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THE PSYCHOLOGICAL ARGUMENTS IN THE STRUCTURE OF SCIENTIFIC REVOLUTIONS BY THOMAS KUHN [1]

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ABSTRACT. The role and recognition of psychology in the field of epistemology has always been the vector of various controversies. Among authors who rejected it and others who chose it as an important element, we highlight the historian and philosopher of science Thomas Kuhn. In the present article we will list the various arguments and all the psychological theories cited by that epistemologist in the course of his most influential work: The Structure of Scientific Revolutions. The way Kuhn uses psychological knowledge reveals how his propositions on scientific construction rescue the epistemological value of psychology because, when describing the processes inherent to a scientific revolution, the sociological and historical approach was invariably supplemented by the field of psychology. Thus, to explain the current conformation and engenderment of the "hard sciences", it was necessary to resort to the "soft sciences". In face of this apparent contradiction, we will depart from the situation in which critiques of Kuhn's alleged subjectivism involve psychology to understand how the author employs it in what he called "the psychology of scientific inquiry." Consequently, we will answer questions arising from this use, such as the statute of scientificity of psychology within its own theories and the legitimacy thereof as an epistemological tool.

Keywords: Psychology of scientific inquiry; epistemology; Thomas Kuhn.

OS ARGUMENTOS PSICOLÓGICOS EM “A ESTRUTURA DAS REVOLUÇÕES CIENTÍFICAS” DE THOMAS KUHN

RESUMO. O papel e o reconhecimento da psicologia no campo da epistemologia sempre foi vetor de diversas controvérsias. Dentre autores que a rejeitaram e outros que a elegeram como elemento importante, destacamos o historiador e filósofo das ciências, Thomas Kuhn. Neste artigo listaremos os diversos argumentos e todas as teorias psicológicas citadas pelo epistemólogo no decorrer de sua obra mais influente: *A estrutura das revoluções científicas*. A forma como Kuhn utiliza o saber psicológico nos revela como suas proposições sobre a construção científica resgatam o valor epistemológico da psicologia, pois, ao descrever os processos inerentes a uma revolução científica, o enfoque sociológico e histórico foi invariavelmente

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complementado pelo campo psi. Assim, para explicar a atual conformação e engendramento das “ciências duras”, deu-se como necessário o recurso às “ciências brandas”. Diante desta aparente contradição, partiremos da situação em que críticas a um suposto subjetivismo de Kuhn envolvem a psicologia, para compreender como o autor a emprega no que ele denominou de “psicologia da investigação científica”. Consequentemente, responderemos questões decorrentes desta utilização, como o estatuto da cientificidade da psicologia dentro de suas próprias teorias e a legitimidade desta como ferramenta epistemológica.

Palavras-chave: Psicologia da investigação científica; epistemologia; Thomas Kuhn.

LOS ARGUMENTOS PSICOLÓGICOS EN LA ESTRUCTURA DE LAS REVOLUCIONES CIENTÍFICAS DE THOMAS KUHN

RESUMEN. El papel y el reconocimiento de la psicología en el campo de la epistemología siempre ha sido vector de diversas controversias. Entre autores que la rechazaron y otros que la eligieron como elemento importante, destacamos el historiador y filósofo de la ciencia Thomas Kuhn. En este artículo enumeraremos los diversos argumentos y todas las teorías psicológicas citadas por el epistemólogo en el transcurso de su obra más influyente: La estructura de las revoluciones científicas. La forma en que Kuhn utiliza el saber psicológico nos revela cómo sus proposiciones sobre la construcción científica rescatan el valor epistemológico de la psicología; pues, al describir los procesos inherentes a una revolución científica, el enfoque sociológico e histórico fue invariablemente complementado por el campo psicológico. Así, para explicar la actual conformación y engendramiento de las "ciencias duras", se dio como necesario el recurso a las "ciencias blandas". Ante esta aparente contradicción, partiremos de la situación en que críticas a un supuesto subjetivismo de Kuhn abarcan la psicología, para comprender cómo el autor la emplea en lo que él llamó "psicología de la investigación científica". En consecuencia, responderemos cuestiones derivadas de esta utilización, como el estatuto de la cientificidad de la psicología dentro de sus propias teorías y la legitimidad de ésta como herramienta epistemológica.

Palabras clave: Psicología de la investigación científica; epistemología; Thomas Kuhn.

