

Title

Local thematic styles: a method for identifying inter-cultural differences in specialists' scientific conceptions. A comparative study of Indian and French physicists

Keywords

themata, styles, comparison, inter-cultural, physics

Abstract/introduction

The question of the universality of science has been the subject of many debates within the philosophy of science community and beyond. Many different positions exist on the question, but what evidence do we have for or against this universality?

This article proposes a methodology for identifying the influence of scientists' cultural background on their representations of central elements of their scientific domain. Thus, using a modified version of Gerald Holton's concept of 'themata', we examine whether Indian and French scientists differ in their approach to central conceptual problems in modern physics. We ask whether the scientists' themata differ and are dependent on their cultural backgrounds, or whether they are relatively uniform, reflecting a homogeneous shared set of values. Our method, applied to a panel of French and Indian physicist, reveals some trends suggesting a difference between the two groups. This result supports the proposition of our own concept to describe the specific local styles related to themata: "local thematic styles". Here, we present this approach, with its virtues and its shortcomings, as well as the empirical findings of our research in order to advance the debate over the issue of universality in science.

I. Theoretical background. Thinking about the physical world described by science: what do local specificities imply?

I.a. Local styles

Can we show that a scientist's local culture influences his or her way of interpreting the nature of scientific theories and their associated worldviews? Here, we propose an empirical method that aims at probing this relationship between scientists' cultural background and their scientific worldview. Evidently, this investigation touches on the question of the universality of science, a recurrent subject of debate in science studies, be it from the perspective of philosophy, sociology or anthropology of science (Durkheim, 1899)(Galison, 1996)(Waast, 2010). Many different positions exist on the question (Gayon, 1996) and we will offer arguments in favour of the influence of cultural background in terms of local styles. In order to identify "local styles", we need to bring to light relevant distinctive elements

capable of characterizing different homogeneous groups within the same disciplinary field. By "local" one might mean a country, a region, a network of connected laboratories or even a single laboratory. There are different categories for these approaches to local style depending on whether they depend on the scientific method employed (Crombie 1994)(Hacking 2003), the mode of reasoning or the scientific thinking itself. The method we propose here analyzes styles of scientific thinking dependent on local cultural differences, an area that remains relatively underexplored.

While several authors have described and analyzed the idea of styles of thinking in science, few have addressed the issue of how styles of thinking might depend on different worldviews or different cultures. In this context, we can cite Ludwig Fleck's concept of "style of thought" (*Denkstil*) (Fleck 1935), and note that while similar to our approach in some respects, it does not depend on local specificities. Feuer's concept of 'mode of thought' (Feuer, 1974, 2005) proposes national characters related to emotions shared among scientists under the influence of such factors as the role of the administration in different countries. Jonathan Harwood has also argued for the existence of different "forms of thought" in one country at a given time (Harwood 1993). While we situate our analytical tool – "local thematic style" – in the same category as these approaches in terms of local styles of thought, our specificity is to decline them from the angle of local worldviews. For this, we have based our approach on the concept of themata. Thus, the concept of "thematic local style" will be used as a means to approach the central issue of the universality of scientific thought in a more direct empirical manner.

I.b. Themata

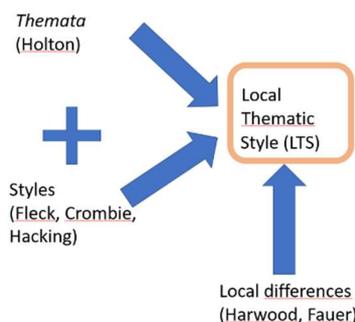


Figure 1: schema of the concept "local thematic style"

Gerald Holton, a "distinguished physicist, drawing from his experience and inspired by the Kantian philosophy" (Moscovici 1984) is at the origin of the concept of themata, which he first used in 1962 (Holton 1962). He observed that because these presuppositions are not derivable from observations or analytical reasoning, they require an appropriate term and so he called them themata (singular, thema, from the Greek word meaning fixed, motif, thesis, topic, Holton, 1996, 456).

Holton considers that in many concepts, methods, hypotheses or scientific proposals (even in most), past or present, we can find elements acting as themata, serving as constraints or as positive motivations for the individual, sometimes determining an orientation (a standard) or a polarisation within the thinking of a scientific community. “During the nascent, ‘private, period of work, some scientists, consciously or not, use highly motivating and very general presuppositions or hypotheses that are not directly derivable from the phenomena and are not provable or falsifiable. But when such work then is proposed for entry into the ‘public’ phase of science, these motivating aids -which the author has termed thematic presuppositions or thematic hypotheses- tend to be suppressed, and disappear from view” (Holton, 1996, 454- 455).

