AAPG2023	MATHY		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

Mathematical Hygiene

Summary table of persons involved in the project:

Partner	Name	First name	Current position	Role & responsibilities in the project (4 lines max)	Involvement (person.month)
Université de Lorraine	ARANA	Andrew	Professor	Coordinator for UL	36
Université de Lorraine	ECKES	Christophe	MCF	Historical studies (Axe 1 WP2)	7
Université de Lorraine	MÉLÈS	Baptiste	CR CNRS	Historical and philosophical studies (Axe 1 WP2)	5
Université Paris Cité	BURNETT	Heather	DR CNRS	Coordinator for UPC	12
Université Paris Cité	ABEILLÉ	Anne	Professor	Corpus construction and studies (Axe 2 WP1)	5
Université Paris Cité	NOVECK	Ira	DR CNRS	Psychological experiments (Axe 2 WP2)	5

There are no significant changes between the pre-proposal and the full proposal.

I. Proposal's context, positioning and objective(s)

a. Objectives and research hypothesis

The goal of our project is to develop a new area of study at the intersection of linguistics and the philosophy of mathematics : (what we call) *mathematical hygiene*. The term is based on the expression *verbal hygiene*, developed by the linguist Deborah Cameron (1995), to refer to the set of normative ideas that language users have about which linguistic practices should be preferred. In a parallel manner, we define *mathematical hygiene* as « the set of normative discourses regulating mathematical practices» (Arana & Burnett 2023). The project has three main objectives: **1) to document mathematical hygiene phenomena, with a particular focus on the history of mathematics, 2) to compare mathematical hygiene and verbal hygiene phenomena synchronically and diachronically, 3) to develop a new understanding of how verbal and mathematical hygiene phenomena arise using insights from the psychology of reasoning.** We believe that studying normative discourses on mathematics in the way that sociolinguists study normative discourses on language will open the door to a better understanding of the diachronic and synchronic relationships between language and mathematics. As such, the project is positioned within the scope of Axe D.5: *Arts, langues, littératures, philosophies*.

One of the most studied kinds of verbal hygiene is *prescriptivism*. When faced with a *sociolinguistic variable*, i.e. two synonymous grammatical alternatives (Labov 1972), prescriptivists identify one of the two alternatives, called *variants*, as superior and promote the use of the « better » variant over its alternative. Decades of research in sociolinguistics (see Joseph 1987, Cameron 1995, Milroy & Milroy 1999, Ayres-Bennett 2020, among many others) has shown that which grammatical variant a grammarian prefers, and the arguments that they employ in defending their choice, bear some relation to the grammarian's social identity and how they position themselves politically. For example, as discussed in Milroy & Milroy (1999), grammarians promoting the use of variants from the standard/formal linguistic variety (ex. *I didn't see anything*) and proscribing the use of variants from the non-standard/vernacular variety (ex. *I ain't seen nothin'*) contribute to « legitimiz[ing] the norms of formal registers of Standard English rather than the norms of everyday spoken English » (M&M 1999), which in turn legitimizes discrimination against English speakers who do not master or regularly employ Standard English. Arguments frequently used in Standard Language prescriptivism can be *legalistic,* "concerned with correctness" (M&M), or *moralistic*, ie "concerned with clarity, effectiveness, morality and honesty" (M&M). For example, a legalistic argument might take the form

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

"One should say *I didn't see anything* because it is more grammatically correct than *I ain't seen nothin'*"; whereas, a moralistic argument would take the form "One should say *I didn't see anything* because it is more elegant/precise/clear etc. than *I ain't seen nothin'*". Arguments can also appeal to the (assumed) purpose of language, which is most often taken to be communication. For example, a grammarian making a *functional* argument might propose something like *"One should say I didn't see anything* because it favors efficient communication more than *I ain't seen nothin'"*. Prescriptivist verbal hygiene is in direct opposition with another kind of verbal hygiene: *descriptivism*. According to descriptivists, the variant identified as the *standard* one is not inherently better than the *non-standard* one, and it is nonsensical, and even problematic, to encourage the use of one over the other. As Cameron observes, descriptivists' discourses about language are often correlated with their political and professional positioning: many linguists adopt the descriptivist perspective because they are opposed to the elitist, conservative political project that prescriptivism about the standard language supports (ex. Labov 1972), and the prescriptive/descriptive ``binarism sets the parameters of linguistics as a discipline" (Cameron 1995), with linguists overwhelmingly adopting the more science-oriented descriptive stance.

