophy that if humans and the earth are unique in the universe. In the early days, due to people’s limited knowledge of the physical world, they tended to agree with the idea, leading to the theories such as geocentrism and heliocentrism. Based on such perception, the main stream was more likely to believe the earth was the center of the universe, and humans were the only intelligent beings in it. Even people know more and more about nature in a much more in-depth way, the controversy on the issue never ceases to stop, and continues up until today. There born two totally contrary epistemologies in physics in the 20th century, namely, the Copernican principle and the anthropic principle.

In 1543, Copernicus’s *On the Revolutions of the Heavenly Spheres* was published, elaborating that the earth was not the center of the universe, and, just like other planets, it was orbiting around the sun, which was the solo center of the system. Drawing on latest researches, scholars developed the theory, i.e., the modern Copernican principle. A basic point of the principle says that the existence of humans and the earth comes from the pure chance. The appearance of

the life and the earth is a matter of probability, which is also true for solar system and the creation of the universe, and the structure of atoms. The Copernican principle ruthlessly denies humans' uniqueness, and takes a further step, claiming that humans are not privileged observers and all positions share the same privilege. The principle can be extended to the extent that any observer in the universe will observe the universe on large scales the exactly same with us, i.e., the universe is generally homogeneous or the same everywhere (at any given time) and is also isotropic about any given point. Such a theory leads to a conception: since human existence is a matter of probability he may never be allowed to have enough time to evolve to have required intelligence to understand the nature of the physical world, including the universe. Due to the large quantities of coincidences in the long process of evolution, such possibility may not exist.

As for language, many believe its nature would remain unknown for us as it is interwoven with consciousness. An embarrassing situation is that the study on human consciousness hardly makes any significant progress. The study of artificial intelligence also faces the dilemma: a little improvement in intelligence of machines would go far beyond our abilities. The current technology enables the machines to have an identical IQ with 4-year old child, leaving out the emotional factors. On the other hand, though there are various language schools with relatively complete theories, they do not reach an agreement concerning the nature of language, and such divergence even exists in different branches within the same school. Such language perspective accords with the Copernican principle.

B. The Anthropic Principle and the Language

There is completely different epistemology from the Copernican principle in physics, that is, the anthropic principle. Looking at the results of studies in nature sciences, a lot of phenomena emerge by coincidence like a miracle, one that cannot be explained by rationality or the logic and incorporates large amount of extremely low probability events. If atomic energy levels are different from what they are today, atoms are impossible to come into formation, let alone the molecules, and the materials composing the physical world. If the earth is too close to the sun, its surface would be over heated, water will be evaporated, losing the source of life; if it is too far from the sun, temperature decreases, chemical activity recedes, leading to a hard condition for life. The density of water reduces when frozen, the ice thus can float on the surface and preserves the heat below, and, adding the effect of terrestrial heat, the underneath water remains liquid. If not so, ice falling on the bottom, the planet would be a frozen world, in which there must be no life evolution, at least not in today's form. All these are so "perfectly designed".

Based on the above discussion, Brandon Carter was the first to propose the anthropic principle in 1973. One point is that the current physical world and objective rules "cater" to the very need of human existence, in a degree like a tailored design for us. The anthropic principle is thus one theory asserting that the physical world fits the intelligent beings observing it. If this is the case, humans then can develop enough wisdom to reveal the laws of universe. A proof by contradiction of the principle goes as follows: the reason why we live in a universe "tuned" so precise that makes life possible is that if it is not so humans will not appear, not even to mention to discuss about it. If any fundamental physical constant differs from what it is now, the universe will be totally different, and the life today may never appear and think about it. Therefore, the universe must have the properties that allow life to evolve. In other words, the principle ensures human privilege and provides the potential for humans to acquire enough intelligence to know and understand the nature of the universe.

Similarly, language is indeed much tailored to human's way of thinking and cognition, a persuasive example being that no species can learn our words on the planet. There is an obvious fact that human's process of mother tongue acquiring is very natural and effortless, regardless of whether it being a simple one like English or the one with complex grammatical rules as Sanskrit. The learning of speech is more distinct since a man can get hold of it whether he is an educated man or not. And even a grown man can still learn many other languages. Thus, language is human's unique and special creation. As the language being what it is today can we believe if the language is not its current formation people would not study it now? In present time, we begin to know language in a more and more complete way, implying humans are endowed with a potential to study it. As the trend keeps in momentum, mankind will reveal the nature of it in the final end.

IV. CONCLUSION

Today's society needs more integration between different sciences, and in these inter-disciplinary areas there would be new approaches to resolve long standing problems and challenges. It is a practical action that European countries have been exploring the possibilities to implement liberal education for quite some time. Another example is the tendency that linguistic studies tend to incorporate with other branches of science, sociolinguistics, computational linguistics, and biolinguistics, to name just a few.

Linguistic studies long have the tradition to learn from on other sciences, because some deep rooted issues cannot be resolved by language study itself. If we can take the advantages of other disciplines and cross the boundary between them, the theories we propose would be superior, with more explanatory power, and more applicability. In recent years, Jim Martin introduced biological and historical conceptions and research methods into the research of genre and register, leading to the integration of systemic functional linguistics and legitimate code theory; making the use of imaging technology to the study of language Jonathan Webster created visual semantics (Pan & Xin, 2012).

On the other way around, other scientific researches also draw on linguistic studies. A prominent instance is artificial intelligence study, which facilitates cognitive research. It is generally recognized that cognitive science is founded and stimulated by philosophy, logic, linguistics, psychology, computer science, and neurology. And cognitive science in turn contributes to cognitive linguistics. In this respect, the relationship of linguistics and other sciences is mutual.

To conclude, linguistics and physics can be mutual stimulus for each other, and the research methods of the later may spur development of the former.

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