To appear in Studies in History and Philosophy of Science 96 (2022) 68–76, https://doi.org/10.1016/j.shpsa.2022.09.006. Please quote the published version

The policy of testing hypotheses in Chilean science. The role of a hypothesis-driven research funding programme in the installation of a hypothesis-driven experimental system in visual neuroscience

Juan Manuel Garrido Wainera,*, Natalia Hirmas-Montecinosb, Nicolás Trujillo Osorioc
a Centro de Estudios en Ciencia, Tecnología y Sociedad, Universidad Alberto Hurtado, Alameda 1869, 8340576 Santiago, Chile
b Faculty of Education, Pontificia Universidad Católica de Chile, Vicuña Mackenna 4860, 7810000, Macul, Santiago, Chile.
c Philosophy Department, Universidad Alberto Hurtado, Alameda 1869, 8340576 Santiago, Chile.
* Corresponding author at: Centro de Estudios en Ciencia, Tecnología y Sociedad, Universidad Alberto Hurtado, Alameda 1869, 8340576 Santiago, Chile. E-mail address: jgarrido@uahurtado.cl

Abstract: O'Malley et al. (2009) and Haufe (2013) suggest that the philosophical idea of science as hypothesis testing generates a pernicious bias towards hypothesis-driven research and against exploratory research in the review process of research proposals and the allocation of resources. This paper addresses a conceptual objection to the argument by O'Malley et al. (2009) and Haufe (2013). We argue that the funding agencies' concepts of good science do not belong to epistemological or philosophical contexts but to political and institutional contexts. This means that correcting (potential) biases in research funding does not entail correcting funding agencies' (supposed) philosophies of science. To illustrate this point, we provide an in-depth historical case study: the granting of funds to neuroscientist Pedro Maldonado by the Chilean funding programme FONDECYT. This is a relevant comparison as FONDECYT's guidelines explicitly promote hypothesis-driven research and endorse a view of "good science" as hypothesis testing. However, we will see that the overall influence of the philosophical idea of science as hypothesis testing over this funding programme, the research project, and the actual practice of hypothesis testing is somewhat limited. The concept of science as hypothesis testing seems to play a crucial institutional or political (not philosophical) role in allowing the conceptual articulation of social expectations and researchers' expectations.

Keywords: hypothesis-driven research; funding agencies; philosophy of science; experimental systems; policy research concepts; Chilean science; FONDECYT; visual neuroscience

1. Introduction

O'Malley et al. (2009) and Haufe (2013) analyse the import of the philosophical idea of science as hypothesis testing in funding agencies. They argue that this philosophical idea generates policy biases towards hypothesis-driven research and against exploratory research. This paper studies the connections between the hypothesis-centred "philosophy" of a Chilean funding programme (FONDECYT) and the installation and development of a hypothesis-driven, theory-oriented experimental system in visual neuroscience, at the Faculty of Medicine of the University of Chile, between 1998 and 2001. In the historical case we study here, the funding agency funds experimental infrastructure, the functioning of which is largely independent from the pre-existing theoretical premises of the research proposal. In other words, we study the case of a hypothesis-driven funding instrument that funds a hypothesis-driven experimental system, and yet it is not clear that there has been a bias towards hypothesis-driven research in the review of the proposal and the allocation of resources.

We want to derive two lessons from our case study. In the first place, the correction of potential biases in research funding is not contingent on the correction of funding agencies' *philosophies* of science. It seems implausible that a philosophical conception of science unifies the different social, political, organisational and technical or methodological levels in which "scientific research" needs to be defined when designing research policies and funding instruments. From the fact that an agency uses concepts and statements with a recognisable origin in the philosophical literature, we should not infer that its policies convey and let alone depend on a philosophical understanding of science. Different contexts of use may introduce substantial differences in the meaning of these statements. In other words, funding agencies' ideas of science are not philosophical in nature. Funding agencies' ideas of science convey the public expectation of having socially legitimate systems for knowledge production. In this paper, we propose to consider the concept of "hypothesis-driven research" as what Désirée Schauz would call a "key term in science policy", that is, a term that harbours different interests and thus facilitates "complex social negotiation processes" (Schauz 2020). As we shall see, the policy of testing hypotheses allows the conceptual articulation of social interests and expectations with researchers' interests and expectations, insofar as “hypotheses” constitute markers of scientific relevance providing useful information to assess research proposals' consistency and viability. Moreover, as we will see, sound pre-existing “hypotheses” may help to anticipate research results and outputs beyond the scope of a three-year project, thereby mitigating the adverse effects of the short-term character of a performance-based funding instrument.

The second lesson we propose to derive from our case study is the following. During the last decades, there has been a growing interest in studying the impact of funding policies on research content and practices (Laudel 2006; Hicks and Katz 2011; Hicks 2012; Whitley 2014; Benninghoff et al. 2014; Gläser et al. 2014; Laudel and Gläser 2014; Laudel et al. 2014; Gläser and Laudel 2016; Whitley, Gläser, and Laudel 2018; Franssen et al. 2018). For example, it has been observed that changes in funding criteria can induce changes in the experimental or theoretical nature of research (Laudel 2006), but it is not clear what mechanisms are involved and their scope. In this context, O'Malley's et al. (2009) and Haufe's (2013) discussion of funding agencies’ philosophy of science might suggest a interesting way to study the mechanisms connecting research funding criteria with the epistemic properties of new knowledge. Applying their argument to this discussion, we could say that the philosophical idea of what constitutes "good science" and distinguishes it from pseudoscience guides both the allocation of resources and researchers' decisions to design experiments and analyse and present their results. For instance, O'Malley et al. state that “by separating exploratory grants from standard ones [i.e. grants for hypothesis-driven research] and limiting them to the early stages of research, this funding policy may hamper researchers from moving back and forth between different approaches in advanced research projects” (O’Malley et al. 2009, 613). Therefore, the philosophical continuity of an idea of science shared by the authority and the practising scientists might explain how a funding policy impacts the kind of knowledge it funds.

Our study case shows, however, that even in the context of total convergence or affinity between hypothesis-driven funding criteria and funded research, there are considerable discontinuities between the philosophical idea of science as hypothesis testing and the actual practices and processes of testing hypotheses. The role that an idea of science plays in a funding agency is not continuous with the methodological and operational order in which actual research occurs. For sure, we would hardly find agencies and researchers free from ideological commitments, free from ascribing to some "spontaneous philosophy" (Althusser 1974; Rheinberger 2014) about what science is or should be; however, it remains to be seen exactly in what sense and to what extent these ideological commitments really influence the "life of their own" of experimental systems producing new knowledge.

In section 2, we discuss the argument by O'Malley et al. (2009) and Haufe (2013) about the philosophical origin of agencies' bias toward hypothesis-driven research. In sections 3 and 4, we provide details about our case study and analyse the effects of the biased funding instrument on research content and practice. Our historical reconstruction considers the narrative of key informants (especially the principal investigator, Pedro Maldonado), the funded research proposals, published papers, and historical studies on Chilean scientific institutions. In section 5, we explain in what sense the idea of scientific research as hypothesis testing allows the conceptual articulation of social and researchers' interests and expectations, and constitutes a marker of scientific relevance providing useful information to assess research proposals' viability in the long term.

2. The funding bias towards hypothesis-driven research

By analysing the guidelines and review process of research grants in the National Institutes of Health (NIH) and the National Science Foundation (NSF) in the US, and in the Biological and Biomedical Sciences Research Council (BBSRC) in the UK, O'Malley et al. (2009) suggest that funding agencies promote the standard model of science as theory-oriented practice that considers experimentation as the subsidiary activity of testing pre-existing hypotheses. To put it in Chris Haufe's terms, "the testability criterion has been influential in shaping the policies for the major US agencies devoted specifically to the funding and promotion of scientific research" (Haufe 2013). The idea of science as hypothesis testing has also been preferred by American courts of law when it has been necessary to find criteria for assessing the value of scientific experts' testimony or the epistemic pretensions of religious beliefs (Haack 2010; Haufe 2013).