Themata escape any logic of proof: no experiment can confirm this type of personal orientation, illustrated, for example, by a choice within the dichotomies holism versus atomism, or determinism versus indeterminism. These themata are too polysemic and too symbolic to be confirmed by their consequences. The reasons why a scientist opts for a thema are not well understood, even if some theories have been put forward. One researcher has suggested that they could result from meanings, affects and intimate values that echo experiences and personal problems (Quidu 2009) while we will here pursue the idea that they have their origins in the scientist’s cultural background.

We chose this concept of themata because it is a useful tool “to explain why at any given time the choice of problems or the reception of theories may be strikingly different among individuals or like-minded groups who face the same corpus of data. Examples on this point are the early, quite different responses to relativity in Germany, England, France, and the United States of America” (Holton, 1996, 456). The approach using themata is thus particularly useful for highlighting scientific controversies (over conceptual issues) because of their structure in opposing pairs, such as determinism versus indeterminism.

We should however be clear concerning the limits of this notion. The concept of themata needs more research concerning what leads scientists to adopt one thema rather than another and we have reflected on this issue elsewhere. Furthermore, it does not seem to us that themata represent the essential reality of someone’s scientific work and that they are only one aspect of this work. Indeed, it is difficult to say when they exercise a significant influence on a scientist’s work. It is not possible, therefore, to affirm that the work of a scientist would have been different in case of a commitment to different themata. Themata, therefore, only allow us to clarify certain tendencies but nevertheless offer an essential contribution to a global history approach where the aim is to analyze wider trends that are invisible in microhistorical studies

Here, we propose using themata in order to define a method that will distinguish specificities in the way scientists relate to the physical world that depend on the scientist’s country of origin. While we do not pretend to prove that these local thematic styles significantly influence scientific research, we seek to identify the preferences shared by culturally-defined groups of scientists as revealed through their themata. We call these specificities “local thematic styles”.

In this article, we will first present the method for identifying these local thematic styles and then illustrate the use of this method by comparing two small groups of physicists, one composed of Indians the other of French scientists. Focusing on the particular theme determinism versus non-determinism, we will show why we believe there to be differences between the Indian and the French scientists. In conclusion, we will explore the wider potential and limitations of this method.

I. Presentation of the method (panel, questions, themata, social bias)

How do we propose bringing to light the representations of the physical world and especially the themata that lie behind them? These themata, being personal ontological representations of reality, are not always conscious, and it is difficult to render them visible. To reveal them, we relied on interviews and writings collected from 70 physicists. The core of our research is an analysis of the representations of these Indian and French physicists, as reflected in their discourse (responses to a panel of interview questions) or their texts (articles, conferences, etc.). Of course, it is not easy to have access to this kind of deep, very abstract representation through the scientists' discourses, but we believe that the tools we have developed allow us a good level of access.

II.a. Methodology: discourses and comparison

We take the discourse of physicists as the raw material for our analyses. This does not mean that we necessarily consider that what they say is true, but rather what they say and how they express it will allow us to understand the underlying representations that lie behind their verbal and written expression. We are not here interested in the working relations that may exist between Indian and French scientists, but in the function of the cultural dimensions of physicists on their thinking, in the way they represent matter and universe, and their choice of interpretations of physical theories. To plunge into the heart of their representations, one must analyze their spoken and written discourse. The texts we analyse are the result of interactive discussions, with interviewer questions and other stimuli that aim at capturing the scientists' intimate representations of physical concepts and their ontological scope.

We chose to use the semi-directive interview method in order to access the inner plurality of the person being interviewed and also to ensure a space of discussion large enough to verify the meaning of words and the scope of the concepts deployed. This was especially true in the context of quantum theory, which uses a complex technical vocabulary. We based these interviews on a pre-established list of questions, as this was an important factor for comparing different scientists, which allowed us to engage an initial statistical analysis.

II.b. A mixed qualitative and quantitative approach.

For this project we conducted 70 interviews, 35 with French and 35 with Indian physicists, followed by an analysis that combined both qualitative and quantitative elements. Work has shown that it is not only possible, but heuristically useful to mix these two approaches, as

illustrated by the area of ethnographic statistics (Cayouette-Remblière 2013). In Figure 2, we show some specificities related to these different approaches.