Like grammarians and linguists, mathematicians are no stranger to normative discourses. In fact, research programs in mathematics are often formulated in normative terms. For example, in his *Lectures on Euclidean Geometry* (1898-1899), Hilbert develops what he calls a "critique of means of proof"; that is, argumentation aiming to determine which of multiple valid proofs is superior. He says ``in modern mathematics such criticism is raised very often, where the aim is to preserve *the purity of method*, i.e. to prove theorems if possible using means that are suggested by the content of the theorem". Mathematicians today call a proof *pure* if it draws only on what is (described as) "close" or "intrinsic" to that theorem (see Arana & Detlefsen 2011), and, in Arana & Burnett (2023), we argue that we find the same kinds of arguments in normative discourses about (im)purity in mathematics that we find in normative discourses about the standard language. For example, Newton, in his *Lucasian Lectures on Algebra* (1680s), argues in favor of the use of purely geometric methods in geometric proofs by citing their correctness (legalistic argument), beauty and simplicity (moralistic argument; see also Dutilh Novaes 2019, Arana 2017) (1).

(1) *Multiplications, divisions and computations of that sort have recently been introduced into geometry, but the step is ill-considered and **contrary to the original intentions of this science** […] The Ancients so assiduously distinguished them one from the other that they never introduced arithmetical terms into geometry; while recent people, by confusing both, have lost **the simplicity in which all elegance of geometry consists**.*

Likewise, very many mathematicians provide functional arguments in favor one style of proof over another, citing the style's epistemic value: they ask if one proof is more *explanatory* than another (Steiner 1978, Kitcher 1989), if one gives more *understanding* than another (Tappenden 2008, Avigad 2008), if one is more *deep* than another (Arana 2015). As with language, which mathematical variant is preferred for functional reasons can vary depending on the mathematician. For instance, in 1964 Jean Dieudonné writes, "*It may well be that some will find this insistence on "purity" of the various lines of reasoning rather superfluous and pedantic; for my part, I feel that one must always try to understand what one is doing as well as one can*"; whereas, in contrast, Bourbaki (1948) view impurity (which they call *unity*) as contributing to "*the profound intelligibility of mathematics*". The descriptivist view is also represented in the purity debate, as shown in (2), from Nathanson (2000).

(2) *In mathematics, when we want to prove a theorem, we may use any method. The rule is "no holds barred." It is OK to use complex variables, algebraic geometry, cohomology theory, and the kitchen sink to obtain a proof.*

Observations such as these have allowed us to formulate the central research hypothesis of the MATHY project: **that there exist significant parallels between argumentation justifying certain linguistic**

2

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

practices and argumentation justifying certain mathematical practices. In the four years of the project, we propose to test this hypothesis through a series of case studies. The now vast literature on verbal hygiene has shown that, while the "desire to meddle in matters of language" (Cameron, 1995) is almost universal, the arguments expressed by verbal hygienists tend to vary depending on time period and social context. The MATHY project therefore focuses on a specific context: France, and has different axes according to time period.

Axe 1: Mathematical and verbal hygiene in a diachronic perspective

WP 1: Mathematical and verbal hygiene in 17th century France (Years 1-2, 1 Postdoc 1)

The first objective of Axe 1 WP1 of the MATHY project is a **detailed historical comparison of mathematical and verbal hygiene in 17th century France**. Our starting point from a mathematical perspective is the work of Descartes and Newton's reaction to it, as we have described in Arana & Burnett (2023). Though Descartes kept the ancient distinction between analysis and synthesis in geometry, whereby one separates the process of discovery from the process of justification, he reversed the traditional view that synthetic, Euclidean-style proof gave the best kind of knowledge. Instead, he emphasized the importance of analysis, which he revolutionized by creating algebraic methods for finding solutions to geometric problems. He demonstrated the power of his revolution by showing how he could find solutions to the ancient Pappus problem for any number of lines (Bos 2003), whereas the ancients could only solve it in particular cases. Descartes stressed not only the power of his approach, but also its *methodicalness*, as opposed to what he saw as the ancients' haphazard approach. He maintained that this method could be mastered by an attentive student, thus reducing the need for unpredictable genius in geometric problem solving. It would also improve the clarity of mathematical writing, since algebraic language was more concise than natural language. Finally, he concluded that he had uncovered the essential unity of algebra and geometry, thus refuting what he saw as the ancient prejudice maintaining the separateness of the branches of mathematics as well as the methodological need to avoid their mixing, which we have called *purity*.

Despite Newton's well-earned reputation as a master of algebra, he was at the same time a strenuous critic of Descartes' geometric revolution.

