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DELIMITING THE FIELD OF PSYCHOLOGY OF SCIENCE: A REVIEW OF THE LITERATURE [1]

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ABSTRACT. The aim of this research was to establish the objects, objectives, methodological strategies and potential applications of the psychology of science. To this end, a systematic literature review was carried out on the CAPES Journal Portal database. The descriptors used were 'psychology of science', 'psychology of the scientist' and 'psychology of research' and, after applying the inclusion and exclusion criteria, 36 articles were selected. The analysis of the sample texts suggests that the psychology of science seeks both to examine the psychological processes involved in scientific practice and also to discuss the scientific process from a psychological perspective. Psychological studies of science prioritize empirical research methods. The potential applications of the area would, in turn, be in the educational context. In view of the results obtained, some controversies of the psychology of science, such as its relationship with internalism, subjectivism, scientism and individualism, were also discussed.

Keywords: Psychology; scientists; science.

DELIMITANDO O CAMPO DA PSICOLOGIA DA CIÊNCIA: UMA REVISÃO DE LITERATURA

RESUMO. Esta pesquisa teve por objetivo delimitar os objetos, objetivos, estratégias metodológicas e potenciais aplicações da psicologia da ciência. Para tanto, foi realizada uma revisão sistemática da literatura, na base de dados Portal de Periódicos da CAPES. Os descritores utilizados foram 'psicologia da ciência', 'psicologia do cientista' e 'psicologia da pesquisa' e, após a aplicação dos critérios de inclusão e exclusão, 36artigos foram selecionados. A análise dos textos amostrados sugere que a psicologia da ciência visa tanto examinar os processos psicológicos que participam da prática científica quanto discutir o processo científico a partir de uma perspectiva psicológica. Nos estudos psicológicos da ciência, métodos de investigação empíricos são prioritariamente empregados. As potenciais aplicações da área se dariam, por sua vez, no contexto educacional. Em vista dos resultados obtidos, algumas controvérsias da psicologia da ciência, como sua relação com o internalismo, com o subjetivismo, com o cientificismo e com o individualismo, também foram discutidas.

Palavras-chave: Psicologia; cientistas; ciência.

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DELIMITANDO EL CAMPO DE LA PSICOLOGÍA DE LA CIENCIA: UNA REVISIÓN DE LA LITERATURA

RESUMEM. Esta investigación tuvo como objetivo delimitar los objetos, objetivos, estrategias metodológicas y aplicaciones potenciales de la psicología de la ciencia. Por ello, se realizó una revisión sistemática de la literatura en la base de datos Portal de Periódicos CAPES. Los descriptores utilizados fueron 'psicología de la ciencia', 'psicología de lo científico' y 'psicología de la investigación' y, tras aplicar los criterios de inclusión y exclusión, se seleccionaron 36 artículos. El análisis de los textos muestreados sugiere que la psicología de la ciencia apunta tanto a examinar los procesos psicológicos que participan en la práctica científica como a discutir el proceso científico desde una perspectiva psicológica. En los estudios psicológicos de la ciencia, se utilizan principalmente métodos de investigación empíricos. Las posibles aplicaciones del área se darían, a su vez, en el contexto educativo. A la vista de los resultados obtenidos, también se discutieron algunas controversias en la psicología de la ciencia, como su relación con el internalismo, el subjetivismo, el cientificismo y con el individualismo.

Palabras-clave: Psicología; científicos; ciencia.

Introduction

Due to their centrality and ubiquity in the routine of modern societies, science and technology are themselves objects of systematic scrutiny (Feist & Gorman, 2013). The study of science and technology is undertaken by meta-science, an interdisciplinary and heterogeneous sphere that examines the scientific process and its products through different theoretical and methodological perspectives. The psychology of science is one of the disciplines that make up this scope, and its contributions to the area would be investigation of the psychological dimension of science. For Feist (1995) and Feist and Gorman (2013), meta-scientific psychology is, broadly speaking, the study of scientific behavior and thought. More specifically, in this discipline, the personal, behavioral, cognitive and psychosocial elements that participate in or influence the production of knowledge in science would be evaluated and discussed. As authors from different fields have argued, the elucidation of the scientific process and its products is also dependent on an analysis of these psychological aspects (Kuhn, 1970; Mahoney, 1979; Shadish & Neimeyer, 1987).