Introduction

The book *The Structure of Scientific Revolutions* (SSR) by Thomas Kuhn (2007), first published in 1962, established a new concept for thinking about scientific work. For that,ite proposed the notions of pre-science, normal science, paradigm, anomaly, scientific revolution, incommensurability, etc. These notions were quickly assimilated - not always in the way they were proposed - and also quickly criticized.

Initially, we will highlight two types of critiques made to Kuhn's book: on the multiplicity of definitions of paradigm, which presents an "excessive plasticity" (Kuhn, 1989a, p. 583); and subjectivism in the analyzes carried out. Criticism of the multiplicity of definitions of the notion of paradigm led Kuhn to revise this concept in the *Afterwords* of the 1969 edition, identifying two basic conceptions for the notion of paradigm: sociological meaning (shared

beliefs, values and techniques)[4] and puzzle solutions (shared examples). The second definition is directly related to the critique of subjectivism and even irrationalism of Kuhn's approach.

Subjectivism is evidenced in several aspects: (a) in the daily work, during the period of normal science, the researcher uses non-explicit knowledge, tacit knowledge, according to Polanyi (1974); (b) the acceptance of a given paradigm by researchers depends on factors that pass over full rationality, because it is supported by beliefs in the future development of science, by aesthetic aspects seen in the new ideas, or even linked to autobiographical idiosyncrasies; (c) after a scientific revolution, from the paradigm shift, the researcher starts to work "in a different world" (Kuhn, 2007, p. 159); (d) in the use of psychological concepts to explain scientific practice. In this article, we will cover, in a specific way, the last of the four elements mentioned above, the different psychological arguments present in SSR by Thomas Kuhn.

In order to analyze Kuhn's uses of psychological arguments, it is important to understand that the model presented concerns the natural sciences, that is, the term paradigmatic (or mature) science refers to certain sciences and does not refer to others. As the notion of paradigm is linked to consensus, "something shared by the members of such communities" (Kuhn, 2007, 224), and psychology unfolds in a variety of competing theories, evidencing the lack of consensus, it should not be considered as paradigmatic and not even as pluriparadigmatic: "The conception of paradigm that emerges from Kuhn's writings is, in its nature, of consensual, and since there is no relative consensus, speaking in paradigm is artificial to the Kuhnian formulations" (Carvalho, 2012, p. 26). And, even if one cannot affirm the prospective nature of Kuhn's conceptions, that is, one cannot say whether psychology will ever reach a consensus (Assis, 1993), the fact is that, in SSR, Kuhn does not postulate "the idea of coexisting plurality of paradigms, but rather the replacement of paradigms after revolutionary episodes" (Carone, 2003, p.14). In this sense, psychology presents itself as a pre-paradigmatic knowledge.

However, the historical method of Thomas Kuhn was not aimed to analyze the scientific character of psychology, which did not prevent him from approaching the scientific field from psychological conceptions (Carone, 2003). Therefore, by using historical elements to analyze the scientific development, inserting various psychological arguments, Kuhn proposes "a true psychology of research" (Brunetti & Ormart, 2010, p. 110). This type of approach is not restricted to the book in question, SSR, but must be seen in perspective, characterizing, according to Brunetti (2013), three steps: former Kuhn (from the early texts from the late 1940s to SSR); transition (elaboration of responses to initial criticisms); and latter Kuhn (texts from the 1990s that attenuate the most peremptory statements and organize the unclear propositions of the initial period). In the first conceptions, the interest was in knowing "what happens in a scientific community", then it passes to the possible recognition that in such communities "there are real individuals", and, finally, to study the processes that contribute to the improvement of scientific achievements that take into account "the nature of these processes in the mind of man of a particular and concrete science that has certain psychological functions" (Brunetti & Ormart, 2010, p. 112).