> To be sure, their [the Ancients'] method is more elegant by far than the Cartesian one. For he [Descartes] achieved the result [the solution of the Pappus problem] by an algebraic calculus which, when transposed into words (following the practice of the Ancients in their writings), would prove to be so tedious and entangled as to provoke nausea, nor might it be understood. But they accomplished it by certain simple proportions, judging that nothing written in a different style was worthy to be read, and in consequence they were concealing the analysis by which they found their constructions. (Guicciardini 2009)

Newton thought that mathematicians should continue to practice geometry as the ancients did, writing only the synthetic, Euclidean-style proofs rather than revealing anything of the analysis that led to their discovery. In practice that meant avoiding writing algebraic details, and Newton even tried to find a purely geometric process of discovery, that he claimed must have been in now-lost texts of Euclid, but which were in fact early versions of what we today call projective geometry. Synthetic proofs were, he claimed, more elegant than algebraic proofs in their simplicity, and in their reproduction of the ancient style of writing, for Newton was a radical neoclassicist who sought to restore ancient wisdom not only in mathematics but also in theology and alchemy.

Newton defended the ancients' seemingly-haphazard search for geometric truth, diminishing Descartes' valorisation of method. Newton thought himself a member of an elite, elect group of researchers, and sought to communicate his results only to a group of disciples close to him (Force 1999). He maintained this elitism in his politics more generally, as a professor at Cambridge and as an elected member of Parliament. Descartes, by contrast, wanted to create a new intellectual elite among

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

the bourgeoisie and courtesans of his time, active in the exercise of their own reason rather than imitating the ancients. To delineate the characteristics of this new class, he appealed to the persona of the *honnête homme*, an ideal member of the court of Louis XIV. He is intelligent but also courageous and generous, without artifice. He aims to be a master of conversation, to entice others with his elegance and wit. He is a generalist so that he can converse with anyone about anything, able to adapt to the needs of his audience, never boring them with pedantry. Examples in the literature of the seventeenth century abound: for instance, Cléonte in Molière's *Le bourgeois gentilhomme* (1670) and Hippolyte in Racine's *Phèdre* (1677).

In Descartes' geometrical work we see different aspects of the *honnête homme*: the aspiration toward brevity, and the push toward self-reliance on reason rather than on imitation of ancient masters. The second arises not only in mastering the algebraic method of analysis in geometry, but also in Descartes' personal life, whereby he responded calmly in public to Fermat's attack on his method of tangents in 1638 (Descotes 2005). In these ways, Descartes and Newton's efforts toward mathematical hygiene can be seen to be rooted in their differing ideological agendas.

Although the *honnête homme* persona appears to have been important for how Descartes conceptualized his mathematical work, there is evidence that it also influenced verbal hygiene in 17th century in France. For example, Claude Favre de Vaugelas (1585-1650), an influential grammarian who was known particularly for his 1647 *Remarques sur la langue française* (see Caron & Ayres-Bennet 2019), is often considered to contribute to the construction of the *honnête homme* persona by scholars of prescriptivism and purism (such as Ayres Bennett 1987). Furthermore, many of Vaugelas' prescriptions value the same properties in language as Descartes values in mathematics. Consider the following example from Vaugelas' follow-up to *Remarques*, published posthumously in 1690, where he makes a legalistic argument (*faute*) and moralistic arguments in favor of *clarté, élégance* and *pureté*.

> Je dis qu'encore qu'une infinité de gens écrivent ainsi; néanmoins c'est une faute contre la pureté du langage, qui veut que l'on dise, *La Philosophie sainte & la Philosophie profane défendent*, ou bien, *La Philosophie sainte & la profane défendent*. Mais je tiens que le premier est meilleur: car il faut toujours se ressouvenir que nôtre Langue aime grandement les répétitions des mots, lesquelles aussi contribuënt beaucoup à la clarté du langage, que la Langue Françoise affecte sur toutes les Langues du monde. Aussi pour l'ordinaire elle ne supprime rien: ce qui est toutefois une grande élégance parmi les Grecs & les Latins, qui engendre néanmoins bien souvent de l'obscurité & des équivoques.

This passage is suggestive, but to properly test the hypothesis that there are non-trivial parallels between mathematical and verbal hygienes in 20th century France, we will hire **a postdoc on a two year contract** at the Archives Poincaré to provide a detailed analysis of the normative mathematical and linguistic discourses during this period. The starting point of the investigation will be the recent (2022) *Grand Corpus des grammaires françaises, des remarques et des traités sur la langue (XIVe-XVIIIe s.)*, ed. B. Colombat, W. Ayres-Bennett and J.-M. Fournier. In order to bring together a community working on these topics, we will hold a **conference on discourses on language and mathematics in Nancy in Year 2**.