In general, the psychological side of science has been largely and historically neglected in the meta-scientific sphere, when compared to the investigations and discussions conducted by the philosophy, history and sociology of science (Feist & Gorman, 2013; Mahoney, 1979; Shadish & Neimeyer, 1987). Although its origins date back to the 1930s, the psychology of science is still in the process of disciplinary consolidation and its productions have less visibility, prestige and impact than other meta-scientific publications (Feist & Gorman, 2013; Guazi et al., 2021; Shadish & Neimeyer, 1987).

In addition, the aspects used to describe a scientific discipline (e.g., objects of study, methods, objectives) are often presented in relation to the psychology of science in a fragmented way, which makes it difficult to recognize and delimit this branch of knowledge. As a result, psychologist-scientists who study the psychological dimension of doing science often don't recognize that what they do falls within the scope of the psychology of science, which makes it little known even among psychologists (Guazi et al., 2021).

With these aspects in mind, the aim of this work was to characterize the psychology of science by identifying and systematizing its objects of study, its objectives, its

methodological strategies and its potential applications. The idea was to contribute to the description and definition of this discipline, especially in Brazil, given the incipient nature of Brazilian productions in the field (Guazi et al., 2021).

Method

To typify psychological studies of science, a systematic literature review was carried out, which is characterised, among other things, by a systematic review of available publications on a given topic, with a view to collecting and collating information that makes it possible to conceptualise and characterise an area of knowledge (Romanowski & Ens, 2006). In this research, the sources selected were articles related to the psychology of science, and the database consulted was the Journals Portal of Coordenação de Aperfeiçoamento de Pessoal de Nível Superior [Capes] (2020), which brings together more than 130 reference bases and 49,000 journals. The search terms selected were *psicologia da ciência*, *psicologia do cientista* and *psicologia da pesquisa*, which are used interchangeably in the literature (e.g., Feist & Gorman, 2013; Kuhn, 1970; Mahoney, 1979); the equivalent descriptors in English (psychology of science, psychology of the scientist, psychology of research) and Spanish (psicología de la ciencia, psicología de lo científico, psicología de la investigación) were also used.

The inclusion criteria used involved selecting articles published in Portuguese, English and Spanish, whose descriptors appeared either in the title and in the abstract or in the abstract and keywords or in the title and keywords, and whose main theme was a theoretical, empirical or methodological discussion on the psychology of science (e.g., studies that highlighted the contributions of the area, or suggested techniques and theories that could contribute to the psychology of science). Studies that discussed different subdivisions of the psychology of science, such as the cognitive psychology of science or the social psychology of science, were also included. The exclusion criteria involved discarding duplicates; articles that were not really research reports (i.e., obituaries, book reviews, instructional articles, editorials or commentaries); abstracts from scientific events; and texts that did not meet the proposed inclusion criteria.

The searches were carried out in June 2021 on the Capes Journals Portal and resulted in 148 articles, of which 143 were retrieved (i.e., accessed in full). Of this total, 107 articles were excluded: 25 duplicates; 21 texts that did not refer to research reports; and 61 articles that did not meet the inclusion criteria. In the end, 36 articles were selected for analysis: 27 in English, eight in Spanish and one in Portuguese.