Without forgetting Thomas Kuhn's long theoretical development path after 1962, our scope will be restricted to the former Kuhn, addressing more specifically the psychological

[4] In order to refine the concept of paradigm, Thomas Kuhn (2007, 1989a) starts to call, in the *Afterwords* of 1969 and in the article *Reconsiderations on Paradigms* of 1974, the sociological meaning no longer as a paradigm, but by *disciplinary matrix*, and the term paradigm only fits to shared examples.

arguments found in the SSR book. In this sense, we have identified the following references to psychology[5]: (a) social psychology; (b) cognitive psychology; (c) Gestalt psychology; (d) the notion of the unconscious and the possibility of enlightenment during unusual states of consciousness, based on the assumptions of Jacques Hadamard (1954); (e) genetic psychology of Jean Piaget (1970; 2001). Before we go through the analyzes of each of these topics, two observations are necessary: Thomas Kuhn makes approximations with varied psychological theories; and some of these approaches are transitory, while others are more permanent (Brunetti & Ormart, 2010; Brunetti, 2013). The first observation cannot be seen as the affirmation of a possible pluriparadigmatic character of psychology, given the incoherence with Kuhn's propositions in SSR (Carone, 2003). The second observation indicates the procedural (historical) and epistemological characteristics of the model of scientific construction presented by Thomas Kuhn.

Social psychology and sociology of scientists

Thomas Kuhn makes only a direct reference to the term social psychology, without however indicating methods, authors or theories: "many of my generalizations concern sociology or the social psychology of scientists" (Kuhn, 2007, p. 27). At this point, Kuhn refers to sociology and social psychology interchangeably. This indistinction is parallel in his opposition to the differentiation between context of discovery and context of justification. Based on these distinctions, Israel Scheffler (1982) criticizes Kuhn's alleged irrationalism. While sociology emphasizes the inherent aspects to the scientific community, which through rules, language and rational debate modulate the persona of the scientist, social psychology inverts the vector and proposes the study of the individual that impacts the collective aspect. In this sense, we would have the differentiation between sociology and social psychology from the distinction between context of justification and context of discovery, respectively. In Kuhn, even though it is too generic, the reference to social psychology points to the attempt to overcome the differentiation between contexts of justification and discovery, as well as the organization of a scientific community. We have, therefore, the articulation method/society, that is, between theoretical parameters, values and beliefs, with daily aspects of a particular group, of a scientific community. We can infer that the main object of analysis from the dyad social psychology/sociology is, for Kuhn (2007), normal science or paradigm-based science. The main "sociological characteristics of scientific communities" (Chalmers 1993, p. 123) presented for this period are as follows:

• Normal science is characterized by the improvement of the current paradigm, through "finishing operations" (Kuhn, 2007, p.44), which occupy almost all the researcher's time. It is, therefore, a research based on past achievements, which that serve as models for the student to be prepared for their inclusion as a member of the scientific community. Examples of problem solving make normal science a highly determined project. This is not to say that it is totally determined. Existing openings and enhancement opportunities enable

[5] As we have just said, we will approach the issue only in reference to the SSR book. In the paper *A Function for Thought Experiments* of 1964 in the book *The Essential Tension*, we find again some of these references, as well as a direct reference to William James's concept of fringe consciousness (Kuhn, 1989b). James is also quoted in SSR in the following excerpt, when the subject of anomaly is approached from the deck of cards experiment which will be addressed ahead in this text: "What a man sees depends both upon what he looks at and also upon what his prior visual-conceptual experience has taught him to see. In the absence of such training there can only be, in William James' phrase, a 'bloomin' buzzin' confusion' "(Kuhn, 2007, p.150). This peripheral reference to the psychology of William James will not be developed in this article. Some studies point to a relation between the conceptions of Thomas Kuhn and the pragmatic philosophy, of which William James is one of the exponents (Marcondes, 2000).

edges to be trimmed, concepts to be improved and technologies to be developed, indicating a cumulative character. The fascination of normal science, for those who practice it, lies in the possibility of problem solving (jigsaw puzzles).

- The scientific community assumes that it knows the world.
- There is little interest in the big news, which are often suppressed.

The scientific community is organized from a current paradigm that provides "modeling problems and solutions for a community of practitioners of a science" (Kuhn, 2007, p.13). The analysis of group (or community) aspects points out that, for the establishment of a paradigm, there is no principle based on rationality (Chalmers, 1993), on experiments or on possible falsifiability, but in aspects referring to a "socialization process" (Kuhn, 1989a, p. 375).