WP 2: Mathematical and verbal hygiene in early 20th century France (Years 1-3, PhD student)

The next objective of the project is to **carry out a historical comparison of mathematical and verbal hygiene in 20th century France**. We propose to focus on the impact of nationalism during this period on mathematics and grammar. While some attention has been given to the so-called "Deutsche Mathematik" (Segal 2003), as well as to verbal hygiene under the Third Reich (Hutton 2012), we propose to investigate French mathematics during the 1930s and the Vichy period.

As we saw in Axe 1, Cartesian analytic geometry brought geometry and algebra together. In the 19th century, analysis, arithmetic, and algebra were brought together by the "arithmetization of analysis"

AAPG2023	MATHY		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

of Cauchy and Weierstrass, and by the development of analytic number theory following advances of Lagrange, Jacobi and Riemann. In the early 20th century the mathematics collective Nicolas Bourbaki took up the project of unification, noting that the question of unity revealed itself even in the grammar of the French language. Whereas one normally writes "les mathématiques", as a plural, they titled their series of texts *Éléments de mathématique*, in the singular. They did so to fight a "progressive splintering… a tower of Babel, in which autonomous disciplines are being more and more widely separated from one another, not only in their aims, but also in their methods and even in their language" (Bourbaki 1948).

Jean Dieudonné, a founding member of Bourbaki, contrasted the "the old obsolete classification of mathematics" into algebra, geometry, arithmetic and analysis, with the "new outlook" in which "mathematicians realized the fundamental unity of mathematics behind the very different appearance of its various parts" (Dieudonné 1982). The key to this "new outlook" is the axiomatic method, as developed in its modern guise by David Hilbert in his *Grundlagen der Geometrie* (1899). This method begins with a particular subject matter, such as elementary geometry, and identifies as axioms a certain number of properties of this subject matter deemed fundamental to its organization. It then ceases to consider the other properties of the objects of this subject matter, treating the axioms as susceptible of holding of other objects besides those originally intended.

Bourbaki called the result of axiomatic abstraction a *structure*, giving groups in algebra as an example. The axioms of a group are realized by various number systems, the isometries of a Euclidean space, and many other particular structures. The notion of a group thus unifies these particular systems into a single general structure characterized by a single set of axioms. Of this "structuralist" unification, Bourbaki writes:

> [T]he axiomatic method has shown that the "truths" from which it was hoped to develop mathematics were but special aspects of general concepts, whose significance was not limited to these domains. Hence it turned out, after all was said and done, that this intimate connection, of which we were asked to admire the harmonious inner necessity, was nothing more than a fortuitous contact of two disciplines whose real connections are much more deeply hidden than could have been supposed *a priori*. (Bourbaki 1948)

The axiomatic method thus reveals the interconnectedness of mathematics that is hidden beneath the usual division of branches of mathematics. Indeed, the axiomatic method makes this unity accessible to everyone, instead of being accessible only to mathematical masters:

> Where the superficial observer sees only two, or several, quite distinct theories, lending one another "unexpected support" through the intervention of a mathematician of genius, the axiomatic method teaches us to look for the deep-lying reasons for such a discovery, to find the common ideas of these theories, buried under the accumulation of details properly belonging to each of them, to bring these ideas forward and to put them in their proper light. (Bourbaki 1948)

The quest for purity in mathematics is in tension with unity. Suppose that both algebra and geometry are, as Bourbaki say, part of a single whole. Then a pure proof of a purely geometric theorem could draw as much on algebraic concepts as it does on geometric concepts. In this way unity renders purity, as traditionally understood, empty. If all branches of mathematics are one, then every proof is pure.

During this period there remained nonetheless many who did not accept the unity of mathematics. An example in the orbit of Bourbaki is the German mathematician Helmut Hasse. In 1930 Hasse wrote on what he called "the new algebraic method", describing it as "the striving *to reduce a given area of mathematics to its most general and therefore simplest conceptual foundation elements and to construct and extend it with their help alone*." Contrary to Bourbaki's unity, he says that "every mathematical discipline has a certain *fundamental attitude* of a philosophical nature that need not be

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

spelled out but is nevertheless decisive for the character and development of the discipline." Thus each branch of mathematics has its own identity, and the algebraic method requires that we prove its truths from foundations of that branch alone. Furthermore, he writes, "the modern algebraist rejects references to *intuitive appeal* and *applicability* as foreign [*fremdartig*] to his fundamental attitude." As an example of this algebraic purity, Hasse turns to the solution of rational algebraic equations. The "natural means" for solving such equations, he says, are the usual algebraic operations, but the classical theory ``goes outside the realm of these natural means…it enters the realm of complex numbers and uses aids from analysis to prove the so-called fundamental theorem of algebra…[with] the essentially new concept of limit.'' The modern algebraic method critiques and seeks to remedy this. As critique, Hasse uses political language:

> It would, of course, be narrow-minded to say that "The nature of this area of mathematics is such that it belongs outside the realm of modern algebra. It should be given citizenship rights [*Bürgerrecht*] in analysis."