The articles eligible for the study were read in full and examined in accordance with the following categories: (i) objects of study covered by the psychology of science; (ii) objectives of the psychology of science; (iii) methodological strategies employed by the psychology of science, and (iv) applications of the psychology of science. For the analysis phase, an adapted version of the two initial stages of the Conceptual Interpretation of Text Procedure (PICT), proposed by Laurenti and Lopes (2016), was used. The first two stages of the PICT aim, respectively, to identify the text's central and secondary concepts, and to identify its theses (theses are an author's statements on a given subject) - which meets the interests of this work. The discussion of the selected texts was supported by secondary sources, which made it possible to understand some of the specificities of the field and highlight some of its controversies and limits.

Results

The results obtained through the literature review will be presented in four subsections, each of which respectively characterizes the psychological studies of science in terms of their objects of study, their objectives, their methodological strategies and their potential applications in the scientific context.

Objects of Study in the Psychology of Science

Regarding the object of study, the psychology of science would investigate at least two sets of aspects: the psychological processes present in scientific activity and scientific activity itself. More specifically, in the psychology of science, the elements evaluated in and by the different psychologies are thought of and examined in relation to scientific endeavor (e.g., motivation and creativity); and the scientific process *per se*, and other events related to scientific production (e.g., the peer review process), are also presented as subjects of psychological studies of science. Table 1 systematizes these two sets of aspects respectively.

Table 1 Objects of study of the psychology of science: psychological aspects of scientific practice and scientific aspects examined from a psychological perspective.

Psychological aspects of scientific practice	Age; Background and family structure; Behavior; Beliefs; Biography; Causal attributions; Cognition; Collaboration; Competition; Confirmation bias; Creativity; Feeling; Formation and emergence of subjectivities and identities; Gender; Intelligence; Interest; Leadership; Mental disorder; Mental health; Mental processes; Motivation; Personality; Power relations; Problem solving; Script; Social skills; Sporting and genetic mechanisms; Talent; Thinking; Values.
Scientific aspects examined from a psychological perspective	Acceptance or rejection of scientific propositions; Authorship in science; Behavioral laws described in historical studies of science; Characteristics of a 'great' science; Citations of scientific works; Communication in science; Crises in science; Differences and similarities between scientists and non-scientists; Differences between graduate students; junior and senior scientists; Differences between high-impact scientists and less influential scientists; Dissemination of scientific knowledge; Identification of future scientific talents; Image of scientists; Multidisciplinary and non-multidisciplinary teams; Peer review; Performance evaluation based on scientific publications; Relationship between science and society; Relationship between science, politics and the state; Research ethics committees; Scientific collaboration; Scientific development; Scientific discovery; Scientific integrity; Scientific objectivity; Scientific revolutions; Scientific training; Stereotypical image of science; Technological innovation; The 'real' scientific practice; The scientific process; The scientist.

Source: Prepared the authors.

As it can be seen in Table 1, phenomena traditionally investigated by psychology, such as personality, values, creativity and motivation, are also emerging as objects of study in the psychology of science. Grosul and Feist (2014, p. 30) aimed, for example, to "[…] assess unique personality characteristics of creative scientists and determine whether certain personality traits may predispose people to be creative in science". Krasner and Houts (1984), in turn, investigated the differences and similarities between the value systems of two groups of scientists: behavioral psychologists and non-behavioral psychologists; the dimensions assessed included values related to the social responsibility of the scientist, theism and atheism, political and social philosophies, among others.

For Simonton (2009, p. 3), the psychology of science refers to the psychological study of scientific activity, "[…] using theoretical systems and methodological techniques comparable to those used in other psychological specialities". Thus, with Simonton (2009), it is possible to state that the phenomena of interest in the area are also derived from the theoretical context from which they themselves will be examined. Frieze et al. (1981), for example, present Attribution Theory as a possible study perspective within the psychology of science. Since this theory investigates the way in which individuals explain their own behavior and that of others, and the effects of these explanations on human actions, Frieze et al. (1981) sought to assess if the explanations given for success and failure in science can affect the choice of a scientific career as well as the achievements in this chosen profession.