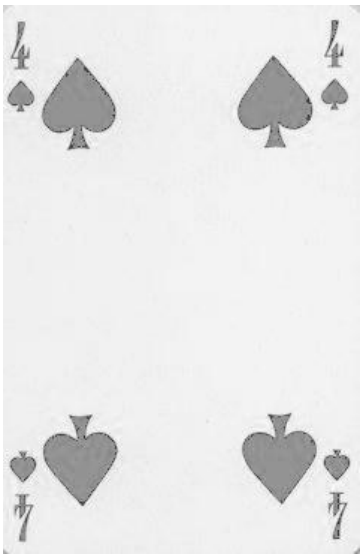
This socialization process is based on educational practices in which the members of a particular scientific community, especially the younger ones, acquire knowledge to establish the significant facts, to correlate them with theoretical aspects and to articulate in a coherent way the theoretical conceptions. For this purpose, problem-solving practices, through laboratory instruments or using pencils and paper, are crucial. The resolution of jigsaw puzzles organizes the process of socialization and the knowledge acquired in these educational games is materialized in the scientific manuals, sedimenting the knowledge in a certain tradition (Kuhn, 2007).

Cognitive psychology

Whereas social psychology serves as a basis for understanding the aspects that make it possible to organize a given scientific community by using a paradigm as a parameter, cognitive psychology is used in Kuhn's arguments for analyzing periods of crisis when an anomaly can no longer be ignored, that is, when "members of the profession can no longer escape anomalies" (Kuhn, 2007, p. 24). Cognitive psychology, therefore, serves as a comprehensive model for anomalous phenomena, of paramount importance in the moments of transition from one paradigm to another. In SSR, the playing cards experiment, which shows some cards with reversed colors (Figure 1), is directly related to the notion that expectancy interferes with perception (Bruner & Postman, 1949). Thus, when the cards are passed, the subjects of the experiment usually cannot immediately recognize the cards with the reversed colors. The same thing happens with anomalous phenomena to a given paradigm.

Over time, however, the anomaly would be perceived, considering three possibilities for the end of the crisis: (a) the anomaly is absorbed by the current paradigm; (b) the anomaly is left aside so that the coherence of the paradigm is maintained; (c) the anomaly cannot be absorbed by the current paradigm and cannot be ignored, provoking a new form of perception, that is, a scientific revolution through a paradigm shift (Kuhn, 2007). This period of crisis, when a new paradigm can emerge, is of "pronounced professional insecurity" (page 95), in which emotional and subjective aspects are involved.

Figure 1. Anomalous letter from Jerome Bruner and Leo Postman[6]



To understand these moments of essential tension (Kuhn, 1989c), the theoretical framework of psychology is of utmost importance in Kuhn's conception. According to Brunetti and Ormart (2010), Kuhn's interest in the psychology of knowledge lies in the possibility of clarifying the paradigm shift from historical examples combined to the cognitive change mechanisms that are experienced by some researchers. In this way, the researches about the scientific communities - with their modes of organization and transmission of knowledge - are added to the understanding of the ways of perception of given situations and conception of the world (Kuhn, 2007).

The notion of scientific activity has a dual statute for Kuhn (2007): the current paradigm consists of groups, establishes norms to be followed, examples that must be learned and a certain world view that directs the researches performed; while the paradigm shift derives, in principle, from the subjects who practice science. These two topics stipulate a critical point in Kuhn's work because he is accused of subjectivism or of claiming that science is based on irrational aspects stipulated by persuasion (characteristic of the scientific community) and by the conversion of perceptions (characteristic of cognitive aspects of researchers) (Scheffler, 1982). The second aspect is clearly the main target of criticism:

> I am occasionally accused of glorifying subjectivity and even irrationality because I insist that what scientists share is not sufficient to command uniform assent about such matters as the choice between competing theories or the distinction between an ordinary anomaly and a crisis-provoking one (Kuhn, 2007, p. 232-233).

[6] "Anomalous" card of Jerome Bruner and Leo Postman, made for the realization of the experiment described in *On the Perception of Incongruity* (1949). This card, a four of swords with red suit, which is normally black, was presented in a tachistoscope. The experimental subject was asked to name the card seen. Kuhn compares the phenomenon of disruption (Bruner & Postman, 1949), perceptual disorganization of the subject that confronts the anomalous card, with the scientist who is incapable of understanding an anomalous phenomenon to the current paradigm.