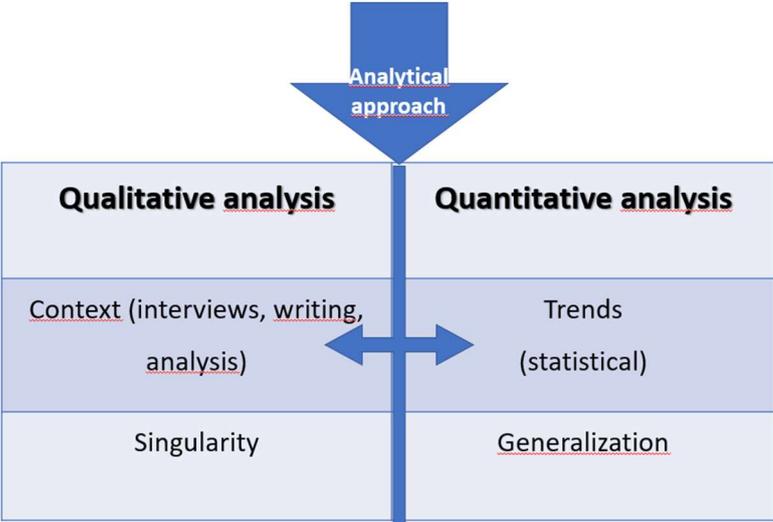


Figure 2 : between qualitative and quantitative analysis

Our analysis is both qualitative (detailed analysis of the interviews and texts produced by physicists), each physicist becoming a case study, and quantitative (statistical comparison of the responses of Indian and French physicists). The categories (for us, themata) were developed before, during and after the survey.

The approach we have favoured is an analytical posture, that is to say a posture that combines the qualitative and quantitative methods, based on the model of an actor with limited rationality. While thought and behaviour is not considered to be completely socially determined, it is not considered to be totally rational either! We are close to the approach propounded by comprehensive sociology that is particularly interested in the meaning people give to their practices and representations. Thus we not only question what the scientists do and say, but also the reasons (whether conscious or not) behind these behaviours.

A. Przeworski and H. Teune (Przeworski and Teune 1970) argue that there is a dichotomy in most social sciences between these two orientations; on the one hand case studies which favor the deepening of knowledge about the subject of research and on the other the more comprehensive, but less precise comparative analysis ("knowing less about more"). The balance to be found between generality and specificity depends on the objective pursued, as well as on the protocol of inquiry.

II.c. The inquiry: who and how?

We selected individuals for interview who had completed their master's degree in physics in France or in India, and who work in research on one of the sub-disciplines of physics. Thus, education was used to define who was a "French physicist" and who an "Indian physicist", with the idea that they should be fully impregnated by the local culture. Within this

population, we selected a sample of individuals, although this sample was not meant to be representative. With all the parameters potentially involved in people's representations – age, gender, discipline, geographical origin, social origin, etc. – it would be impossible to control for them all. In addition, we wanted to have comparable samples between the Indian and French physicists in terms of discipline, gender and age, but the distribution is not the same in the two countries. We selected the different physicists in an attempt to have a sample that reproduced to a good degree the variety of Indian and French physicists in terms of age, gender and disciplinary specialization. We have ensured that the physicists were sufficiently diversified to avoid excessive bias related to age, gender, etc. Our selection was based on criteria of disciplinary diversity (theoretical physics, experimental physics in particular), as well as diversity of age and gender.

Nevertheless, theoretical physicists are substantially more present in our Indian population than among the French. This is explained by the importance of this discipline in India, for historical and economic reasons, which we explain elsewhere. It should be borne in mind, however, that pure theoreticians also work in other departments than in theoretical physics, especially in India.

Interviews with Indian physicists were conducted in 2013 and 2014 at CERN in Geneva, as well as in Bombay and Poona and in various research centers, in particular the Tata Institute of Fundamental Research (TIFR) and The Inter-University of Astronomy and Astrophysics (IUCAA) in India. A few interviews with Indian physicists working in French laboratories were conducted in France. Interviews with French physicists were conducted in various laboratories in the Rhône-Alpes region and in the Paris region, in particular at the Lyon Nuclear Physics Institute (IPNL) and the Saclay site of the Atomic Energy Commission (CEA).