As mentioned, the term 'psychology of science' also designates a psychological perspective for analyzing and discussing the typical activities of doing science. The peer review process (Mitroff & Kilmann, 1975), technological innovation (Paletz & Schunn, 2010), the citation network of scientific papers, the attribution of authorship in science and the work of research ethics committees (Rueda & Monguilod, 2002) are some of the scientific aspects that the psychology of science would focus on. Rueda and Monguilod (2002) point out that many psychologists have been interested in the criteria used by scientists to rank the names of authors in scientific articles (e.g., alphabetical order, magnitude of contribution, status of authors), to assess whether and how these criteria change depending on the field or journal, to evaluate the conflicts that can arise in this process, among other aspects.

The scientific elements eligible for psychological analysis also seem to be selected according to the theoretical framework that will subsidize the investigation. Carré (2018), for example, proposes a cultural psychology of science, based on the principles and assumptions of the theory of personal knowledge and cultural psychology. According to the author, in the light of these theoretical elements, the primary object of study of meta-scientific psychology would be the figure of the scientist itself. For Carré (2018), the study of this professional - understood here as a person inserted in and influenced by different cultural environments - would be fundamental to understanding how knowledge in science is produced.

Objectives of the Psychology of Science

In general terms, the psychology of science aims to track, identify, describe and evaluate the psychological elements that participate in scientific activity and determine the influence of these events on the making and products of science. In defending the use of the psychobiographical strategy by the psychology of science, Runyan (2006, p. 147) states that "[…] understanding the relationships between life and work can help in understanding the sources and meanings of a theory". Hershey et al. (1996, p. 308) emphasize the

importance of the psychology of science answering questions such as: “Where do good scientific ideas come from? What specific thinking skills facilitate good science and, in turn, lead to significant contributions to the literature?” - which exemplify the abovementioned point.

On the other hand, some research in the psychology of science aims to specify the influence of the scientific context on certain psychological phenomena. For Simonton (2009), scientific practice influences the creation or maintenance of superstitious beliefs by individuals, and the study of this influence is the responsibility of meta-scientific psychology. Domènech et al. (2000) emphasize that the processes and practices responsible for producing science also directly affect scientists, so that ‘new’ identities and subjectivities emerge for these professionals from the scientific context - and it would be the task of the (social) psychology of science to investigate this phenomenon.

The psychology of science would also be dedicated to analyzing scientific activity itself from a psychological perspective. Under this approach, aspects involved in the choice of questions, the planning and execution of research, the development and selection of hypotheses and theories, the dissemination of results and the training of scientists would be evaluated. As Tweney (1998, p. 150) asks, “[…] what does psychology know about the processes by which the results of science are achieved?”. In more general terms, the analysis of the scientific process *per se*, undertaken by the psychology of science, would involve the search for psychological explanations of scientific practice, scientific development and scientific revolutions, which would be added to the knowledge produced by other meta-scientific subjects.

Methodological Strategies in the Psychology of Science

Some of the texts selected characterize the psychology of science as an empirically based subject, whose methodological strategies are primarily empirical (Carré, 2018; Downes, 1999; Feist, 2006a, 2006b, 2011; Feist & Gorman, 1998; Gholson & Houts, 1989; Hershey et al., 1996; Kumar, 2001; Romo, 1992; Simonton, 1995). Feist and Gorman (1998, p. 3) describe the psychology of science as the ‘empirical study’ of the psychological elements that influence or participate in the scientific process and state that the field “[…] applies empirical methods of psychological investigation to the study of the behavior […]” of scientists. The methodological tools of psychology would even be “[…] unique among the studies of science […]”, since only psychologists would employ, for example, experimental methods in meta-scientific investigations (Feist, 2006b, p. 184).

The generation of empirical psychological evidence about the scientific process would also be demanded by other areas of meta-science. Downes (1999), in submitting contributions from the psychology of science to a philosophical examination and recognizing the importance of psychology for the meta-scientific sphere, urges psychological studies of science to develop empirical research into scientific activity. For the philosopher, the contributions of the psychology of science should above all be of an empirical nature.