The perceptual processes surveyed by Jerome and Bruner (1949) stipulate, according to Kuhn (2007), the ways in which researchers deal with anomalies in times of crisis. The possibility of new discoveries or scientific inventions is counterbalanced by the way in which this expectation presents itself as a backdrop, against which novelty can only emerge with difficulty. When he mentions the parallel between the paradigm shift and the experiment of cards with reversed colors, Kuhn states:

> Either as a metaphor or because it reflects the nature of the mind, that psychological experiment provides a wonderfully simple and cogent schema for the process of scientific discovery. In science as in the playing card experiment, novelty emerges only with difficulty. [...] I have already urged that that process or one very much like it is involved in the emergence of all fundamental scientific novelties (p. 90-91).

Gestalt Psychology as a Perceptual Metaphor and its Intersection with Cognitive Psychology

Gestalt psychology is widely used in SSR and characterized as an explanatory model to evidence the fundamental difference in the way scientists of distinct paradigms observe their objects of study. The period in question is crisis/revolution and the term Gestalt exchange is used by Kuhn as a metaphor for the process of scientific discovery, which resembles a turning point in perception. To clarify this phenomenon, Kuhn (2007) uses the psychological study conducted by Jerome Bruner and Leo Postman (1949). As mentioned above, in this research, playing cards are presented to the experimental subjects through a timed device in small intervals. Amidst the usual cards, there were anomalous cards, whose colors were reversed. Only a few participants were able to correctly recognize the modified cards, while the majority neglected the difference or presented confusion and stunning in the face of the break of their expectations. Having this experiment as a parameter and metaphor, Kuhn understands the process of paradigm shift:

> Therefore, at times of revolution, when the normal-scientific tradition changes, the scientist's perception of his environment must be re-educated - in some familiar situations he must learn to see a new form (gestalt) (p. 148).

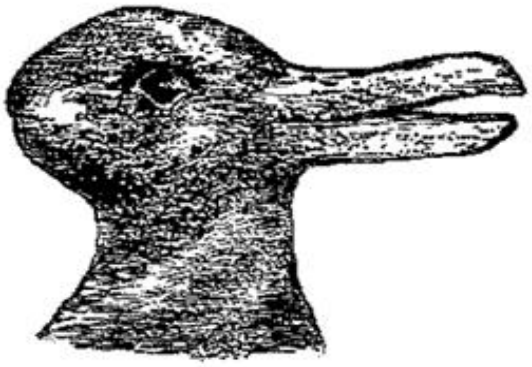
In this case, Kuhn uses the result of a cognitive psychology experiment, combining it with conceptions of Gestalt psychology to clarify the mechanism of the distinct way of seeing the world, making an amalgam between theories[7] (Bruner & Postman, 1949; Bruner, Postman & Rodrigues, 1950; Kofka, 1975). The way in which perception is restructured is compared to the discovery and differentiation of scientific paradigms: "It is suggestive as elementary prototypes for these transformations that the familiar demonstrations of a switch

[7] This kind of amalgam does not take into account that the experiments of Bruner and Postman (1949) conclude that the expectations and previous experiences of the subjects interfere completely in the construction of their perceptions, whereas the Gestalt psychology excludes these factors and the observer's intention as determinants of the perceptual result: "the sensory organization, with its interaction of strengths resulting in a minimum of tension remaining in the sensory field, is a relief of tension without action "(Koffka 1975: 353). Bruner, Postman, and Rodrigues (1950) affirm the issue of noetic perception, while Gestalt gives indications that interest and ego can at best co-determine the articulation of the field. The difference is that the noetic perception poses a "hypothesis" to be confirmed or not in relation to the external event, whereas for the Gestalt the interest factor is only a condition for the formation or not of the image. Thomas Kuhn's (2007) use of multiple theories and their combined results to explain his own views are important data on how psychology is viewed and used by him.

in the visual form (gestalt) prove so suggestive" (Kuhn, 2007, p. 148). Such a correlation can be understood by looking at an iconic figure for demonstrating processes in Gestalt psychology.

The image to which Thomas Kuhn refers to has two characteristics: the figure of the rabbit and duck are mutually exclusive; and there is no middle ground between one outcome and another (Scheffler, 1982). In this way, the subject observes a rabbit or a duck, while some people cannot vary this perception until someone indicates the other possibility (fig.2).

Figure 2. The rabbit-duck of J. Jastrow [8]



The intersection of this psychological argument with scientific discovery is that the possibility of altering the way in which a given phenomenon is observed occurs at times when new solutions are needed to solve hitherto unsolvable problems: "the switch of preception (gestalt), particularly because it is today so familiar, is a useful elementary prototype for what occurs in full-scale paradigm shift" (Kuhn, 2007, p. 117).