As remedy, he points to the following purity program, successful in his estimation:

> Now if there exists a development of the theory of algebraic equations that eschews the limit concept and relies solely on the elementary operations, then such a development must, of course, be preferred to others. Such a development, with the additional qualities of clarity and simplicity, relies on abstract field theory…[and] has actually been done by Artin and Schreier. [By their work] real algebra and the fundamental theorem of algebra regain their citizenship rights in algebra.

Hasse thus supports disunity and purity as counter-ideals to Bourbaki.

These two examples, Bourbaki and Hasse, are linked by more than their time period. The Bourbaki group began with a project to write a new mathematics textbook for analysis, to be used in French university courses, in order to modernize French mathematics and keep up with German advances. The founders of Bourbaki met as participants of the mathematics seminar at the École Normale Supérieure in Paris, organized by Gaston Julia. Several members of Bourbaki were Jewish, and this led to tension in 1938 when Szolem Mandelbrojt, one such Bourbakiste, competed with an associate but non-member of Bourbaki, Jean Leray, for a position at the Collège de France. According to André Weil, another Jewish founding member of Bourbaki, Leray admitted to Weil that he used a "xenophobic and also, I believe, antisemitic, argument", aimed at Julia, to win the position against Mandelbrojt (Eckes 2020). Though Mandelbrojt finally won the post, the episode marks a turning point in the Bourbaki project. Bourbaki broke with the Julia seminar, and Julia became a collaborator with Germany during the Vichy occupation. As part of this collaboration, Julia developed his relationship with Hasse, who was by then a Nazi sympathizer (and perhaps party member) in Göttingen and Berlin. Julia and Hasse corresponded about the status of French prisoners of war of the German forces, but also about the recruitment of French authors for *Zentralblatt*, the journal of mathematics reviews, that lost many of its writers when it became subject to Nazi rules and Jewish correspondents were banned.

As mentioned earlier, in the Nazi era in Germany there was a movement of "Deutsche Mathematik", that identified talents for particular branches of mathematics with racial archetypes. The movement was led by world-class mathematicians like Ludwig Bieberbach and Oswald Teichmüller. Bieberbach edited a journal named for the movement; this journal published about two times as many pure geometry articles as other leading journals like *Mathematische Annalen*, reflecting the Nazi identification of geometry with the thought of the racially pure German mind (Segal 2003).

The normative discourses about mathematics in this context involve concepts of clarity, simplicity, and purity, with a background in the varying nationalisms and related antagonisms of the actors. In this WP we will investigate this case study of mathematical hygiene, toward our objective in this WP of giving a **detailed historical comparison of mathematical and verbal hygiene in early 20th century France**.

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

For the second part of this comparison, we will explore to what extent the normative discourses about mathematics in the first half of the 20th century may parallel the normative discourses about language and language policy. Preliminary investigations suggest that language ideologies in France during this time were characterized by a similar tension between universalism/unification and anti-universalism as mathematics. The "universalist" perspective is exemplified by the French state until Vichy, which had been carrying out assimilationist policies since the 16th century aiming at installing French as the single universal language of France and its colonies (see Lodge 1993 among others for a review). The "anti-universalist" perspective is exemplified by members of the Vichy regime, who, as described in Martel (2014) and Calcagni (2013) among others, went against previous French language policies and instituted classes in regional languages (Occitan, Breton etc.) for the first time since the French revolution. This interest in the preservation of regional languages did not arise from a concern about linguistic diversity or linguistic discrimination, but rather appears to have arisen from the adoption in Vichy France of the linguistic ideologies of the Third Reich. As Hutton (2012) describes (p. 4), "For Nazi thought was steeped in anti-universalism and in the rhetoric of cultural difference. Different peoples were held to have different world-views, and no one nation had the right to impose its understanding of the world on any other; different languages embodied different cultural and ethical values."