According to O'Malley et al. (2009) and Haufe (2013), the idea of science as hypothesis testing generates a bias towards hypothesis-driven research, inhibiting higher-risk research funding, namely exploratory research. In the long run, this bias may hinder highly innovative research and the development of technologies with potentially greater payoffs. For sure, there are grants designed to promote exploratory research. In fact, the growing development of successful non-hypothesis-driven research programmes since the late 1990s makes it plausible to talk even of the 'emergence of a new paradigm' in research funding (Aragon 2011). However, the perception prevails that these non-hypothesis-driven research grants promote preparatory activities, i.e. referred to early stages of research, or are instrumental and oriented to empower hypothesis-driven research. For instance, grants for exploratory and developmental research, such as the R21 at the NIH, are said to "support the early and conceptual stages of project development" (NIH 2020; O'Malley et al. 2009). Exploratory research activities are "conceptually subordinated to devising, testing, and confirming hypotheses and models" (O'Malley et al. 2009), and a general climate of anti-innovation affects the evaluation and awarding process of projects as a whole (Haufe 2013).

If this argumentation is correct, then funding agencies would not primarily have the purpose of channelling the social need for organising the production of useful knowledge legitimately. Their goal would rather be to generate true or genuine knowledge, that is, to organise research activities so that these activities adequate to the representation we have of science's essence. The very authority of funding agencies would be based on and legitimised by the normative idea of genuine, true science. This idea of science would eventually generate criteria modelling the social and individual practices associated with research. It would guide the design of research grants, scientists' strategies to obtain them and reviewer's evaluations. Since funding agencies' bias towards hypothesis-driven research derives from a specific idea of true science, both O'Malley et al. (2009) and Haufe (2013) consider that the neutralisation of this bias entails rectifying the concept of science that agencies operationalise, particularly by incorporating a wider range of practices, which are not restricted to hypothesis testing activities. In O'Malley et al. terms, "the structure of these funding programs *does not adequately reflect* the scientific importance and pervasiveness of non-hypothesis-driven modes of investigation" (2009, our emphasis). In the same paper, the authors also claim: "We maintain that *an adequate theoretical account of how science works* will need to subordinate the generation and testing of hypotheses to a far more inclusive range of practices, and that one of the most crucial arenas in which this widening of perspective must occur is in the funding of science" (O'Malley et al. 2009, our emphasis).

Since, according to O'Malley et al. (2009) and Haufe (2013), at the basis of science policy there lies a concept of science that has been profusely discussed by philosophers of science (for a convergent conclusion, see also Rowbottom and Alexander 2012), and since philosophy is a discipline of conceptual analysis concerned with true definitions, then philosophy would have, in this context, a special responsibility. Philosophy should play a central role in rectifying the bias towards hypothesis-driven research. "Because funding agencies use philosophical conceptions of good scientific methodology to guide funding decisions, philosophy affects science progress. It is therefore important that funding philosophies reflect the complete body of strategies used to achieve scientific ends" (O'Malley et al. 2009). Philosophy can and should contribute to generating a "wider conception" of science, where—to use a formula by Michael Hagner and Hans-Jörg Rheinberger—"the function of the experiment as an instance of testing hypotheses appears to be largely marginal" (Hagner and Rheinberger 1998). This broader conception of science should also clarify the epistemic conditions for technological development and the exploration of phenomena.

O'Malley et al. (2009) 's and Haufe (2013) 's propositions find their context in the so-called "practice turn" in the history and philosophy of scientific experimentation. The label "practice turn" refers to an ensemble of works that seek to understand the import of epistemic processes and practices unframed by pre-existing scientific theories in the generation of new knowledge (for reviews about the "practice turn", see Soler et al. 2014; Feest and Steinle 2016). One of the most notable cases of experimental practice independent from theory is exploratory experimentation (Burian 1997; Franklin 2005; Waters 2007; Elliott 2007). Pre-existing hypotheses do not directly determine exploratory experimentation, and discoveries do not require referring to available concepts and theories. In Haufe's words: "Exploratory research can be described essentially as the negative of hypothesis-driven inquiry. While often employing theory in peripheral ways, what makes exploratory research distinctive as a form of inquiry is its application to substantially undertheorized phenomena, the concomitant lack of theory-derived expectations, considerable latitude with respect to technology, and a paucity of mature conceptual frameworks in which to potentially place findings" (2013).

The mere mission of generating genuine scientific knowledge would not explain the alleged hegemony that the idea of scientific research as hypothesis testing would have achieved in funding agencies. There is also a pragmatic aspect that should not be neglected. Haufe (2013) suggests that agencies' main reason to adopt the idea of science as hypothesis testing is the adaptability of this idea to managerial requirements of research funding. It is easier to detect the qualities of good science in hypothesis-driven research than in exploratory research. Pre-existing theory sets in advance satisfaction criteria for its confirmation. In sum, theory works as a managerial tool, an instrument for evaluating merits, feasibility and results of research proposals. "If the project is hypothesis-driven, the reviewer can derive much of that information directly from the relevant scientific theories, since the theory often sets the terms for what will count as a solution to a problem. If a project aims to test a hypothesis, the theory under which the hypothesis is formed will tell us what could possibly constitute a test of that hypothesis" (Haufe 2013). Theoretical knowledge informs about the relevance of experimental hypotheses and predictions, and this information facilitates the assessment of the significance of research proposals. "The strong dependence of hypothesis-driven inquiry on theory makes it a rich source of data for referees' theory-mediated perceptions of significance" (Haufe 2013). In sum, the epistemic properties of theory-oriented and hypothesis-driven research are likely to be valued because funding agencies may instrumentalise them. Therefore, biases towards hypothesis-driven research would not only derive from philosophical convictions but also managerial concerns. Haufe considers that this pragmatic aspect renders the hegemony of the idea of science qua hypothesis testing in agencies' funding policies even more unjustified.

The methodology of O'Malley et al.'s (2009) and Haufe's (2013) studies consists of analysing statements of research grants' guidelines and general descriptions. "The NIH offers very clear statements about what hypothesis testing is and why it is so central to research and the evaluation of funding applications" (O'Malley et al. 2009). This methodology assumes that statements explicitly promoting hypothesis-driven research would constitute enough evidence of the biases they identify and question. It also assumes that since funding policies are a matter of discourse and statements, philosophical conceptual analyses are legitimate and pertinent. It is important to consider the limitations of this methodology. It assumes that a unitary idea of science (of true or genuine science) governs funding agencies' policies, conveys the values of knowledge communities and is subject to philosophical analysis. However, there are different meanings of the idea of science according to the different contexts in which this idea is discoursively evoked and used. In the context of science policy, concepts of "science" (of true science or genuine science) do not function in the same way as in philosophical analysis or internal debates of scientific communities. In science policy, concepts need to keep certain vagueness allowing them to harbour different meanings so that they can provide a space for negotiating interests of different kinds—interests of researchers, policymakers and the general public—in different social and historical contexts (Schauz 2020). For instance, the concept of "basic research" has historically tolerated a great multiplicity of meanings, sometimes conflicting meanings, which has made possible to connect different political, scientific, economic and social expectations (Kaldewey and Schauz 2018; Pielke 2012; Schauz 2014). Something similar occurs with the concept of "research quality". "Research quality" is not a unitary notion (Langfeldt et al. 2020). On the one hand, it conveys the values that knowledge communities assign to scientific work. In this first sense, the notion follows the dynamics of research fields. On the other hand, it conveys the interests of funding agencies, which are operationalised in instruments of governance and management of science practice. In this second sense, the notion follows the dynamics of policy spaces (for the notions of "research fields" and "research spaces", see Nedeva (2010)). Different notions coexist in the concept of "research quality". "[R]esearch quality notions originating in research fields, or knowledge communities, and in policy and funding domains coexist. This coexistence of research quality notions creates complex and multi-dimensional dynamics implying that research quality cannot adequately be studied and understood as a unitary notion" (Langfeldt et al. 2020).

O'Malley et al. (2009) and Haufe (2013) seem to overlook the fact that the statements and concepts they analyse belong not so much to logical or philosophical contexts as to political and institutional contexts, "where research quality is negotiated between researchers (using quality notions from the 'research field') and organisational elites (translating policy pressures from the policy and funding-related 'research space')" (Langfeldt et al. 2020). As we will see in section 5, in the context of performance-based research policies, the idea of "hypothesis-driven research" manages to operationalise the idea of "research quality" very effectively. This is evident from Haufe's own analyses about the suitability of the idea of "hypothesis-driven research" for the managerial requirements of funding. Different notions of quality research, originating from knowledge communities and science policy, co-exist in the concept of "hypothesis-driven research".