Although issues involving a discovery or reinterpretation of scientific phenomena are much more complex than the mere reconfiguration of perception, Thomas Kuhn (2007) says that the process is analogous: "The conversion experience that I have likened to a perspective (gestalt) switch remains, therefore, at the heart of the revolutionary process" (p.253). The difference between the observer of a dubious image and the scientist who changes a scientific concept is that, for the latter, there is no possibility of choosing the moment to alternate from one view to another, nor is it possible to return to the previous view through conscious effort.

[8] The rabbit-duck of J. Jastrow. The perceptual result of the image has two possibilities. The shift from one to the other is what was called the Gestalt switch by Thomas Kuhn. The epistemologist uses as an example the optical illusion of J. Jastrow (2007), originally published in *Fact and Fable in Psychology* in 1900.

The concept of the unconscious through Jacques Hadamard

The notion of the unconscious is used by Thomas Kuhn (2007) in SSR only once, when he addresses the possibility of paradigm shift: "What happened between a first perception of the problem and the recognition of an available alternative must have been in largely unconscious"(p 118). In addition, the word archetype is used once to designate paradigm: "Other problems that were previously non-existent or trivial may, with a new paradigm, become the very archetypes of significant scientific achievements" (p.137). We should not, however, draw hasty conclusions by inferring that Kuhn refers to psychoanalysis or analytical psychology.

In addition to unconscious aspects, Thomas Kuhn (2007) points to the important role of consciousness and also the lightening of intuition. These two aspects are essential for the emergence of new phenomena, which must consider "the previous awareness of anomaly, the gradual and simultaneous emergence of recognition" (p.89). But this process is not always gradual and can break new ideas abruptly:

> Scientists then often speak of the "scales falling from the eyes" or of the "lightning flash" that "inundates" a previously obscure puzzle [...] On other occasions the relevant illumination comes in sleep. No ordinary sense of the term 'interpretation' fits these flashes of intuition through which a new paradigm is born (Kuhn, 2007, p. 160).

At this point, Kuhn (2007) observes that the process of sudden knowledge sometimes occurs from oneiric images. For that, his observations are based on the studies developed, not by psychologists, but by the mathematician Jacques Hadamard (1954). Psychodynamic aspects lead Hadamard to establish a correlation between unconscious manifestations and scientific practice. The theoretician who supports the propositions of the mathematician is the English social psychologist Graham Wallas (2014), who has reservations about the Freudian assumptions[9].

Thomas Kuhn (2007) uses the term lighting, which structures Jacques Hadamard's thinking (1954), constituting one of the four stages of the process through which an idea arises in the mind of a scientist: (a) Preparation, a conscious attitude of attempting to solve a given problem; (b) Incubation, unconscious processes of combining difficult-to-solve or insoluble ideas in the first attempts; (c) Enlightenment, emergence of a partial result from the unconscious to the field of consciousness; (d) Verification, a conscious lapidation work, with the intention of confirming and expressing the discovery in articulated terms and in suitable language for communication.

According to Polanyi (1974), these four stages were conceived by the mathematician Henri Poincaré (2014), consisting of the mobilization of unconscious processes, which arise from initial conscious effort. This long path occurs partly autonomously and can produce ideas that emerge in the consciousness and often configure solutions to scientific problems satisfactorily (Hadamard, 1954). We thus have psychological aspects parallel to those of sociological scope in the crisis of a paradigm.

[9] For Graham Wallas (2014), Freud's theory fits into what he calls the *Mechanistic School*, a group of theories describing the psychic system through metaphors that refer to mechanical functioning. The mechanistic view determines a clear separation in psychological phenomenology: the division between a machine that is moved and an engine that is the driving energy. Besides Freud, the author indicates MacDougall and MacCurdy as members of this field. In this case, the libido of psychoanalytic theory, according to Wallas, rescues the image of the mechanical driving energy. Such explanations are, according to Wallas, a rather inaccurate picture of psychic functioning, as well as inhibitors of the progress of a more adequate description of the psychological apparatus, since they offer an easy metaphor that prevents deepening in relation to the aspects of psychic phenomenology.