We mention briefly two other aspects that will merit our attention in this comparison. Firstly, Bourbaki's structuralism is related to the broader intellectual movement of structuralism that included structural linguistics (Dosse 1991, Toutain 2015). André Weil contributed a group-theoretic analysis to Claude Lévi-Strauss' anthropological work on kinship (Lévi-Strauss 1949), and the psychologist Jean Piaget tried to illustrate the relations between Bourbaki's most-basic structures and child perception (Corry 1996) — though there is ongoing debate about the nature of the relations between Bourbaki's structuralism and those in the social sciences, as well as ongoing debate about the internal coherence of these various structuralisms even within their own sciences (Corry 1996, Krömer 2007). Furthermore, there were interactions between Bourbaki and the members of the experimental literary movement Oulipo after the war (Aubin 1997). This interaction between Bourbaki and contemporaneous work in literature and the social sciences, and this ongoing reflection on this interaction, promises to add another dimension to our comparison of mathematical and verbal hygiene in this case study. Secondly, Bourbaki is also known for its abstract style, influential still today in the writing of mathematics. The notion of style in mathematics, including Bourbaki's, has been the subject of recent philosophical work (Marquis 2022, Rabouin 2017, Mancosu 2021, Granger 1968). We will also investigate how mathematical and verbal hygiene relate in relation to Bourbaki's style.

Toward this **historical comparison of mathematical and verbal hygiene in early 20th century France,** we will hire **PHD student 1 (years 1-3, philosophy/history of math).** The PhD student's thesis will have a dimension comparing mathematical hygiene in France in the 1930s and 1940s with verbal hygiene (French vs regional language policies).

Our work will be aided by consultation of the Archives Bourbaki, constructed by the group itself. It is housed today at the **Archives Henri Poincaré (Arana's laboratory)** and the Institut Élie Cartan at U. Lorraine, and at the École normale supérieure - Ulm and the Archives of the Académie des Sciences in Paris. Collaborators **Arana (U. Lorraine)**, **Eckes (U. Lorraine)** and **Mélès (U. Lorraine)** will carry out this work, in concert with the digital humanities team at the Archives Poincaré for whom the digitalisation and analysis of this corpus is an ongoing project. We will hold a **conference on language and mathematics in 20th century France in Nancy in year 3.**

Axe 2:   Mathematical and verbal hygiene in a synchronic perspective

WP1:   Mathematical and verbal hygiene in 21st century France (years 1-3)

As described above, verbal hygiene has a very long history in France, with points of extremely high activity around the French Revolution and in the 19th century, although a high level of prescriptive

AAPG2023	MATHY		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

activity was maintained throughout the 20th century (see, for example, Lauwers 2004). This long history has been recently reflected in the *Recueil historique des grammaires du français* (Poplack et al. 2002, Poplack et al. 2015), a compilation of 163 grammars of French published between 1530 and 2000. Poplack and colleagues use this large historical corpus to track how grammarians' choices of grammatical forms vary and change throughout time, as do the discourses that they employ to justify those choices. Using both qualitative and quantitative analyses, they show that that there is an enormous amount of synchronic and diachronic variation in grammarians' normative discourses around, for example, which verbs select the subjunctive mood (Poplack et al. 2013), which semantic factors favor the use of the simple future rather than the periphrastic future (Poplack & Dion 2009), or whether one should use *on* or *nous* for the first person plural (Poplack et al. 2015).

Poplack and colleagues' corpus provides a valuable database of French verbal hygiene, especially of the prescriptivist variety, covering until the end of the 20th century. However, the digital revolution, which advanced greatly in the early 2000s, created a new boom in verbal hygiene, expanding the practice outside the domain of classical publishers, and onto the Internet and especially onto social media (blogs, journals, Twitter, YouTube etc.). In the digital age, verbal hygienists from professional scholarly and media institutions, such as l'Académie Française and the newspaper *Le Figaro*, have started online prescriptivist blogs, and YouTube, Twitter and TikTok abound with accounts where non-professionals weigh in on what constitutes a *faute de français* and why. Two illustrative examples are shown in Figure 1, where individuals who are not language professionals correct public officials on Twitter.

Figure 1: Prescriptive verbal hygiene on Twitter

This "democratization" of verbal hygiene through social media is not limited to standard language prescriptivism. It has also resulted in a unprecedented boom in descriptive verbal hygiene on social media, driven by linguists (for example, the Youtube channels *Elles comme linguistes* and *Linguisticae*), and the podcast *Parler comme jamais*, among many others, but also non-linguists espousing descriptivist ideals, as shown in the Twitter exchange in Figure 2, where a (non-professional) standard language prescriptivist is "corrected" by a (non-professional) descriptivist, for "correcting" the former Justice Minister's use of subject doubling (*La France elle a…*).