It is important to note that, in psychological literature, the appeal for an empirical psychology of science is sometimes linked to the defense of an empirical epistemology (Dauder, 2003; Kumar, 2001; Romo, 1992). For Kumar (2001, p. 158), empirical data would be preferable to assumptions derived from “[…] abstract epistemological doctrines”. The psychology of science, as a meta-scientific subject, would be well placed to produce the foundations of an empirical epistemology of scientific knowledge (Kumar, 2001; Romo, 1992). This is because traditional epistemological questions could be replaced by psychological questions, which would be answered using the empirical methods available

in psychology (Kumar, 2001). As Dauder (2003) summarizes, what is ultimately being advocated is the replacement of epistemology by a psychological study of science - which should preferably use the experimental method to investigate the nature of science (Dauder, 2003; Romo, 1992).

In any case, with an empirical focus, the methodological strategies employed by the psychology of science generally involve the production of experimental analogues of scientific phenomena (Gholson & Houts, 1989; Mahoney & DeMonbreun, 1977; Tweney, 1998); the observation of the scientific process *in vivo* and *in loco* (Feist, 2011; Tweney, 1998); producing biographies or psychobiographies of scientists (Anaya-Reig & Romo, 2017; Reyes & López, 1996; Runyan, 2006; Tweney, 1998), carrying out psychometric evaluations (Feist, 2011; Feist & Gorman, 1998; Grosul & Feist, 2014; Krasner & Houts, 1984; Kumar, 2001) and interviews (Mitroff, 1972).

Applications of the Psychology of Science

The potential applications of the psychology of science are particularly in the educational field (Anaya-Reig & Romo, 2017; García, 2016; Grosul & Feist, 2014; Hershey et al., 1996; Simonton, 2009). Psychological studies of science could, for example, contribute to improving the training of future researchers (Anaya-Reig & Romo, 2017; Hershey et al., 1996; Mitroff & Kilmann, 1975; Simonton, 2009). As Simonton (2009) illustrates, once the conditions that optimize the production of answers to scientific questions and problems have been identified, it would be appropriate to introduce these findings into training courses for scientists.

Similarly, specifying the psychological elements present in science would make it possible to identify potential scientific talent at an early stage (Anaya-Reig & Romo, 2017; Grosul & Feist, 2014; Simonton, 2009), and pedagogical and instructional decisions could be made based on this recognition, with a view to promoting the skills and abilities already identified (García, 2016). A third application of the psychology of science would involve the development of educational practices favorable to the emergence of new talents, with innovative and creative capacities, through the creation and maintenance of "[…] optimal environments" (García, 2016, p. 378).

Meta-scientific psychological discoveries could also improve the process of recruiting and selecting students for master's and doctoral programs (Simonton, 2009). According to Simonton (2009), if personality traits and developmental characteristics prove to be predictive of scientific talent in general and scientific talent in specific areas of knowledge, this information could be used in the selection of postgraduate students. A fifth application of the psychology of science, outside the educational sphere, would derive from the description of the working practices of eminent scientists, which could result in an improvement in the scientific process itself (Simonton, 2009), by identifying practices that would encourage the advancement of science or speed up the discovery process.

Discussion

The description of the psychology of science in terms of its object of study, objectives, methodological strategies and potential applications suggests that this discipline is approaching some of the 'isms' identified in the psychology itself. More specifically, meta-scientific psychology seems to be somehow committed to internalism, subjectivism, scientism and individualism.