The dialogue with Jean Piaget and genetic psychology

The meeting of Thomas Kuhn (2007) with the genetic psychology of Jean Piaget happened by chance and developed as an intense dialogue[10] between the two authors: "a footnote encountered by chance led me to the experiments by which Jean Piaget has illuminated both the various worlds of the growing child and the process of transition from one to the next" (p.11) . The various worlds of the child served as an analogy to think of the different worlds of scientists who do not share the same paradigm. The parallel between the development of the individual and the processes of the history of science is present even in Piaget's own studies, which "displayed concepts and processes that also emerge directly from the history of science" (p. 11). Genetic psychology makes it possible to clarify the dual importance that the scientific community and the individual have for the development of scientific ideas. In addition, Piaget's (1970; 2001) propositions about the different stages of childhood, in which cognitive orientation occurs through jumps and reorganizations of contents, served as the basis for Kuhn's conceptions on the ruptures that occur between scientific models with paradigms. Just as children in the same stage tend to make the same mistakes in the face of identical experiments, scientists adhering to a particular paradigm observe the world through patterns that make it difficult or even impossible to see phenomena in any other way. We would thus have an analogy between child development and the construction of scientific knowledge.

Genetic psychology is important, for Kuhn (2007), also because it brings different contributions to Gestalt psychology. In an attempt to elucidate two aspects - referring to the scientific community and the individual's participation - Kuhn observed that Gestalt psychology makes it possible to understand the incommensurability between paradigms from the historical point of view, but it was insufficient in relation to the psychological mechanisms involved in this process (Brunetti & Ormart, 2010). The issue of continuity/discontinuity in psychogenetic processes served as an index, leading Kuhn to find correlates in the history of science, such as the non-cumulative development of scientific theories (Garcia & Piaget, 2011; Kuhn, 2007; Piaget, 1970; 2001).

The relationship between psychology and epistemology

At the beginning of SSR, Thomas Kuhn (2007) reports that he moved from physics to the history of sciences and from this to philosophy. We can see, however, that in the midst of these changes there is also the use of various psychological knowledge, complementary to sociological knowledge: "From Kuhn's point of view, the types of factors that prove efficient in making scientists change of paradigm is a matter to be discovered by psychological and sociological research" (Chalmers, 1993, p. 133). Aiming at clarifying the scientific context through a retrospective analysis (Assis, 1993), Kuhn's arguments are therefore permeated by three disciplines: history, sociology and psychology. While Kuhn explicitly states

[10] In addition to Thomas Kuhn's (2007) references to Piaget's work in *Psychogenesis and the History of Science*, Garcia and Piaget (2011) address issues related to the relationship between the individual and the social environment, taking into account Kuhn's conceptions. Even though Piaget does not fully agree with Thomas Kuhn's statements, the dialogue between them is evident. Specifically in SSR, this dialogue can be divided into two moments: the psychologist's studies serve as a starting point for the elaboration of certain ideas by Kuhn on the construction of analogous systems of understanding between the psychogenesis of intelligence and the history of scientific ideas; and as a theoretical model that goes beyond the propositions of Gestalt psychology in the understanding of the aspect of incommensurability between two paradigms (Brunetti & Ormart, 2010; Garcia & Piaget, 2011; Kuhn, 2007).

the functions of history and sociology in his theoretical framework, there is no accurate description in relation to psychology, although he uses a variety of psychological approaches. The historical approach allows Kuhn (2007) to bring to light different forms of thinking and point to the periods of changes in the conception of scientific models and, consequently, of the world. Sociology, in turn, provided the means to study the social contexts that interfere in the production of scientific knowledge, especially in organizations in research groups and communities that share 'paradigms'. Therefore, we should outline the role of psychology in his theory of knowledge.

Kuhn (2007) adds aspects of the individual's participation in the construction of scientific knowledge that are complementary to the organization of a scientific community, having as parameter a paradigm. Brunetti & Ormart, 2010). By emphasizing the psychological aspects, he prints a differential mark in relation to other authors, since he points out the intersection between aspects referring to the scientific community and the subjective aspects of the scientist that studies the solution of a problem. This complementary character is also pointed out by Chalmers (1993):

> An understanding of the choices made by a given scientist will require an understanding of what the scientist values and will involve a psychological inquiry, while the choices made by a community will depend on what it values and an understanding of these choices will encompass a sociological investigation (p. 139).