Regional origins

We observed that a majority of our Indian interviewees originated from the State of Bengal and more specifically from its capital, Calcutta. It seems that Calcutta is *the* city for theoretical physics in India, partly because it was for a long time the capital of British India and became the country's intellectual capital. We have not noticed any similar phenomenon for the French, with no region appearing to be particularly dominant in its production of physicists. In terms of education more generally there are greater regional differences in India than in France. In the State of Kerala almost all children are enrolled in primary school, while in Bihar State only half are. These disparities can be explained to a large extent by the differences between rural and urban areas, with children from rural areas being less likely to attend school.

Family and social environment

Social class is not a neutral parameter in our samples either, particularly for the Indians for whom the social origin of the parents is an important factor in their career as a physicist. The selection to become a researcher in India is more competitive than in France, and an average Indian child has statistically less chance of becoming a physicist. Most of the researchers are

from higher castes or intellectual families (often both) with an over-representation of children of teachers, doctors or lawyers. India is a country where social and financial status are important factors in job-choice and a researcher has a relatively low status in society at large. Engineers, for example, enjoy more social recognition than physicists so a gifted student will tend to choose the career of engineer over researcher, except in the intellectual or academic circles where people are more receptive to the value of pure research. These factors are very complex and taking them into account would require a detailed analysis for each individual physicist, which was not possible.

How to draw the comparison?

It is difficult to apply the comparative method that we used to reveal themata to large groups because of the qualitative side of the analysis. The relatively small size of the groups of French and Indian scientists means that we could not establish reliable statistical differences. Nevertheless, we still use statistics to identify the trends that arise in the comparison, although we want to emphasize that these are only trends and not statistically significant differences. We use the qualitative discourse analysis to confirm the value of these trends, and to suggest possible influences behind them, looking at the pertinent aspects of the scientists' culture, the intellectual postures and more specific arguments. Thus, the qualitative analysis of the scientists' discourses allowed us to assess the significance of the observed trends by comparing the difference between the two groups in terms of postures and arguments.

In the statistical tables that follow, we present the distribution of responses in percentages (rounded to the nearest unit) as this allows the reader to see the differences more easily.

II.d. Revealing the themata

To highlight the themata of physicists, we developed a set of questions (on average 3 questions per thema). We ensured that the questions were different for each thema, with no overlap, and for some we also relied on evidence drawn from the writings of the physicists. The questions were posed in an interview situation with the aim of bringing the themata to light. We selected 5 themata: determinism / indeterminism, objectivity / subjectivity, continuity / discontinuity, reductionism / systematism, and order / disorder. Some of the questions were inspired by philosophical inquiries conducted by philpapers¹. Many of these questions relate to the interpretation of quantum mechanics. Indeed, this domain provides a very good opportunity to express themata because, while the theory is widely deployed and used in its formal and applied aspects, its interpretation is far from achieving unanimity. It also raises many ontological questions². We considered it important to spread questions related

¹ The PhilPapers Survey was a survey of professional philosophers and others on their philosophical views, carried out in November 2009. The Survey was taken by 3226 respondents, including 1803 philosophy faculty members and/or PhDs and 829 philosophy graduate students (<http://philpapers.org>).

² In order to elaborate these questions, we have drawn on surveys on the attitudes towards the fundamentals of quantum mechanics, published in 2013 (Schlosshauer, Kofler, & Zeilinger, 2013), (Sommer 2013) and

to the same thema out across the interview so as not to induce a link between them, thereby facilitating access to deeper beliefs rather than triggering superficial associations.

The interview and its various questions make it possible to classify physicists with respect to the various possible answers and postures following an analysis of their responses complemented by an analysis of their published work. The use of these publications is not systematic because few physicists have publications that reveal these themata. This being said, while themata are difficult to identify in scientific publications, they become clearer in less specialized publications or conferences, although most physicists limit themselves to specialist journals.

Certain questions revealed notable differences between the groups, with, for example, 26% of Indian physicists considering matter to be continuous while 74% of French physicists considered it to be discontinuous. Nevertheless, overall the thema continuity/discontinuity failed to reveal differences between groups because of a smoothing effect generated by the plurality of responses related to this thema. Taking into account this effect, a gap of a few degrees of adhesion that may seem small, can be very suggestive. We have opted for differences related to the themata rather than differences with respect to individual questions, because we believe this gives a better idea of the physicists' deep representations, even if the differences are smoothed out when the questions are grouped together. Furthermore, isolated issues are more easily biased by parameters other than thematic preferences. Thus, for example, many Indian physicists accept arguments of authority, lending credence to an interpretation defended by an authority figure in the domain, without necessarily taking into account their own adherence to this interpretation. However, it is not always easy to find appropriate questions, ones that probe ontological preferences, even unconscious ones. Thus, directly asking physicists: "Do you prefer determinism or indeterminism?" will not reveal the real thema, as the physicists may not have asked themselves the question and so risk responding so as to conform to what they feel is expected of them, rather than according to their own conviction. While if the terms of the question are well understood and the interviewees respond in a direct way a single question could be sufficient to identify a thema, these conditions are rarely satisfied, and so we relied on two or three questions related to each one.