The specification of the objects of study and aims of the psychology of science, together with a broader analysis of the articles sampled, allows, for example, the

identification of an internalist explanatory pattern (Tourinho, 1999) in the psychological studies of science. In other words, when looking at scientific phenomena, the psychology of science often offers explanations that choose entities internal to the subject as the cause of the phenomenon under scrutiny. The internalist tradition seems to be particularly evident in studies evaluating the influence of psychological elements on the scientific process (see Table 1). Grosul and Feist's (2014, p. 38) propositions exemplify this fact: considering the Big Five personality structural models and the one proposed by Eysenck, the authors state that "[…] being open but not impulsive (psychoticism) makes creative productivity in science more likely". Feist (2006c) states that first-borns are more likely to endorse and support conservative scientific theories than youngest-borns; and youngest-borns are more likely to accept or propose revolutionary scientific theories than first-borns. In the examples, personality traits and birth order are presented, respectively, as independent variables of scientific creativity and acceptance of theories in science.

By explaining scientific elements through the identification of variables within the individual, the internalist tradition also favors the emergence of psychologism in the psychology of science. According to Carré (2018, p. 8), psychologism or subjectivism can be understood as "[…] the reduction or subordination of non-psychological entities to psychological entities […]", which results in the non-observance of the social, cultural, economic, political and historical aspects that contribute to the production of the phenomenon under analysis. With this in mind, meta-scientific psychology begins to propose explanations of science based exclusively on psychological characteristics immanent to the scientist. The 'sin of psychologism', as Carré (2018), Kožnjak (2017) and Shadish and Neimeyer (1987) point out, may even be one of the reasons why the psychology of science occupies a secondary role in the meta-scientific field.

Among the psychological studies of science, however, there are alternatives to the internalist tradition and subjectivism. The cultural psychology of science (Carré, 2018), the feminist psychology of science (Dauder, 2003), the behaviorist psychology of science (Guazi et al., 2021) and some strands of the social psychology of science (Cordeiro, 2009; Domènech et al., 2000; Grupo de Estudios Sociales de la Ciencia y la Tecnología [GESCIT], 2007; Rueda & Monguilod, 2002) propose a more contextual and historical analysis of the scientific process and its products. For Guazi et al. (2021), understanding the scientific process from a psychological perspective requires examining the relationships established between scientists and their environment, which requires the inclusion of political, economic, social and cultural variables in the analysis. Dauder (2003), based on feminist epistemological discussions, argues that psychological studies of science should assess how issues of gender, ethnicity, social class and space-time context play a role in producing scientific knowledge. Carré (2018), in line with this, argues for a more receptive meta-scientific psychology, attentive to institutional and historical-cultural aspects.

According to Kumar (2001), the psychology of science presents the typical plurality of the psychological field, so that it is possible to identify psychologies of science, as a whole. The biological, developmental, social, cognitive, personality, educational, clinical, cultural and behaviorist psychologies of science (Carré, 2018, Feist, 2011; Feist & Gorman, 1998; Guazi et al., 2021) illustrate the diversity of the field. However, the numerous subdivisions of the psychology of science also imply a multiplicity of explanatory proposals for scientific phenomena. Thus, although internalist or psychologizing explanations are observed in the psychology of science, meta-scientific psychology also offers and defends contextual and relational analyses of the scientific process.

Psychological studies of science are also close to scientism when they give priority to the use of empirical methods in meta-scientific investigations and defend an empirical epistemology. According to Köche (2011), scientism is the belief that science is superior to other forms of human knowledge, given that it considers scientific knowledge to be the only truly valid, true and reliable knowledge. In the light of scientism, empirical methods, with special emphasis on those of an experimental nature, would be the methodological strategies of choice in any scientific investigation, as only they would allow us to truly understand the world. As Köche (2011) summarizes, from a scientistic perspective, knowledge would only have value if derived from empirical-experimental scientific research.

In the psychology of science, the scientistic perspective seems to support the choice of the empirical scientific method, especially the experimental one, as the only means by which it would be possible to examine the psychological dimension of science (e.g., Dauder, 2003; Feist & Gorman, 1998; Kumar, 2001; Romo, 1992). The call for an empirical epistemology and other discussions in psychological studies of science also indicate the presence of scientism in meta-scientific psychology (e.g., Dauder, 2003; Romo, 1992). Romo (1992), for example, in defending an empirical meta-science, seems to be calling for philosophical analysis to be overcome in this field. For the author, the time has come for meta-science to start from "[…] a completely new and no longer philosophical perspective, where different disciplines must converge in the scientific study […]" of science (Romo, 1992, p. 126). According to Romo (1992, p. 124), it is necessary to consider "[…] science itself as an object of analysis that is more scientific than philosophical".