3. A FONDECYT grant to install free-viewing as experimental system to test the Temporal Correlation Hypothesis in visual neuroscience

"At that time, we worked on theory because we were penniless", explains Pedro Maldonado evoking his training time at "Experimental Epistemology (*Epistemología experimental*)", the laboratory that during the eighties gathered in Santiago de Chile two leading and prolific figures of neuroscience, Humberto Maturana and Francisco Varela. Today Maldonado leads one of the most prestigious, well-funded and productive laboratories of neuroscience in the country, located in the Faculty of Medicine of the University of Chile. He still thinks of theory as an essential part of scientific practice, especially in neuroscience. "We lack what in physics seems to be a more common practice: to move forward by testing hypotheses" (Interview).[1]

After his doctoral studies in Philadelphia at George Gerstein's laboratory, in 1993 Maldonado came to Davis, California, to pursue his postdoctoral training in Charles Gray's laboratory. At the time, Gray was collecting evidence confirming the Temporal Correlation Hypothesis (TCH). The TCH is a model to explain how the brain encodes information from the visual environment. Specifically, it refers to the mechanisms through which ensembles of neurons, in tiny fractions of seconds, segment visual scenes and group the features belonging to different objects. In 1997, Maldonado obtained a position as Assistant Professor at the University of Chile's School of Medicine and returned to Santiago. That same year he was

[1] This case study was carried out within the context of a multidisciplinary research project on the production and institutionalisation of scientific knowledge in Chile (2018-2022). We integrated historical, ethnological and epistemological evidence on scientific practice in Excellence Research Centers (more details of this project in https://www.cienciachilehoy.cl). The "Neurosistemas" laboratory, led by Pedro Maldonado, is part of one of the Centers we studied. The historical and epistemological reconstruction of the research program on "free-viewing" aimed to understand the Centre's origins and current identity.

awarded a research grant from the National Science and Technology Research Fund (FONDECYT) for three years (1998-2001). This grant allowed him to set up surgical capabilities, hire technical staff, and acquire electrophysiological, informatical, and eye-tracking equipment to carry out a series of experiments to test TCH-related predictions. The research proposal that he submitted to FONDECYT was entitled "Neuronal population dynamics in the cat's visual cortex". He proposes to study the simultaneous activity of groups of neurons in cats' visual cortex freely exploring images of natural scenes.

Before turning to Maldonado's research proposal, we briefly describe the funding instrument. The National Science and Technology Research Fund (FONDECYT) programme was created in 1981, i.e. in the context of the military dictatorship's (1973-1989) neoliberal reforms, and has been the main instrument for funding basic science in Chile for the last 4 decades. This parformance-based funding programme subsidise research through public competitions for projects in all areas of knowledge. There can be only one principal investigator in each grant, who can form teams of co-investigators, technical and professional staff, and undergraduate and graduate students. Today, a regular research project (FONDECYT Regular) lasts 2, 3 or 4 years, and the amount per year can reach 57,000,000 CLP (75,000 USD, according to the exchange rate in early 2021). In 1998, FONDECYT financed projects up to 3 years, and the amount per year could reach 45,000,000 CLP (100,000 USD, according to the exchange rate in 1998). In 2006, the programme created FONDECYT Initiation, aimed at young researchers starting their career. An initiation project lasts 2 or 3 years, and the maximum amount per year is 30,000,000 CLP (56,000 USD, according to the exchange rate in 2006).

It is worth noting that FONDECYT operates in a context of meagre national investment in science (Chile is by far the OECD country that invests the least in research and development, with only .36% of its GDP) and that Chilean science system may fairly be described as what Hollingsworth (2008) would call an organisationally rigid system with no diversity of authoritative actors. Basic research has depended for years, and still dramatically depends, only on FONDECYT. Therefore, it is pretty reasonable to conjecture that research practices that FONDECYT promotes significantly impact shaping the national scientific culture.

Another relevant remark concerns the scale of the Chilean community of researchers. According to Goldflam et al. (Manuscript), there are no homogeneous and precise data regarding the number of researchers in Chile for the period between 1970 and 1990, but their paper report some interesting numbers. According to a 1972 analysis of the scientific and technological system, there were a total of 3,669 researchers in science and technology in the early 1970s (Castro 1972). According to a 1983 study by CONICYT and the National Institute of Statistics, in 1981 Chile had a total of 5,242 researchers in science and technology (CONICYT-INE 1983). In 1982, the first version of Fondecyt funded slightly more than 500 researchers. According to Saavedra and Vergara (1989), between 1982 and 1989, this new funding program had financed a total of 4,009 researchers (Saavedra and Vergara 1989). The funding increased exponentially until 1995, year in which the program financed 3,000 researchers. By the end of the decade, the creation of new funding programs made FONDECYT fund fewer researchers. In 1998, for example, Fondecyt funded about 2000 researchers (FONDECYT 2000). According to a CONICYT Report[2], Chile has approximately 10.000 active researchers in 2018. According to a

[2] https://www.conicyt.cl/wp-content/uploads/2018/03/Interior_Conicyt.pdf

R&D Expenditure and Personnel Survey from 2021[3], Chile currently has a total of 1.1 researchers (people with doctorates) per 1000 workers (equivalent to 18,352 people, 6,730 women and 11,622 men), which means that it is the country with the second lowest number of researchers in the OECD.

In the regular 2021 competition, the most important criteria for project selection are the quality (40 %) and viability (30 %) of research proposals, while PI's productivity represents slightly less that one third of the total score (30 %). In the 1998 competition, there is no score assigned to the different items under evaluation. However, it is clear that proposals' viability and scientific quality constitute the most important criteria for selection, and PIs' productivity is measured in its suitability to the project. The regulations for the 1998 competition list nine factors that will be taken into account in the evaluation of research proposals: 1) originality and 2) relevance of the research proposal; 3) CV and suitability of researcher(s); 4) Compliance with previous contractual commitments and demonstrated productivity in other projects financed by FONDECYT; 5) feasibility and 6) pertinence and relevance of the project; 7) projected publications; 8) total cost of the project with respect to the objectives; 9) funding committed by other institutions. Note that factors 2, "Relevance of the research proposal (*Relevancia de la investigación propuesta*)" and 6, "Project's pertinence and relevance (*Pertinencia y relevancia del proyecto*)" are repetitive. In the 1998 competition form, the research proposal's relevance and feasibility should be explained in sections III. Summary, VII.1. General formulation of the project, VII. Specific objectives, Methodology, Work plan. In other words, if an actor in the scientific system (a researcher) wishes to be funded by the State using the FONDECYT instrument, then this actor must provide evidence that their research raises scientific questions that are immediately relevant to a field. A crucial component determining the quality of the research proposals is found in section VII.2, "Working hypothesis" ('*Hipótesis de trabajo*'), where the principal investigator is asked to "indicate the new that you propose to do and the hypothesis behind it (*Señale lo nuevo que usted propone hacer y la hipótesis que lo sustenta*)" (FONDECYT 1998). Therefore, the formulation of hypotheses is a necessary condition of the application. FONDECYT explicitly and strongly favours hypothesis-driven research. Regulations for the competition 1998 state: "FONDECYT funds only scientific or technological research projects, i.e. projects that lead to new knowledge or anticipated applications through the verification or demonstration of working hypotheses explained in the project" (FONDECYT 1998).

Let us now consider Pedro Maldonado's application to the 1998 competition. The proposal asks funding to advance in the explanation of a phenomenon not yet understood, namely the neural mechanisms for processing visual information. In the "Bibliographic discussion" section, Maldonado explains the Temporal Correlation Hypothesis (TCH) relevance in the context of contemporary neuroscience of visual perception. As we said before, the TCH seeks to explain how the brain segments an image and groups the visual features of different objects in tiny fractions of a second. In different visual cortex areas, neurons are receptive to simple visual characteristics (shape, orientation, etc.). Since the visual cortex areas are interconnected, the representation of an object most likely involves establishing relationships