As an example, here are the questions related to the thema determinism / indeterminism.

II. Illustration: thema déterminisme/indéterminisme

"Determinism is the basis of science, I believe in determinism in the same way that I believe in science." M.X

(Norsen & Nelson, 2013) on the Tegmark's survey in 1997 (Tegmark 1997). However, unlike the three surveys cited above, our survey is based on qualitative interviews in which we have taken care to define the terms and to gather the arguments that justify the deep adhesions of physicists.

"I do not conceive the evolution of the universe as determined, because it would be sad." M.Z

In order to analyze whether the country and the culture of origin of physicists influence the thematic adherence to determinism, we asked them two questions during the interviews, and for some we also explored their publications to supplement their answers.

The two questions that make it possible to classify physicists in terms of their degree of adhesion to this thema (determinism / indeterminism) are:

"Disintegration": What do you think of the randomness of individual quantum events such as the radioactive decay of an atom? Is there a hidden determinism or is the randomness a fundamental concept in nature?

"Universe": Do you agree with this sentence: the future of the universe is determined by the present state of the universe now (independently of our ability to predict it)?

In the context of quantum mechanics, determinism is called into question. Indeed, measurements made on quantum objects seem to produce non-deterministic results. In other words, the same causes do not necessarily produce the same effects. The orthodox interpretation of quantum mechanics, which is the interpretation usually presented in textbooks (in France as well as in India, since they generally use the same textbooks), considers that, in a measurement, the state of the system changes spontaneously and probabilistically. Depending on the experimental result of this measurement, the state is projected - also called reduced - according to the vector corresponding to the result of the measurement. Thus, the measurement disrupts the system in an unpredictable manner. The question is; how should one interpret this dual behavior, apparently both deterministic and non-deterministic? For the founders of the current orthodox interpretation, quantum probabilities do not reflect ignorance on our part – as is the case in statistical mechanics – but underline the fundamentally indeterminate nature of the system. The orthodox interpretation suggests that since predictions can only be probabilistic, the world - in any case the microscopic or more generally the quantum world - is fundamentally non-deterministic. Some alternative interpretations that put determinism back into the theory have been proposed such as David Bohm's updated version of the hidden variables approach in 1951³. The fact that the debate is not closed thus makes it possible to highlight the thematic preferences of individual physicists.

An analysis of the interviews and publications allows us to classify the physicists into different groups (figure 3):

Thema - Determinism	Individual quantum event	The whole universe
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³Hidden variable approaches are often called "Bohmian approaches" in reference to the physicist David Bohm, who developed this interpretation, following L. de Broglie.

	Determinist	Non-determinist	both	Determinist	Non-determinist	Both
French physicists	24%	76%		48,4%	48,4%	3,2%
Indian physicists	47%	50%	3%	64%	29%	7%

Figure 3 : Synthesis of the distribution of responses referring to the determinist nature of the universe or of an individual quantum event, such as the radioactive decay of an atom, depending on the origin of the physicists, French or Indian. Percentages indicate the number of physicists who opted for such a response, based on the total number of responses.

	French physicists	Indian physicists
Degree of thematic affinity towards determinism	-0,26	0,18

Figure 4 : This coefficient expresses the adherence of physicists to determinism: the closer it is to 1, the more the physicists lean towards determinism, the closer it is to -1, the less they favour determinism. The calculation is based on the answers to two questions: - "disintegration": the "random" response gives a score of -1, while the answer "there is an underlying determinism" gives 1 - with respect to the "universe": an answer in favour of a deterministic evolution gives 1, while the answer in favor of an undetermined evolution counts for -1. Intermediate responses of the type "both" are rated 0 while a non-response ("I do not know") is not counted.

We can observe in figure 4 that a greater proportion of Indian physicists than French favour determinism. While the distribution of the answers suggests that Indian physicists are more attached to determinism, the small number of interviews limits the statistical pertinence of the result. On the other hand, these interviews allow us to perform more in-depth analyses, looking at the terms of the arguments offered by the different groups. And it is this more detailed analysis of the arguments that allows us to better understand what is behind this preference and to add evidence in favour of the thematic preference of Indian physicists for determinism when compared to the French. Several elements differentiate the arguments of the French and Indian physicists.