Figure 2: Non-expert standard language prescriptivism and descriptivism on Twitter

AAPG2023	MATHY		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

The blossoming of descriptive verbal hygiene practices on Twitter has been accompanied by the recent publication of descriptivist works from traditional publishers, such as *Le français est à nous* (Candea & Véron 2019. La Découverte.), *Je parle comme je suis* (Neveu 2020. *Grasset.*), and *La Grande Grammaire du Français* (Abeillé & Godard 2021. Actes Sud.), which is the first comprehensive descriptive grammar of oral and written French across the francophonie. We therefore propose that the current time period constitutes a particularly interesting case study of the relation between language ideologies, political ideologies and the influence of technology, and so the **first objective of Axe 2 WP1 of MATHY is to document the wide range of verbal hygiene practices found in both traditional media and on social media.** More concretely, inspired by the work of Poplack and colleagues, we will **construct a corpus of verbal hygiene** about (France) French in the 21st century composed of published grammars and essays, blogs, Twitter threads, and transcripts of podcasts, and YouTube and TikTok videos. The corpus will be constructed by collaborators **Burnett (CNRS-UPC)** and **Abeillé (UPC)** in collaboration with a **M2 student**, funded by a 9 month internship at UPC. We will aim to have around 4000 instance of verbal hygiene (i.e. sociolinguistic variant choice and justification of this choice), and we will aim to balance it across 4 dimensions: 1) written texts vs audio/video, 2) hygiene produced by language experts (linguists, lexicographers, grammarians) vs non-experts, 3) time period (2000-5; 2006-10; 2011-15; 2016-2020; 2021-2023); 3) topic of verbal hygiene: standard language prescriptivist, descriptivist, pro-feminist prescriptivist, and anti-feminist prescriptivist. In addition to the democratization of verbal hygiene practices via social media, the past decade also distinguishes itself by an enormous resurgence of feminist language practices and normative discourses about them. Although feminist linguistic prescription and opposition to it have been present in France since Christine de Pizan and Olympe de Gouges, debates concerning gender inclusive language, known as *écriture inclusive,* have come to the political forefront since 2017, when members of the Macron government proposed to outlaw it in administrative documents and in public education (see Abbou et al. 2018 and Burnett & Pozniak 2021). The practices known under the label *écriture inclusive* vary greatly, ranging from using conjunctions, as in Prime Minister Élisabeth Borne's *celles et ceux* in Figure 1 (left), which is criticized by means of a legalistic argument by a Twitter user, to forms that combine masculine and feminine marked expressions by use of a wide range of punctuation marks, as shown in (4).

(4)   Forms of *écriture inclusive* for 'students', from Burnett & Pozniak 2021:

étudiant·e·s, étudiant(e)s, étudiant-e-s, étudiant.e.s, étudiantEs

In order to get ideas and feedback for the construction of the corpus, we will hold a **workshop on francophone verbal hygiene in Year 1.** Once the corpus is completed, we will extract all the sociolinguistic variables discussed in the texts, videos and audio material, and study the arguments that are mobilized to justify preferring one variant instead of another.

The second objective of Axe 2 WP1 involves **constructing a similar corpus for current day mathematical hygiene**. This corpus will be constructed by collaborators **Arana (U. Lorraine), Burnett (UPC),** and another **M2 student** funded by a 9 month internship at U. Lorraine. While, unlike language, the practice of mathematics still remains inaccessible to those who have not had appropriate education, the digital turn has also somewhat democratized the practice of mathematics and therefore mathematical hygiene in the sense that there are now large social media sites, such as Stack Exchange or MathOverflow, where both professionals and non-professionals can discuss mathematical problems and the best ways to solve them. Thus, in addition to "Math Twitter" and Youtube (*Bourbaki* seminars, *Mathematic Park*), these social media sites contain a treasure trove of mathematical hygiene, which this WP will exploit. To give an example of the kind of data, consider the exchange in Figure 3 from MathOverflow, a social media site for professional mathematicians. Here, two commenters are criticizing the original poster's characterization of their argument as *simple*.