[3]https://api.observa.minciencia.gob.cl/api/datosabiertos/download/?handle=123456789/191348&filename=2019-I-mas-D-presentacion-de-resultados.pdf

between these simple visual features. Maldonado explains the TCH in relation to two other theoretical models. According to one of these models, the coding process is achieved through a series of hierarchically organised stages in which neurons of higher stages integrate information provided by neurons receptive to simpler features in earlier stages. However, there are several theoretical limitations to this model. Each conjunction of features would need one specialised unit, and the limited number of cells in the system does not seem consistent with the complexity of the visual world. Additionally, new constellations of features would suppose that we dispose of an a priori specialised stock of neurons ready to codify unseen combinations. According to the other model, concerted firing of parallel groups of neurons distributed across different cortical areas perform the grouping of visual features. The same neuron representing one feature and the same group of neurons representing a group of features can participate in the representation of different patterns. This second hypothesised mechanism turns out to be very efficient. The number of firing patterns in cell assemblies is much larger than the number of cortical neurons. However, this model entails severe theoretical limitations. The concerted firing mechanism is not context-sensitive, whereas visual features and their relations always appear in specific contexts. The visual system must avoid the overlapping of objects sharing similar features (i.e. coded with the same subgroup of neurons) and avoid the interference that occurs when similar objects are present simultaneously. The TCH adds a parameter (the timing of synchronous firing) that avoids these two theoretical problems of the second model. The coincident firing of groups of neurons may occur within a millisecond range and in rapid successions. Therefore, synchrony might serve as a mechanism to enhance rightly and timely the saliency of groups of firing neurons and, correlatively, the features they encode. Milner (1974) and von der Malsburg (1981, 1985) first hypothesised synchrony as visual processing mechanism. Using microelectrodes in the visual cortex to register both the spiking activity of individual cells and the extracellular current generated by localised groups of cells (the "local field potential" or LFP), evidence supporting the TCH began to accumulate since the late 1980s. For instance, Charles Gray and Wolf Singer (1987a, b; 1989; 1989) found that groups of neurons in cat's visual cortex, when presented with the appropriate stimulus, discharge synchronously at rhythmic intervals of 15-30 ms. Eckhorn and collaborators (Eckhorn et al. 1988) found stimulus-evoked coherent resonances between spikes and LFPs within the same column, between neighbouring columns, and between different cortical areas. As can be seen, Maldonado's project is genuinely and seriously oriented toward testing a pre-existing hypothesis.

Even if the funding requested from FONDECYT is meant to make possible a hypothesis-driven research project that aims at explaining a phenomenon still poorly understood, the resources are not invested in theoretical work as such, i.e. in generating explanations that would reinforce or replace the TCH. As we will show in section 4, resources are invested in setting up the experimental infrastructure to test the TCH (and as one may expect, experimental infrastructure is useful not only to test one particular hypothesis). Based on the theoretical limitations of the hypothesis of hierarchical convergence and the hypothesis of concerted firing by groups of neurons distributed in different places in the cortex, and based on the TCH's plausibility, Maldonado ask funding to design and implement *a new experimental paradigm* to test predictions generated by TCH (and as one may expect, experimental infrastructure is useful not only to test one particular hypothesis). All the evidence confirming the TCH and most of the evidence confirming the other two competing hypotheses has been obtained within a dominant experimental paradigm. This cominant experimental paradigm (that Maldonado calls the "classical experimental paradigm") uses anaesthetised or awake but fixating animals and attempts to correlate cells' electrical discharge with simple and parametrised physical stimuli. The new experimental paradigm Maldonado proposes to use alert animals freely viewing natural scenes.

In his FONDECYT, Maldonado proposes to measure cortical electrical activity in alert cats freely exploring images of natural scenes. If the TCH is valid, then it should be possible to observe and study the correlations between the presentation of stimuli in free-viewing and synchronous discharges. First, the investigator proposes to determine whether neurons that are receptive to visual features under conditions of simple and parametrised stimuli are also activated when these features appear in natural scenes. Secondly, to determine how neuronal response's temporal patterns during free-viewing differ from the neuronal response in the classical paradigm. Finally, to observe the patterns of electrical discharge during ocular movements. It is relevant to note that the first two objectives involve comparing neurons' behaviour in classical conditions with their behaviour during free-viewing. Eventually, this comparative exercise will turn out to be more difficult than expected, and in the long run, the most significant results of these experiments (and of others using *Cebus apella* monkeys instead of cats) will refer only to the third objective.

4. An experimental system with a life of its own

FONDECYT funds hypothesis-driven research projects. However, the funding it provides is often invested in experimental infrastructure and capacities for work in the long run. In other words, the performance-based, hypothesis-oriented and short-term characters of FONDECYT grants do not prevent from installing experimental systems "with a life of their own", i.e. systems that generate capacities and knowledge the scope of which goes far beyond the goals and outcomes of specific projects. The objective conditions of an experimental system's installation and development do not depend on pre-existing hypotheses making it relevant. Hypothesis-driven research does not diminish the autonomy of experimental systems. This autonomy should not be taken as a failure or a pathology of the funding instrument. The purpose of an instrument like FONDECYT is not to shape the epistemic properties or to direct the content of research itself. Any funding mechanism must assume that researchers continuously reconfigure aspects of their projected research according to the continuously unanticipated possibilities and limitations or challenges that they find. A funding programme conveys objectives that are not scientific in their nature or origin but belong to the space of science policy, which in turn conveys a (more or less explicit and more or less unitary) State policy concerning the social interest in knowledge production. In this section, we will show how resources allocated to test the TCH generated, on the one hand, skills that transcend the objectives of the original research project, and installed, on the other hand, the capacities for the autonomous development of the experimental system using free-viewing. Skills and capacities are certainly compatible but in no case subordinate to theory-oriented research. Section 5 will show what role a funding policy that promotes hypothesis-driven research may or should have in this context.

In Maldonado's FONDECYT project, the financial resources are mainly invested in the acquisition or construction of equipment and human capital training. $ 90,000 USD were employed in operative expenses, surgical and animal maintenance, components for manufacturing amplifiers and tetrodes, computer supplies, among others. Another $ 33,000 USD were invested in equipment (eye-tracker, anaesthesia machinery, computers, graphic cards, monitors, among others). It was assigned honoraria for the principal investigator ($ 7,950 USD) and travel funding to attend the Annual Meeting of the Society for Neuroscience in the United States ($ 2,500 USD) and the Annual Meeting of the Society for Biology in Chile ($ 270 USD). Finally, $ 8,000 USD were allocated in grants for thesis students and $ 24,000 USD for technical staff. Researchers, technical staff, and thesis students developed skills to construct or install and maintain equipment for surgeries, electrophysiological recording (tetrodes), data-production, and data-analysis. They also participate in experimental design, behavioural training and animal care, and the laboratory's organization and administration.

In 1999, Maldonado applied for a 3-years grant from the Volkswagen Foundation (a programme of partnerships in the natural and engineering sciences with institutes in Africa, Asia and Latin America). In this project, he proposes to study the dynamics of neuronal interactions in monkey's (instead of cat's) visual cortex during free-viewing. In the application's form's section about "available equipment", Maldonado refers to his 1998 FONDECYT project. He explains that the FONDECYT grant will provide equipment to set up surgical capabilities in the laboratory and other basic equipment appropriate to achieve this new research proposal's goals and other future proposals. In the same section, Maldonado highlights that appropriate laboratory equipment will serve not only to achieve the proposal's objectives but many other projects in the future (Maldonado and Singer 1999-2002). In sum, the FONDECYT funding served essentially to set up the experimental infrastructure. It is important to stress that investment in infrastructure is usually the explicit and defining target of non-hypothesis-driven research funding programmes, which seek to strengthen the overall research system's basis in the long term (Aragon 2011; Rheinberger 2002).

An experimental system understood as a set of apparatus, instruments, models, knowledge, skills, etc., determines the possibility and scope under which an object (for example, the neurophysiological correlates of free-viewing) is subjected to a feasible investigation producing new knowledge. Researchers make a number of strategic decisions when building an experimental system. In a case such as the one we are studying here, researchers seek to introduce a “new experimental paradigm”. Therefore, the results they obtain should be comparable and integrable with results obtained in the "classical paradigm". Evidence on TCH had until now been obtained using anaesthetised or awake but fixating animals (cats and monkeys) and simple and parametrised stimuli. If researchers want to compare and integrate these results with those they will obtain using free-viewing, then it seems reasonable to use the same model organisms. There exists accumulated knowledge about these models, which facilitates both data collection and analysis. Gray and Singer's classic papers on synchrony in the visual cortex use cats (Gray and Singer 1987b; Gray et al. 1989; Gray and Singer 1989). Moreover, Maldonado participated in the adaptation of tetrode technology to measure the electrical activity in cat's visual cortex (Maldonado and Gray 1996; Maldonado et al. 1997; Gray et al. 1995). All this explains Maldonado's first choice of cats as a model organism. The use of cats is conducive to effective changes in the experimental paradigm and to the comparative exercise of neuronal behaviour under classical conditions and free-viewing conditions. The new experimental system needs to inscribe a steady reference to experimental variables in the classical paradigm. This reference to the classical experimental paradigm conditions researchers' decisions when setting up an experimental system capable of registering the neurophysiological correlates of free ocular movements. Once installed, the system generates intrinsic epistemic capacities that in turn condition what researchers will be able to know. For example, the chosen model organism has the advantages we have already pointed out (i.e. it facilitates the comparison and integration of results obtained using different experimental paradigms). However, this choice eventually limited the extraction of ocular movements: facing images with natural scenes, cats do not explore much visually, besides being difficult to train them for complex tasks like the one required in this case. The functioning of experimental systems forces researchers to reduce their interventions' arbitrariness (Rheinberger 1997).