French physicists are more ready to criticize determinism, either because they see it as a concept constructed to reassure humans or because they feel freer than their Indian peers to question certain fundamental principles of modern science such as determinism. Indeed, it seems that Indian physicists are less likely to question canonical concepts.

For a certain number of Indian physicists, the principle of determinism rests on a particular conception of science, with some remarking explicitly that "determinism is the basis of science", an argument that is not found among the French.

A number of the French physicists expressed their belief that a deterministic world would be sad or dull, while for Indian physicists determinism more often corresponds to a well-ordered, more reassuring world. For several Indian physicists, man cannot act in a non-deterministic world, whereas the opposite idea appears in the discourses of French physicists for whom man cannot act in a deterministic world.

Here we have insisted on the main trends, but concerning some other aspects, Indian and French physicists were very close in their positions, in particular on distinguishing between the determinism of open and closed systems or confusing chaos with randomness. Of course, there are a number of Indian physicists who adhere to indeterminism and many French physicists to determinism, but here we focus on the overall difference suggested by the analysis of the two groups.

III. Principal results of our study

This approach via themata, gives us a global overview (see figure 5) of a set of personal postures and complex representations of physicists, and we were able to identify certain trends that support this idea of themata. Indian physicists appear :

- more deterministic than the French,
- more attached to a discrete conception of matter, rather than conceiving it as a continuum,
- grant a greater role to the subjective character of knowledge, and conceive consciousness as more immaterial,
- have a more systemic approach to natural phenomena,

French physicists appear

- less deterministic,
- more attached to a continuous conception of matter,
- grant a more important role to the objective character of knowledge, and conceive consciousness as more material,
- have a slightly more reductionist approach to phenomena.

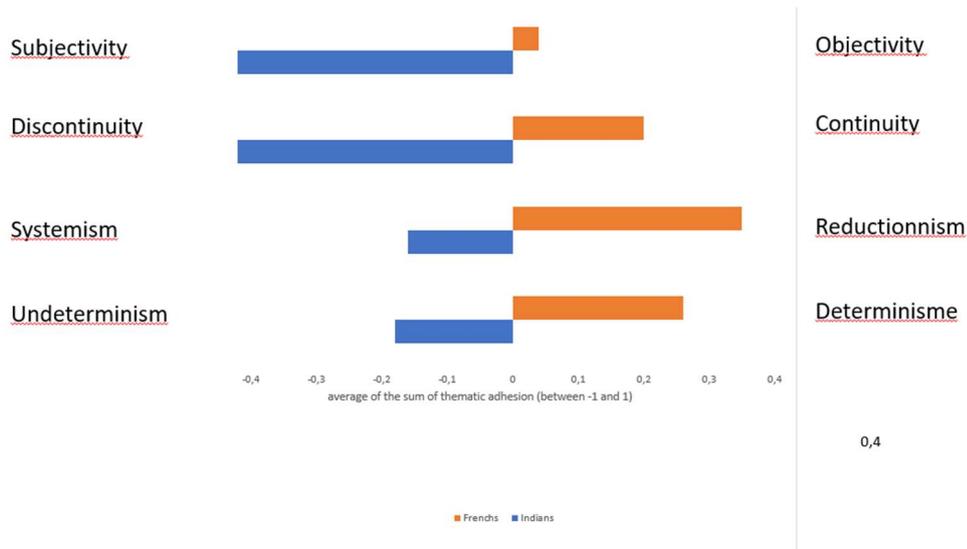


Figure 5 : representation of the thematic trends of Indian and French physicists as revealed by the study

We studied the influence of other parameters on the themata. For example, do the age groups or the type of scientific discipline reveal differences in the themata of the physicists? We did not observe a marked difference according to the different ages or research disciplines. As a result, we concluded that cultural origin is the principal parameter that influences the themata.

IV. Possible methodological criticisms

We would like to signal several issues concerning our research, notably possible bias in the interviews and bias associated with our own position of observer. Another issue is the universality of epistemological values associated with science (determinism, objectivity, etc.), and their status in countries whose scholarly traditions are based on different values. What happens when these values come into contact with others, such as scientific values? Finally, another methodological discussion concerns the language used in the interviews, and how it modifies the signification of themata.