Although the events that have followed the development of meta-scientific disciplines have called into question epistemological assumptions that guided dogmatic conceptions of science and scientists, and thus changed the way in which the scientific process is investigated (see Carré, 2018; Dauder, 2003; Romo, 1992), the empirical study of science does not necessarily make it impossible or devalue analyses of other kinds. The texts sampled in this work illustrate the contributions of theoretical studies to the psychology of science (e.g., Brunetti & Ormart, 2010; Carré, 2018; Feibleman, 1960; Johnson, 2018; Kožnjak, 2017, Mahoney, 2003; Mitroff & Kilmann, 1975, 1977; Rueda & Monguilod, 2002). Of the 36 articles selected, 29 are theoretical works.

Understanding science depends on interdisciplinary analysis - which requires the articulation of different types of knowledge, produced from different theoretical perspectives - and methodological pluralism - which involves interlocution between different research strategies (empirical, experimental and non-experimental, as well as non-empirical approaches) when examining scientific activity and its products (Guazi et al., 2021). Furthermore, in seeking to establish itself as an autonomous field, the psychology of science must, above all, seek ways of communicating with other meta-scientific disciplines (Gholson & Houts, 1989). The scientific study of science's psychological dimension does not fully cover the set of elements and dimensions that make up scientific activity and products, and the contributions of the psychology of science are specifically restricted to elucidating the psychological factors present in the scientific process. Claiming to replace or surpass non-scientific academic analyses of science (e.g., philosophical analyses) only contributes to the disciplinary marginalization of the psychology of science in the meta-scientific field.

It should be noted, finally, that there are also proposals in psychological studies of science that emphasize the supplementary relationship between psychology and other meta-science disciplines. The psychological investigation of the scientific process would supplement - and not replace - the philosophical, historical, sociological and anthropological analysis of science (Gholson & Houts, 1989). According to Feist (1995) and Gholson and

Houts (1989), psychological analysis does not compete with, contradict or undermine the knowledge produced by other meta-scientific areas. The inclusion of psychological variables in the analysis only aims to expand the available explanations of the scientific process, as argued by Kuhn (1970).

In turn, the characterization of the potential applications of psychological studies of science, added to the analysis of other information identified in the selected texts, suggests a certain commitment of meta-scientific psychology to individualism. In individualism, the emphasis is on the individual, who is described as a free subject, "[…] autonomous, master of himself and independent" (Dimenstein, 2000, p. 97), who is immune to contextual and historical influences and who can act solely and exclusively according to his desires (Cruz, 2010). Personal fulfillment, from an individualist perspective, would depend solely on the commitment and strength of the particular individual (Tourinho, 1993).

In the psychology of science, individualism emerges in the election of individual elements as those primarily responsible (Tourinho, 1993) for the production of scientific knowledge. Scientific triumph would thus be an individual and personal achievement of those who produce science, a product unrelated to the historical, cultural, political and economic context in which the scientist is inserted (e.g., Anaya-Reig & Romo, 2017; García, 2016; Grosul & Feist, 2014). From this individualistic perspective, if contextual elements participate in any way in scientific discovery, it is only to serve as an ideal setting for its emergence. For García (2016, p. 371-372), for example, scientific success is the result of the balance between genuine qualities of the scientist, "[…] such as the genius to conceive ideas, the keenness to perceive where real problems lie, the decision to achieve what one wants and the energy devoted to one's work, although it also depends […]", to some extent, on an opportune environment.