In retrospect, the project's leading and most productive achievement is linked to its third objective concerning eye-movements' neurophysiological correlates. This objective overrides the other two, related to the comparative study of neuronal response in classical conditions and free-viewing. TCH-based predictions about the neurophysiological correlates of eye-movements no longer concern the correlation between an external stimulus and neuronal synchrony. They now concern the correlation between eye movements and synchrony. When freely exploring a scene, human and non-human primates move their eyes between 3 and 4 times per second. Therefore, eye movements are natural markers of brain states during visual processing. If it is true that synchrony is part of the mechanisms for segmenting and grouping the visual features of natural scenes, then the timing of synchronous firing must be consistent with that of ocular movements. TCH-based predictions will now depend on the system of techniques allowing eye-movement units (composed of rapid, “saccadic” movements of the eyes and their subsequent fixation at a point in the visual field) to be extracted and mapped onto the activity of single neurons and the curve that records variations in synchrony and extracellular signals. In other words, experimental predictions are not derived from the previous “theory”; they need the auxiliary hypotheses generated and materialised by the experimental system itself. Faced with the difficulty of extracting eye movement units from cats, Maldonado soon developed a series of experiments using monkeys. These experiments allowed him to explore, for example, the prediction that saccade-onset generates a signal that modulates the timing of the highest synchrony in the processing of the external visual input (Ito et al. 2011). This prediction is inconceivable without the experimental system operationalising the concepts of “saccadic movement”, “synchrony”, “timing”, etc. In the long run, the main achievements of the 1998 FONDECYT will be its contribution to building a new "space of representation" (Rheinberger 1997) producing questions and predictions that previous theory had not logically foreseen or implied.

According to Haufe (2013), theories provide useful information to reviewers in that "theory often sets the terms for what will count as a solution to a problem". Theories tell us "what sorts of predictions are good for testing our hypothetical solution", and they even provide details about "the specific ways in which hypothesis tests are to be carried out". We agree that pre-existing theories and sound hypotheses may be used to assess proposals' coherence and feasibility. However, they neither shape the epistemic properties of research nor condition experimental systems' functioning (their "life"). As we have seen, the experimental procedures, scientific problems, predictions and solutions to which Maldonado's project eventually led could hardly be said anticipated by the pre-existing theory about the TCH. Insofar as testable predictions are not contingent on the pre-existing theory about TCH, the "exploratory" dimension *of* hypothesis-driven research is far from marginal[4]. There is no reason to believe that this aspect of hypothesis-driven scientific practice is ignored by peer reviewers and those who design and manage a funding instrument like FONDECYT. This instrument, explicitly biased in favour of hypothesis testing, is a policy instrument, not a methodological instrument. It likely conveys a philosophical idea of science only by name.

5. The policy of hypothesis testing

FONDECYT as a funding instrument seems to have a restricted, if not null, impact on the epistemic properties of the research's content. This content is strongly dependent on the autonomous development of experimental systems and their infrastructural basis. Experimental systems and not the action of researchers, let alone funding agencies' philosophies of science, determine the epistemic properties of the knowledge that eventually is produced. The orientation and biases favouring hypothesis-driven research in funding instruments like FONDECYT determine, at most, researchers' choices and decisions (for a start, the decision to apply or not to apply to the grant). However, experimental predictions and the impact that their confirmation may have on pre-existing knowledge depend on the technical, professional and methodological capabilities that the system will be able to implement. Moreover, any experimental system is determined beforehand by the techniques, models and research methods converging in its construction.

There is a growing interest in studying the impact of funding and authority changes on research content and practices (Laudel 2006; Hicks and Katz 2011; Hicks 2012; Whitley 2014; Benninghoff et al. 2014; Gläser et al. 2014; Laudel and Gläser 2014; Laudel et al. 2014; Gläser and Laudel 2016; Whitley, Gläser, and Laudel 2018; Franssen et al. 2018). It is not clear how and to what extent funding policies, with a predictable impact on researchers' decisions as social agents, can also determine the epistemic properties of research. For example, it has been observed that changes in funding criteria may induce changes in the experimental or theoretical character of research (Laudel 2006), but it is not clear what mechanisms are involved and their scope. O'Malley's et al. (2009) and Haufe's (2013) discussion of funding agencies' philosophy of science might suggest a novel way to study the mechanisms connecting research funding criteria with the epistemic properties of new knowledge. Following their argument, one may suggest that the philosophical idea of what constitutes "good science" and distinguishes it from pseudoscience guides both the allocation of resources and researchers' decisions to design experiments and analyse and present their results. For instance, O'Malley et al. state that "by separating exploratory grants from standard ones and limiting them to the

[4] This claim is consistent with Rowbottom's and Alexander's study (2012) on the role of hypothesis testing in biomechanical research. In their study, the authors analyse 100 papers in biomechanics and show that most of those who claim to test hypotheses (none claim to do purely exploratory research) do not do so, which indicates a bias against presenting research results as produced merely through exploratory research, presumably in order to increase the chances of publication.

early stages of research, this funding policy may hamper researchers from moving back and forth between different approaches in advanced research projects" (O'Malley et al. 2009, 613). Therefore, the philosophical continuity of an idea of science shared by the authority and the practising scientists might explain how a funding policy impacts the kind of knowledge it funds.

However, our case reveals that even in the context of total convergence or affinity between funding criteria and funded research, we find a gap between agencies' ideas of science and research activities and outcomes. As we show in section 4, there are considerable discontinuities between the idea of science as hypothesis testing and the actual practices and processes of testing hypotheses. The influence of research policies upon funded research processes and the epistemic properties of the research content seems to have intrinsic limitations. Performance-based competitive research funding programmes like FONDECYT have often been criticised for the restrictions they would impose on research contents. They tend to favour mainstream, short-term and risk-averse research, to the detriment of long-term, high-impact and exploratory research (Heinze 2008; Heinze et al. 2009). They reduce the chances of "unconventional projects" (Laudel and Gläser 2014) and perpetuate areas of undone science (Gross 2007; Frickel et al. 2009). They encourage the homogenisation of scientific practice and research goals (Whitley, Gläser, and Laudel 2018, 129). Wang et al. (2018) have recently relativised the unnuanced claim that competitive funding inhibits innovation, but only in the case of specific segments (e.g., senior or male researchers). If duly complemented and compared with other studies[5], the case we have studied in this paper may constitute an interesting counter-example to these critical approaches, as it relativises the idea of a direct causality of the performance-based funding instrument upon research contents.[6] As Jochen Gläser and Grit Laudel (Gläser and Laudel 2016, 146) have also rightly noted, the autonomy of experimental systems limits the changes that researchers may want to inflict on the directions of their research.

Despite its time frame constraints (three years) and modest funding, the FONDECYT project that we analysed here allowed the installation of relevant and long-term experimental infrastructure. It allowed the installation of the surgical, technical, informatical and electrophysiological capacities required to enable free-viewing as an experimental system with a "life of its own". The pre-existing hypothesis and theory did not condition the autonomous functioning of the system. Based on the anslyses of section 4, we are tempted to say that the opposite was true: by operationalising theoretical concepts and materialising experimental predictions, the experimental system conditioned the scope of the results to confirm the TCH. Moreover, a cursory look at the laboratory's subsequent activities reveals that free-viewing as experimental system eventually had a very productive life since the initial research funded by

---

[5] It would be, of course, premature to draw definitive and general conclusions from a single case study. It would be advisable to strengthen our analysis with comparative studies. For example, it would be desirable to compare with cases of research funded by FONDECYT, which, however, were not, in reality, oriented to the testing of pre-existing hypotheses (e.g., research whose investigators, after awarding funds, acted more freely and in an exploratory manner, accommodating their results eventually to the initial planning in the final reports to the funding agency). Another helpful comparison would be with cases funded by other instruments in Chile (e.g., for associative research) and cases of hypothesis-driven instruments in other countries.