V.b. Is what the physicists say a reliable source of information? The exchange between the interviewer and the interviewee

The possibility that some of the physicists adapt their discourse for various reasons should not be ruled out: by wanting to present a stance that they judge preferable to the investigator or for other reasons, unconscious or not. It is not a question of the subjects not saying what they think, but rather the possibility of the adaptation of the discourse to the context disrupting the detection of themata. Laurent Thévenot (Thévenot 2006) speaks of "a personality with drawers" and exchange with different interlocutors might be considered to open different drawers. Nevertheless, despite the added variability, we should not imagine that a change in interlocutor would affect the expression of thematic commitments as they are such deep structures. As an investigator, I have also asked what influence I might have had on the interviewees' expressions. I suspect that being a woman, french and trained as a physicist had an effect on the attitude of the interviewees, with pre-conceptions that varied according to their personal background and culture. This is a difficult parameter to evaluate

because the influence may well act on an unconscious level. During the interviews, I put myself in the posture of listening and relaunching the discussion while trying not to interfere with the train of thought, the representations and therefore the discourse of the physicists. Here, I just want to signal these possible sources of bias.

V.c. Ethnocentrism and choice in themata

In the case of international research, constructing comparative research requires special vigilance to reduce the risk of ethnocentrism and avoid the introduction of cultural bias. "The first form of ethnocentrism resides in a formulation of the problematic too rooted in a particular culture" (Ardilly, 1994, 220). It is therefore necessary to ask whether our research problem is not itself ethnocentric. Is 'thema' a western concept that has no relevance in an Indian context, for example? Indian thought constructs the representation of man and the universe on principles that do not fit into the axioms of identity and non-contradiction that form part of the Western rationalist tradition (Angot, 2001) (Satapathy and Das 2013). Therefore, the functioning of themata as an exclusive duality might not be relevant. We would be interested in putting into (Ardilly 1994)dialogue the opposing postures within each themata, to see how these apparent oppositions interact within the same individual.

Moreover, are the questions asked in the interviews and the concepts involved, such as determinism, continuity, universal? Do they have the same meaning in Indian thought or have I tainted them with a style of Western thought? Have I not interpreted the discourses in the terms of my own discourse, according to my own modes of conception? While this is possible, I have done everything I can to explain the concepts in a common language. In the choice of the subject and the manner of apprehending it, linked in particular to my origins and upbringing. One reassuring aspect of the results of my research with respect to these methodological doubts concerning my personal bias was that I was surprised by my results, expecting, for example, to find the Indians less deterministic, more interdisciplinary. These results have reassured me about the influence of my expectations on my research.

V.e. Is it the same thing to discuss physics in French with French subjects and English with Indian physicists?

In this study, we were confronted with a problem of language. We interviewed the French physicists in French, and, except for the few who spoke French (who work in France), we used English to interview the Indian physicists. We therefore interviewed Indian physicists in a language that is not their mother tongue. But no language would have been the common mother language for Indian physicists, since there are multiple official language in this country.

Nevertheless, it does not seem to us that this use of different languages for the interviews raises significant problems. The language of science is relatively common at the international level. This is certainly the case in the "natural sciences" (the so-called "hard sciences") like physics. The words "electron", "string theory", "gravity" are usually just transliterated into non-Western languages. This is less the case with more philosophical scientific terms which do not have the same meaning in all languages, like space, matter and time. Nevertheless, these terms do not have the same meaning for different individuals and in different contexts.

The best way to overcome this language problem is to explain what we mean when we use these words in the interviews. To limit the impact of these language differences, we have as much as possible used scientific technical terms and multiplied the questions referring to the same concept or the same thema. In addition, we conducted preliminary discussions to clarify the concepts and their correct translation. As Vigour has argued, "the comparatist must be satisfied with a translation which never constitutes a perfect equivalent, but which either loses part of the information or adds a special connotation" (Vigour, 2005, 141).

VI. Conclusions.

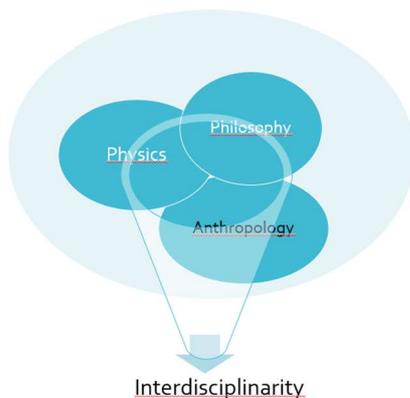


Figure 6: schematic representation of interdisciplinarity engaged in this research