This step marks the entry of psychology into Thomas Kuhn's theory of knowledge (epistemology). More specifically, we can say that sociological aspects, including social psychology, are best observed in periods of normal science, whereas in the paradigmatic crises, that is, in periods of scientific revolution, Kuhn's arguments turn more to the psychology, in different strands. Thus, a more comprehensive explanation of the phenomenon of the construction of scientific knowledge must address socio-historical and psychological aspects. This complementarity is also defended by Garcia and Piaget (2011):

> Scientific progress, the search for certain forms of explanation, the acceptance or rejection of concepts and certain theories most commonly respond to a complex set of interactions in which the social factors and internal demands of the cognitive system itself are complementary, reinforcing themselves, or opposite, attenuating themselves (p. 347).

In addition to the complementarity between community and subjective aspects, another important correlation between psychology and epistemology, based on the work of Thomas Kuhn (2007), is that psychology does not have a unified paradigm and, even so, serves as the basis for the analyzes made. When Kuhn uses several branches of psychology, he demonstrates that a scientific field do not need to be unified to have heuristic value.

Although Kuhn (2007) points out that "it remains an open question what parts of social science have yet acquired such paradigms at all" (p.35) and affirms the possibility that in the future, the unified sciences can organize their knowledge in a paradigmatic way, his propositions are retrospective. Therefore, such an approach is not intended to predict or determine the state of a scientific field (Assis, 1993). We can conclude, therefore, that psychology can be defined as pre-paradigmatic in SSR (Carone, 2003) and Kuhn recognizes the legitimacy of the claims of psychological schools, even through they are not completely congruent.

Final considerations

In addition to proving Thomas Kuhn's (1995) fruitful use of psychology as an epistemological tool, the present research on which theories he used as basis allowed for three findings: the first on the complementary character between sociological and psychological aspects in Kuhn's approach; the second on the issue of the possible scientificity of psychology in the Kuhnian model; the third is based on the pre-paradigmatic character of psychology. Thus, in SSR, each psychological aspect corresponds, in Kuhn's approach, to a specific agenda:

• Social Psychology: signals the existence of important group issues in the communities that make up the research laboratories. The reference to social psychology lies at the intersection with sociology and the events inherent in the organization of scientific activity, typical of the period of normal science;

• Cognitive Psychology: in addition to the experiments of Jerome Bruner and Leo Postman (1949), combined to Gestalt psychology, other authors of cognitive psychology were cited by Kuhn, such as G.M. Stratton, A.H. Hastorf, and N.R Hanson. But although there is this multiplicity of authors, the anomalous card experiment is described as a prototype and metaphor of what occurs in the paradigmatic crisis situation, when an anomaly can or cannot be observed;

• Gestalt psychology: it is characterized as the conceptual basis of Gestalt switch, at which point a scientist modifies his conceptual structure, that is, when a paradigm shift occurs. In this sense, the conformation of the field of perception is the metaphorical mechanism of recognition, equivalent to the change of world conception and being characteristic of the periods of scientific revolution;

• Dynamic Psychology: although Jacques Hadamard is not a psychologist, his propositions in the field of mathematics are based on psychological conceptions. At this point, Kuhn highlights the complementarity between social and psychological aspects. The events that occur during a paradigmatic crisis have been approached from knowledge that can be acquired, apparently, suddenly, as enlightenment. This, however, requires previous periods of preparation (conscious) and incubation (unconscious), in addition to subsequent verification;

• Genetic Psychology: Jean Piaget's conceptions serve as a starting point and analogy, going beyond the strictly sociological approach, developing parallels between the cognitive development of children and the mental processes that promote changes in the way scientists see the phenomena they study.

The fact that Kuhn uses psychology to make claims about the natural sciences seems at first to be a contradiction. But with the later analysis, it becomes clear that the way in which he deals with data from psychology or the social sciences in general, even if he considers it as pre-paradigmatic, is not a threat to the veracity of a particular psychological school. As a result, it could not be said that the existence of competing theories is worse for the understanding of a given phenomenon than the existence of successive paradigms (Assis, 1993; Brunetti & Ormart, 2010; Hacking, 2013), for "Kuhn has never postulated the paradigmatic phase as a law for the development of science or as a ‘perfection’ to be achieved, but as a possible historical occurrence from certain previous conditions" (Carone, 2003, p. 62).

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