[6] See Gläser (2017) on methodological challenges to studying the causal impact of performance-based funding on funded research.

the FONDECYT grant from 1998-2001. During the following 20 years, the work in free-viewing was developed in its theoretical (Maldonado 2007; Maldonado, Ossandón, and Flores 2009), its experimental (Maldonado et al. 2008; Ossandón et al. 2010; Ito et al. 2011; Berger et al. 2012; Ito, Maldonado, and Gruen 2013; Montefusco-Siegmund, Maldonado, and Devia 2013; Ito et al. 2017; Astudillo, Muñoz, and Maldonado 2018; Montefusco-Siegmund et al. 2018; Mariman, Burgos, and Maldonado 2019) and applied dimensions (Loyola et al. 2015; Fajnzylber et al. 2017; Vasquez-Rosati et al. 2017; Vera et al. 2017; Fajnzylber et al. 2018; Gajardo, Madariaga, and Maldonado 2019). From 2020 on, the laboratory has three new principal investigators in addition to Pedro Maldonado. Currently, there is an ongoing project on free-viewing and predictive coding (led by principal investigator Christ Devia), one on free-viewing and neuroplastic phenomena in people with low vision (led by principal investigator María de los Ángeles Jurisic) and one on free-viewing and homeostasis (led by Pedro Maldonado).

Judging by the case we have analysed, a performance-based, short-term funding instrument seems entirely compatible with the development in the long term of an autonomous experimental system. We believe that there is more than just compatibility here. Paradoxical as it may seem, we would like to suggest that an instrument like FONDECYT should favour in principle the continuity and projection of research in the long term, precisely because of the "working hypothesis" component. In the case we have studied, the pre-existing hypothesis's theoretical soundness, which did not constitute a relevant epistemic operator in the functioning of the experimental system, allows to anticipate that the project is conducive to results and outputs that should go far beyond the results and outputs of its three-year period. In other words, the "working hypothesis" requirement may help to mitigate the adverse effects of the short-term character of performance-based funding instruments. Maldonado's 1998 research proposal makes clear this point when justifying the request of resources: "(...) this project will allow the development of a new line of research in Chile associated with the study of the nervous system at a global level. This area, which takes part in the so-called Cognitive Neurosciences, has emerged as a priority in many countries due to its integrative nature in the understanding of the nervous system's functioning (…). The importance of the understanding of the dynamics of the nervous system is enormous. *Therefore, the verification of current theories about the brain's functioning and the development of new hypotheses about the nervous system have significant long-term consequences*" (the emphasis is ours).

The concept of "working hypothesis" is not an epistemic operator, but a research policy concept. It is a marker of scientific quality and relevance. Article 5 of the decree creating FONDECYT in 1981 states that the "main selection criteria" for basic research projects are twofold: "the project's contribution to the Nation's scientific enrichment and the personnel's suitability for directing and developing the project". It is clear that "Nation", in this quotation, refers to contributors who fund scientific research and need its outcomes. Nation makes its interest explicit: namely, its own scientific enrichment. The scientific community (applicants, grantees, peer reviewers) are in the obligation to account to society (or to the "Nation") for the scientific quality and relevance of selected research projects, even if–as it is the case in "basic research"–these projects do not have a particular explicit social or economic application or benefit in view. The "working hypothesis" in the FONDECYT form seems to be a suitable instrument for indexing scientific relevance and quality, thereby operationalising the first selection criterion (Nation's scientific enrichment). Research judged suitable for testing sound pre-existing hypotheses allows the different social actors to predict that the information that researchers generate is likely to be robust enough to serve valid scientific purposes. And if it serves that purpose, it can serve others as well, which means that researchers will be generating useful or usable information eventually, and thus they will be contributing to the "scientific enrichment of the Nation".

The "working hypothesis" is an excellent example of the kind of instruments that funding agencies develop to articulate different interests when fulfilling their role as intermediaries (Van der Meulen 1998; Braun 1993) between the State (or public representatives in general) and researchers. The concept of "working hypothesis" conveys both the public interest in legitimate, relevant and quality science and the interests of research communities, without inhibiting the development of basic objective infrastructural conditions of knowledge production processes.

The concept of "working hypothesis", like any concept of science policy in general, does not derive from the representations and philosophical ideas we may have about genuine science. To understand the meaning of science policy concepts, it seems much more important to keep in mind the social and economic values that societies assign to knowledge production. Science policies convey our expectations about the contributions of science to society's development (Kaldewey 2013; Schauz 2020). The value of knowledge is coherent with the interpretation that society makes about itself and about the role that knowledge production has in its development. The interpretation that our society makes about itself and about the conditions for its development does not seem to include (at least as a priority) curiosity about the universe. Instead, modern societies seem to be driven by the idea that they are capable of and responsible for generating the material and institutional conditions for their progress, if not their survival. In this context, knowledge plays a central role.

6. Conclusion

We have studied how an instrument for funding hypothesis-driven research participated in the installation of a hypothesis-driven experimental system. The convergence between funding instrument and funded research did not inhibit the installation and development of research processes highly autonomous vis-à-vis the pre-existing hypothesis. Therefore, the funding instrument's influence degree (along with that of any alleged ideology or philosophy supporting it) upon the funded research's epistemic properties is somewhat limited. The funding instrument's influence degree, on the one hand, and the development of research's "life of its own", on the other hand, probably entail discontinuous or mutually independent rationalities. The first pertains to the realm of science policy, which seeks to articulate the interests of the various actors in the system (e.g. funding agencies and research communities). The second corresponds to the methodological and technical field of knowledge-generating processes. This discontinuity not only explains why the pre-existing "working hypothesis", as an instrument of science policy, did not inhibit the formation of questions that were unanticipated or uncontained in the pre-existing theory and conceptuality; it also explains why the "working hypothesis" might have contributed to counter some adverse effects typically attributed to performance-based funding instruments (e.g. its short-term character).

References

Althusser, Louis. 1974. *Philosophie et philosophie spontanée des savants*. Paris: La Découverte.
Aragon, Richard. 2011. "Thinking Outside the Box: Fostering Innovation and Non–Hypothesis-Driven Research at NIH." *Science Translational Medicine* 3 (70):70cm5. doi: 10.1126/scitranslmed.3001742.
Astudillo, Carolina, Kristofher Muñoz, and Pedro E. Maldonado. 2018. "Emotional Content Modulates Attentional Visual Orientation During Free Viewing of Natural Images." *Frontiers in Human Neuroscience* 12 (459). doi: 10.3389/fnhum.2018.00459.
Benninghoff, Martin, Raphaël Ramuz, Adriana Gorga, and Dietmar Braun. 2014. "Institutional Conditions and Changing Research Practices in Switzerland." In *Organizational Transformation and Scientific Change: The Impact of Institutional Restructuring on Universities and Intellectual Innovation*, edited by Richard Whitley and Jochen Gläser, 175-202. Emerald Group Publishing Limited.
Berger, Denise, Antonio Pazienti, Francisco J. Flores, Martin P. Nawrot, Pedro E. Maldonado, and Sonja Grün. 2012. "Viewing strategy of Cebus monkeys during free exploration of natural images." *Brain Research* 1434:34-46. doi: https://doi.org/10.1016/j.brainres.2011.10.013.
Braun, Dietmar. 1993. "Who Governs Intermediary Agencies? Principal-Agent Relations in Research Policy-Making." *Journal of Public Policy* 13 (2):135-162. doi: 10.1017/S0143814X00000994.
Burian, Richard. 1997. "Exploratory Experimentation and the Role of Histochemical Techniques in the Work of Jean Brachet, 1938–1952." *History and Philosophy of the Life Sciences* 19:27-25.
Castro, Beatriz. 1972. "Análisis del sistema científico-tecnológico." *Serie Política Científica* 2 (Diciembre).
CONICYT-INE. 1983. *Actividades de investigación y desarrollo experimental*. Santiago de Chile: CONICYT.
Eckhorn, R., R. Bauer, W. Jordan, M. Brosch, W. Kruse, M. Munk, and H. J. Reitboeck. 1988. "Coherent oscillations: A mechanism of feature linking in the visual cortex?" *Biological Cybernetics* 60 (2):121-130. doi: 10.1007/BF00202899.
Elliott, K. C. 2007. "Varieties of Exploratory Experimentation in Nanotoxicology." *History and Philosophy of the Life Sciences* 29 (3):313-336.
Fajnzylber, V., L. González, P. Maldonado, R. Del Villar, R. Yáñez, S. Madariaga, M. Magdics, and M. Sbert. 2017. "Augmented film narrative by use of non-photorealistic rendering." 2017 International Conference on 3D Immersion (IC3D), 11-12 Dec. 2017.
Fajnzylber, V., S. Madariaga, R. Del Villar, P. Maldonado, D. Vargas, A. Serra, M. Magdics, and M. Sbert. 2018. "Pupillary Reactivity to Non-Photorealistic Rendering: A Case Study of Immersion in 3D Cinema." 2018 International Conference on 3D Immersion (IC3D), 5-6 Dec. 2018.
Feest, Uljana, and Friedrich Steinle. 2016. "Experiment." In *The Oxford Handbook of Philosophy of Science*, edited by Paul Humphreys.
FONDECYT. 1998. Formulario del Concurso Nacional de Proyectos Fondecyt 1998.