Once predictive factors of success in science have been specified (e.g., genuine qualities or personality traits), meta-scientific psychology could help in the early identification of scientific talents and support pedagogical actions that stimulate these talents from the beginning of life (Grosul & Feist, 2014). It could also improve the selection of students for *stricto sensu* courses, by determining the area of knowledge in which a young talent would be most likely to make major contributions (Simonton, 2009). According to Carré (2018), to the extent that meta-scientific psychology moves closer to individualism, it goes against the path of meta-scientific efforts to dismantle and overcome the individualistic descriptions once disseminated by philosophers of science.

According to Shadish and Neimeyer (1987), a substantial difference between the psychology of science and other meta-scientific disciplines is its focus on the individuals who produce scientific knowledge. Although this characteristic may favor the occurrence of individualistic explanations in psychological studies of science, as has been observed, it is essential not to mistake the individual for individualism (Abib, 2001). There are important differences between the 'individual' as a unit of analysis and as a member of a community or culture; and the 'individual' as a value, as an abstract category, whose characteristics involve autonomy, self-sufficiency, freedom, among other features (Dimenstein, 2000).

The selection of the individual-scientist as the object of psychological study does not necessarily link the psychology of science to individualism. As already mentioned, contextual and historical analyses of the psychological phenomena involved in scientific activity are available in the meta-scientific psychological literature (e.g., Carré, 2018; Cordeiro, 2009; Dauder, 2003; Domènech et al., 2000; Guazi et al., 2021; Rueda & Monguilod, 2002), which are, at the same time, alternatives to internalism, psychologism and individualism. To study the individual scientist, a member of the scientific community, is

simply to include those who do science in the examination of science (Carré, 2018). The meta-scientific field often overshadows the figure of the knower, either by idealizing him or her as a rational subject detached from psychosocial factors (Runyan, 2006), or by subsuming psychological elements into collective elements (Carré, 2018). However, understanding science depends on including the scientist in the analysis (Mahoney, 1979, 2003). As Brunetti and Ormart (2010, p. 114) state, "[…] [scientific] communities don't think, but the subjects who make them up do […]" - it is therefore necessary to investigate these individual subjects; and it is necessary to do so in a contextualized way and not by taking them as subjects locked up in themselves.

Final considerations

Through a systematic literature review, we sought to gather elements to characterize the psychology of science in terms of its objects of study, objectives, methodological strategies and potential applications. In general terms, the psychology of science aims both to elucidate the psychological processes that take part in scientific activity and to examine the scientific process from a psychological perspective, dimensions that are usually neglected by the meta-scientific field (e.g., Carré, 2018; Runyan, 2006). To investigate the psychological dimension of science, meta-scientific psychology prioritizes the use of empirical methods in its studies (e.g., Feist & Gorman, 1998), such as *in vivo* and *on-site* observation of scientific activity (Tweney, 1998). The potential applications of the field would, in turn, be in the educational sphere: the psychology of science could improve the training of future scientists (e.g., Simonton, 2009).

Although the psychology of science can be accused of psychologism, scientism and individualism, there are alternative paths in psychological studies of science that offer more plural and contextual explanations of the scientific phenomenon and recognize the importance of different methodological strategies and analyses from various fields of knowledge (e.g., Guazi et al., 2021). By collecting and systematizing characteristics of the psychology of science often portrayed in a fragmented way in the literature, this study advances towards a more comprehensive characterization of this discipline. In doing so, this work gives visibility to meta-science as a field that can benefit from psychological reflections and research, while at the same time serving as a context for psychological studies to turn critically to their own epistemological assumptions.

In any case, this study has limitations that may be overcome in other investigations. The methodological strategies adopted imposed restrictions on both the number and nature of the texts covered and the information included in the analysis. Further literature reviews, aimed at providing a broader overview of the psychology of science, could include texts of a different nature (e.g., dissertations and theses) and in other languages. They could also analyze other categories of information in order, for example, to identify the specific objects, objectives and methods of each subfield of the psychology of science.

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