Are scientific representations of reality different from one country to another, and can we understand such specificities as manifestations of different themata? We believe so, although we do not claim to have proved this, a general proof would require a much more ambitious project than the one presented here. We studied a relatively small group of physicists and conclude that the philosophical preferences of scientists concerning the structure of reality - which we have classified under the codified term of "themata" - fall within the description of a style of scientific thought. We have shown that these styles of scientific thought, in general, could be defined according to geographical and cultural parameters, linked to the intellectual histories of different countries. This led us to develop the concept of "local thematic style". Our "local thematic styles" are concerned with the common ground that anchors the scientific representation of reality. As a result of this research, we believe that this tool could be used for analyzes involving other countries or disciplines other than physics. And with more work on this topic, one could envisage a generalization of this result.

What can we conclude from the fact that, according to the culture of researchers, they do not attach the same importance to a thema? The themata can be seen as tools to understand the differences in psychological functioning between physicists, and ideally they could be extended to any individual. They allow us to better understand the sometimes unconscious influence of the epistemological values that run through the history of peoples.

In the field of science, recognizing the existence of personal themata makes it possible to avoid the situation in which the commitment to a thema unconsciously induces choices concerning certain theories or interpretations. Faced with this recognition of the existence of themata, we can recognize them, and try to break with them, considering them as obstacles (Bachelard 1938). But physicists can also be enriched by the observation of what influences their modes of representation: tradition, reason, intuition, social recognition, etc. As with any individual, researchers are often unaware of the philosophical choices and preferential modes of representation conveyed by their culture of origin. On the question of the internationalization of science and the standardization of knowledge, the existence of cultural themata shows that local parameters still need to be taken into account.

Bibliography

- Angot, Michel. 2001. *L'Inde Classique*. Paris: Les belles lettres. Guide des civilisations.
- Ardilly, Pierre. 1994. *Les Techniques de Sondage*. Paris : Editions Technip.
- Cayouette-Remblière, Joanie. 2013. "Le Marquage Scolaire : Une Analyse 'statistique Ethnographique' des Trajectoires Des Enfants de Classes Populaires À l'École (Thèse de Doctorat)." Paris : Ecole des Hautes Etudes en Sciences Sociales.
- Crombie, Alistair C. 1994. *Styles of Scientific Thinking in the European Tradition: The History of Argument and Explanation Especially in the Mathematical and Biomedical Sciences and Arts*. London: Duckworth.
- Feuer, Lewis Samuel. 2005. *Einstein et Le Conflit Des Générations*. Translated by Paul Alexandre. Bruxelles: Editions Complexe.
- Fleck, Ludwik. 1935. *Entstehung Und Entwicklung Einer Wissenschaftlichen Tatsache? Einführung in Die Lehre Vom Denkstil Und Denkkollektiv*. Basel: B. Schwabeund Co., Verlagbuchhandlung.
- Hacking, Ian. 2003. "Philosophie et Histoire Des Concepts Scientifiques." In *Des Styles de Raisonnement Scientifique : Cours Au Collège de France*. Paris: Collège de France.
- Harwood, Jonathan. 1993. *Styles of Scientific Thought: The German Genetics Community, 1900-1933*. Chicago: University Of Chicago Press.
- Holton, Gerald. 1962. "Scientific Research and Scholarship: Notes toward the Design of Proper Scales." *Daedalus* 91: 362–99.
- . 1996. "The Role of Themata in Science." *Foundations of Physics* 26 (4): 453–65.
- Moscovici, Serge. 1984. "Gerald Holton, L'invention Scientifique. Themata et Interprétation, Trad. P. Scheurer." *Revue D'histoire Des Sciences* 37 (2): 159.
- Przeworski, A., and H. Teune. 1970. *The Logic of Comparative Social Inquiry*. New York: John

Wiley & Sons.

Quidu, Matthieu. 2009. "Les Thémata Dans La Recherche En STAPS : Motivations et Modalités D'intervention." *Staps* 84 (2): 7–25.

Satopathy, Sandeep, and Siddharth Sekhar Das. 2013. "Transitions of Undergraduate Scientific Research in India: An Attempt to Perceive Science." *American Scientific Publishers, Advanced Science Focus* 1 (4): 1–7. doi:10.1166/asfo.2013.1048.

Thévenot, Laurent. 2006. *L'action Au Pluriel. Sociologie Des Régimes D'engagement*. Paris: Editions La Découverte.

Vigour, Cécile. 2005. *La Comparaison Dans Les Sciences Sociales*. Paris: Editions La Découverte.