FONDECYT. 2000. *Programa Fondecyt: Impacto y Desarrollo: 1981-2000* Santiago de Chile: CONICYT.
Franklin, L. R. 2005. "Exploratory Experiments." *Philosophy of Science* 72:888-899.
Franssen, Thomas, Wout Scholten, Laurens K. Hessels, and Sarah de Rijcke. 2018. "The Drawbacks of Project Funding for Epistemic Innovation: Comparing Institutional Affordances and Constraints of Different Types of Research Funding." *Minerva* 56 (1):11-33. doi: 10.1007/s11024-017-9338-9.
Frickel, Scott, Sahra Gibbon, Jeff Howard, Joanna Kempner, Gwen Ottinger, and David J. Hess. 2009. "Undone Science: Charting Social Movement and Civil Society Challenges to Research Agenda Setting." *Science, Technology, & Human Values* 35 (4):444-473. doi: 10.1177/0162243909345836.
Gajardo, Abraham I. J., Samuel Madariaga, and Pedro E. Maldonado. 2019. "Autonomic nervous system assessment by pupillary response as a potential biomarker for cardiovascular risk: A pilot study." *Journal of Clinical Neuroscience* 59:41-46. doi: 10.1016/j.jocn.2018.11.015.
Gläser, Jochen. 2017. "A fight on epistemological quicksand: Comment on the dispute between van den Besselaar et al. and Butler." *Journal of Informetrics* 11 (3):927-932. doi: https://doi.org/10.1016/j.joi.2017.05.019.
Gläser, Jochen, Enno Aljets, Eric Lettkemann, and Grit Laudel. 2014. "Where to Go for a Change: The Impact of Authority Structures in Universities and Public Research Institutes on Changes of Research Practices." In *Organizational Transformation and Scientific Change: The Impact of Institutional Restructuring on Universities and Intellectual Innovation*, edited by Richard Whitley and Jochen Gläser, 297-329. Emerald Group Publishing Limited.
Gläser, Jochen, and Grit Laudel. 2016. "Governing Science: How Science Policy Shapes Research Content." *European Journal of Sociology* 57 (1):117-168. doi: 10.1017/S0003975616000047.
Goldflam, Margarita, Daniel Sierra, and María Soledad Zárate. Manuscript. "¿Más cientificos, más ciencia? Caracterización histórico-cuantitativa de la comunidad científica en Chile, 1960-1990."
Gray, C. M., and W. Singer. 1989. "Stimulus-specific neuronal oscillations in orientation columns of cat visual cortex." *Proceedings of the National Academy of Sciences* 86 (5):1698. doi: 10.1073/pnas.86.5.1698.
Gray, Charles M., Peter König, Andreas K. Engel, and Wolf Singer. 1989. "Oscillatory responses in cat visual cortex exhibit inter-columnar synchronization which reflects global stimulus properties." *Nature* 338 (6213):334-337. doi: 10.1038/338334a0.
Gray, Charles M., Pedro E. Maldonado, Mathew Wilson, and Bruce McNaughton. 1995. "Tetrodes markedly improve the reliability and yield of multiple single-unit isolation from multi-unit recordings in cat striate cortex." *Journalof Neuroscience Methods* 63:43-54.
Gray, Charles M., and Wolf Singer. 1987a. "Stimulus-dependent neuronal oscillations in the cat visual cortex area 17." *2nd IBRO-Congress, Neurosci Suppl*:1301.
Gray, Charles M., and Wolf Singer. 1987b. "Stimulus-specific neuronal oscillations in the cat visual cortex: A cortical functional unit." *Society of Neuroscience Abstracts* 13:4033.

Gross, Matthias. 2007. "The Unknown in Process: Dynamic Connections of Ignorance, Non-Knowledge and Related Concepts." *Current Sociology* 55 (5):742-759. doi: 10.1177/0011392107079928.

Haack, Susan. 2010. "Federal Philosophy of Science: A Deconstruction - And a Reconstruction." *New York University Journal of Law and Liberty* 5 (2):394-435.

Hagner, Michael, and Hans-Jörg Rheinberger. 1998. "Experimental Systems, Object of Investigation, and Spaces of Representation." In *Experimental Essays – Versuche zum Experiment*, edited by M. Heidelberger and F. Steinle, 355-373. Baden-Baden: Nomos.

Haufe, Chris. 2013. "Why do funding agencies favor hypothesis testing?" *Studies in History and Philosophy of Science Part A* 44 (3):363-374.

Heinze, Thomas. 2008. "How to sponsor ground-breaking research: A comparison of funding schemes." *Science and Public Policy* 35 (5):302-318. doi: 10.3152/030234208X317151.

Heinze, Thomas, Philip Shapira, Juan D. Rogers, and Jacqueline M. Senker. 2009. "Organizational and institutional influences on creativity in scientific research." *Research Policy* 38 (4):610-623. doi: https://doi.org/10.1016/j.respol.2009.01.014.

Hicks, Diana. 2012. "Performance-based university research funding systems." *Research Policy* 41 (2):251-261.

Hicks, Diana, and J. Sylvan Katz. 2011. "Equity and Excellence in Research Funding." *Minerva* 49 (2):137-151. doi: 10.1007/s11024-011-9170-6.

Hollingsworth, J. Rogers. 2008. "Scientific Discoveries: An Institutionalist and PathDependent Perspective." In *Biomedicine in the Twentieth Century: Practices, Policies, and Politics*, edited by C. Hannaway, 317-353. Bethesda: National Institute of Health.

Ito, Junji, Pedro Maldonado, and Sonja Gruen. 2013. "Cross-frequency interaction of the eye-movement related LFP signals in V1 of freely viewing monkeys." *Frontiers in Systems Neuroscience* 7 (1). doi: 10.3389/fnsys.2013.00001.

Ito, Junji, Pedro Maldonado, Wolf Singer, and Sonja Grün. 2011. "Saccade-Related Modulations of Neuronal Excitability Support Synchrony of Visually Elicited Spikes." *Cerebral Cortex* 21 (11):2482-2497 %@ 1047-3211. doi: 10.1093/cercor/bhr020.

Ito, Junji, Yukako Yamane, Mika Suzuki, Pedro Maldonado, Ichiro Fujita, Hiroshi Tamura, and Sonja Grün. 2017. "Switch from ambient to focal processing mode explains the dynamics of free viewing eye movements." *Scientific Reports* 7 (1):1082. doi: 10.1038/s41598-017-01076-w.

Kaldewey, David. 2013. *Wahrheit und Nützlichkeit. Selbstbeschreibungen der Wissenschaft zwischen Autonomie und gesellschaftlicher Relevanz*. Bielefeld: Transcript.

Kaldewey, David, and Désirée Schauz, eds. 2018. *Basic and Applied Research. The Language of Science Policy in the Twentieth Century*. New York: Berghahn.

Langfeldt, Liv, Maria Nedeva, Sverker Sörlin, and Duncan A. Thomas. 2020. "Co-existing Notions of Research Quality: A Framework to Study Context-specific Understandings of Good Research." *Minerva* 58 (1):115-137. doi: 10.1007/s11024-019-09385-2.

Laudel, Grit. 2006. "The art of getting funded: How scientists adapt to their funding conditions." *Science and Public Policy* 33 (7):489-504. doi: 10.3152/147154306781778777.

Laudel, Grit, and Jochen Gläser. 2014. "Beyond breakthrough research: Epistemic properties of research and their consequences for research funding." *Research Policy* 43 (7):1204-1216. doi: https://doi.org/10.1016/j.respol.2014.02.006.

Laudel, Grit, Eric Lettkemann, Raphaël Ramuz, Linda Wedlin, and Richard Woolley. 2014. "Cold Atoms – Hot Research: High Risks, High Rewards in Five Different Authority Structures." In *Organizational Transformation and Scientific Change: The Impact of Institutional Restructuring on Universities and Intellectual Innovation*, 203-234. Emerald Group Publishing Limited.

Loyola, Pablo, Gustavo Martinez, Kristofher Muñoz, Juan D. Velásquez, Pedro Maldonado, and Andrés Couve. 2015. "Combining eye tracking and pupillary dilation analysis to identify Website Key Objects." *Neurocomputing* 168:179-189. doi: https://doi.org/10.1016/j.neucom.2015.05.108.

Maldonado, P. 2007. "What we see is how we are: New paradigms in visual research." *Biological Research* 40:439-450.

Maldonado, P., José P. Ossandón, and Francisco J. Flores. 2009. "Attention and Neurodynamical Correlates of Natural Vision." In *From Attention to Goal-Directed Behavior*, edited by Francisco Aboitiz and Diego Cosmelli, 67-82. Berlin / Heidelberg: Springer.

Maldonado, Pedro, Cecilia Babul, Wolf Singer, Eugenio Rodriguez, Denise Berger, and Sonja Grün. 2008. "Synchronization of Neuronal Responses in Primary Visual Cortex of Monkeys Viewing Natural Images." *Journal of Neurophysiology* 100 (3):1523-1532. doi: 10.1152/jn.00076.2008.

Maldonado, Pedro E., Imke Gödecke, Charles M. Gray, and Tobias Bonhoeffer. 1997. "Orientation Selectivity in Pinwheel Centers in Cat Striate Cortex." *Science* 276 (5318):1551-1555.

Maldonado, Pedro E., and Charles M. Gray. 1996. "Heterogeneity in local distributions of orientation-selective neurons in the cat primary visual cortex." *Visual Neuroscience* 13 (3):509-516. doi: 10.1017/S095252380000818X.

Maldonado, Pedro, and Wolf Singer. 1999-2002. Dynamics of Neuronal Interactions in Monkey Visual Cortex During the Free Viewing of Natural Images. Volkswagen-Stiftung. Programe of Partnerships in the Natural and Engineering Sciences with Institutes in Africa, Asia and Latin America.

Mariman, Juan J., Pablo Burgos, and Pedro E. Maldonado. 2019. "Parallel learning processes of a visuomotor adaptation task in a changing environment." *European Journal of Neuroscience* 49 (1):106-119. doi: 10.1111/ejn.14258.

Milner, Peter M. 1974. "A model for visual shape recognition." *Psychological Review* 81 (6):521-535.

Montefusco-Siegmund, R., P. E. Maldonado, and C. Devia. 2013. "Effects of ocular artifact removal through ICA decomposition on EEG phase." 2013 6th International IEEE/EMBS Conference on Neural Engineering (NER), 6-8 Nov. 2013.

Montefusco-Siegmund, Rodrigo, Mauricio Toro, Pedro E. Maldonado, and María de la L. Aylwin. 2018. "Unsupervised visual discrimination learning of complex stimuli: Accuracy, bias and generalization." *Vision Research* 148:37-48. doi: https://doi.org/10.1016/j.visres.2018.05.002.

Nedeva, Maria. 2010. "Public Sciences and Change: Science Dynamics Revisited." In *Society, Culture and Technology at the Dawn of the 21st Century*, edited by Janusz Mucha and Katarzyna Leszczynska, 19-38. Cambridge: Cambridge Scholars Publishing.

NIH. 2020. "NIH Exploratory/Developmental Research Grant Award (R21)." accessed December 16th. https://grants.nih.gov/grants/funding/r21.htm.
O'Malley, MA, KC Elliot, C Haufe, and Burian RM. 2009. "Philosophies of funding." *Cell* 138 (4):611-615.
Ossandón, José P., Andrea V. Helo, Rodrigo Montefusco-Siegmund, and Pedro E. Maldonado. 2010. "Superposition Model Predicts EEG Occipital Activity during Free Viewing of Natural Scenes." *The Journal of Neuroscience* 30 (13):4787. doi: 10.1523/JNEUROSCI.5769-09.2010.
Pielke, Roger. 2012. "'Basic Research' as a Political Symbol." *Minerva* 50:339-361.
Rheinberger, Hans-Jörg. 1997. *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube*: Stanford University Press.
Rheinberger, Hans-Jörg. 2002. "Die Stiftung Volkswagenwerk und die Neue Biologie. Streiflichter auf eine Förderbiographie." In *Impulse geben - Wissen stiften. 40 Jahre VolkswagenStiftung*, edited by M. Globig, 197-235. Göttingen: VAndenhoeck & Ruprecht.
Rheinberger, Hans-Jörg. 2014. *Rekurrenzen. Texte zu Althusser*. Berlin: Merve.
Rowbottom, Darrell P., and R. McNeill Alexander. 2012. "The Role of Hypotheses in Biomechanical Research." *Science in Context* 25 (2):247-262. doi: 10.1017/S0269889712000051.
Saavedra, Francisco, and Patricio Vergara. 1989. *Recursos humanos en investigación científica y tecnológica: su participación en FONDECYT*. Santiago de Chile: CONICYT.
Schauz, Désirée. 2014. "What is Basic Research? Insights from Historical Semantics." *Minerva* 52:273-328.
Schauz, Désirée. 2020. *Nützlichkeit und Erkenntnisforschritt. Eine Geschichte des modernen Wissenschaftsverständnisses*. Edited by Deutsches Museum, *Abhandlungen und Berichte*. Göttingen: Wallstein.
Soler, Léna, Sjoerd Zwart, Michael Lynch, and Vincent Israel-Jost, eds. 2014. *Science After the Practice Turn in the Philosophy, History, and Social Studies of Science*. London / New York: Routledge.
Van der Meulen, Barend. 1998. "Science policies as principal–agent games: Institutionalization and path dependency in the relation between government and science." *Research Policy* 27 (4):397-414. doi: https://doi.org/10.1016/S0048-7333(98)00049-3.
Vasquez-Rosati, Alejandra, Enzo P. Brunetti, Carmen Cordero, and Pedro E. Maldonado. 2017. "Pupillary Response to Negative Emotional Stimuli Is Differentially Affected in Meditation Practitioners." *Frontiers in Human Neuroscience* 11 (209). doi: 10.3389/fnhum.2017.00209.
Vera, F., V. D. Cortés, G. Iturrra, J. D. Velásquez, P. Maldonado, and A. Couve. 2017. "Akori: A Tool Based in Eye-Tracking Techniques for Analyzing Web User Behaviour on a Web Site." 2017 IEEE International Conference on Data Mining Workshops (ICDMW), 18-21 Nov. 2017.
Von Der Malsburg, C. 1981. The correlation theory of brain function. Max-Planck-Institute for Biophysical Chemistry.

Von Der Malsburg, C. 1985. "Nervous Structures with Dynamical Links." *Berichte der Bunsengesellschaft für physikalische Chemie* 89 (6):703-710. doi: 10.1002/bbpc.19850890625.

Wang, Jian, You-Na Lee, and John P. Walsh. 2018. "Funding model and creativity in science: Competitive versus block funding and status contingency effects." *Research Policy* 47 (6):1070-1083. doi: https://doi.org/10.1016/j.respol.2018.03.014.

Waters, C. Kenneth. 2007. "The Nature and Context of Exploratory Experimentation." *History and Philosophy of the Life Sciences* 29:1-9.

Whitley, Richard. 2014. "How do Institutional Changes Affect Scientific Innovations? The Effects of Shifts in Authority Relationships, Protected Space, and Flexibility." In *Organizational Transformation and Scientific Change: The Impact of Institutional Restructuring on Universities and Intellectual Innovation*, edited by Richard Whitley and Jochen Gläser, 367-406. Emerald Group Publishing Limited.

Whitley, Richard, Jochen Gläser, and Grit Laudel. 2018. "The Impact of Changing Funding and Authority Relationships on Scientific Innovations." *Minerva* 56 (1):109-134. doi: 10.1007/s11024-018-9343-7.

Credit author statement

Juan Manuel Garrido Wainer: Conceptualization, Field work, Methodology, Writing - Original Draft, Supervision, Project administration, Funding acquisition.
Natalia Hirmas: Investigation, Field work, Review & Editing.
Nicolás Trujillo: Investigation, Field work, Review & Editing.

Funding: This work was supported by the Agencia Nacional de Investigación y Desarrollo (ANID, Government of Chile) under Grant PIA-Anillo SOC180039 and Grant FONDECYT 1210091

Acknowledgement: The authors would like to thank Pedro Maldonado, Cecilia Babul and Neurosistemas Laboratory staff at the Biomedical Neuroscience Institute, Facultad de Medicina, Universidad de Chile. Soledad Zárate and Berta Ríos helped us to obtain relevant historical documents about FONDECYT. We would also like to thank Chris Haufe, Grit Laudel and an anonymous reviewer for precious and generous feedback, which has allowed us to reformulate and clarify various ideas in this paper.