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

> 1 Your "simple argument" that there are no nontrivial ways to assign the signs for $n = p - 1$, p prime, solves the question as stated, since it shows that there is no N so that there are nontrivial solutions for $n > N$. – ████████ Sep 2, 2011 at 0:11
>
> I agree with Douglas, why isn't your "simple argument" in fact showing that, as you wrote, B(n)=2 for infinitely many n? – ████ Sep 2, 2011 at 5:21
>
> Great, I edited the answer to reflect that. – ████████ Sep 2, 2011 at 7:09

Figure 3: Expert mathematical hygiene on MathOverflow

Taking into account that the French mathematics community is much smaller than the community of people who speak French, the mathematical hygiene corpus will ideally consist of around 2000 instances of mathematical hygiene (mathematical variable and justification), and we will aim to balance it according to 1) text type: academic articles vs. popular science magazines (*Pour la science, Science et avenir* etc.), and social media (*Stack Exchange, MathOverflow, YouTube* transcripts, etc.); 2) hygiene produced by experts (professional mathematicians, PhDs) vs non-experts (students, hobbyists); and 3) time period. The verbal and mathematical hygiene corpora and their associated qualitative and quantitative analyses have two purposes: 1) they will give us a new descriptive picture of verbal and mathematical hygiene in current day France, the ways in which they are similar and different, and 2) they will serve to generate the set of empirical phenomena (sociolinguistic/mathematical variables and justifications) that will be the subject of the reasoning experiments in Axe 2, WP2.

WP2: Mathematical and verbal hygiene in a cognitive perspective (years 2-4)

While verbal hygiene of many types has been intensely studied from a linguistic perspective and from a social perspective, the cognitive aspects of this practice remain completely unexplored. On the one hand this is unsurprising, given that literature on verbal hygiene has been almost universally produced within sociolinguistics, a subdiscipline of linguistics that has had few connections with cognitive science (see Burnett 2017). On the other hand, verbal hygiene involves people choosing between two alternatives and then providing arguments justifying one's choice. It therefore transparently appears to be an instance of reasoning and argumentation, two phenomena that are central to the cognitive sciences. In contrast, mathematical reasoning has been widely studied in cognitive science (see Dehaene 2011, among many others), although obviously the discourses around how to do mathematics have not received such attention. The main objective of the final work package of MATHY is therefore to **examine verbal hygiene and mathematical hygiene in the light of theories from the psychology of reasoning**. More precisely, we propose to **experimentally test the hypothesis that verbal hygiene and mathematical hygiene are kinds of *rationalizations***. Rather than rational action, in which we choose an action based on our beliefs and desires, rationalization involves "takes an action that has already been performed and then concocts the beliefs or desires that would have made it rational" (Cushman 2020: 1). Rationalization is a core human cognitive behavior, and there is a consensus among psychologists that it plays an important role in phenomena like cognitive dissonance (Festinger 1962), self-perception (Bem 1967, Nisbett & Wilson 1977), and confabulation (Gazzinga 1967). Classic "dual system" models of human reasoning, such as Kahneman 2011, Evans & Wason 1976, among others, distinguish between Type 1 "intuitionistic" processes, those which are unconscious, automatic and associative and Type 2 "reasoning" processes, which are proposed to be conscious, analytic and rule-based. While many researchers in the psychology of reasoning assume that both Type 1 and Type 2 systems are frequently used in human decision making, others, such as Mercier & Sperber (2011, 2017, 2020) or Carruthers (2011), argue that many instances of what appear to be Type 2 rational reasoning are actually instances of Type 1 "intuition" combined with rationalization, meaning that rationalization is actually a much more common and fundamental kind of cognitive behavior than it is often thought to be. For psychologists and philosophers who espouse

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

the dual system model, verbal hygiene ought to be a classic case of Type 2 reasoning: individuals, who are often language experts, choose which sociolinguistic variant they prefer, justifying their choice with arguments that they, presumably, have arrived at through careful conscious analysis. This being said, there are ways in which the properties of verbal hygiene correspond to those of rationalization, which those who believe that Type 2 reasoning is extremely restricted would predict. Firstly, studies of rationalization have highlighted that the kinds of reasons that individuals provide to justify their choices depend highly on the individual's cultural and socio-political context (see for example Briley et al. 2000), just like verbal hygiene. Secondly, as discussed above, research on French standard language prescriptivism has shown that the arguments that grammarians employ to justify their choice of variant are very unstable. Not only is there variability within and between grammarians' prescriptions and justifications, but, as discussed by Poplack & Dion (2009), Poplack et al. (2015) and Viennot et al. (2016), the reasons that grammarians give for prescribing one variant over another can even be contradictory. Poplack & Dion (2009) illustrate this property through looking at the prescriptions of the semantic environments in which the simple future vs periphrastic future should be used. In addition to identifying other contradictions, they show, for example, that grammarians in the 20th century sometimes argue that the simple future [SF] encodes certainty (5a), in opposition to the periphrastic future [PF]; other times, they argue that it is the periphrastic future that encodes certainty while the periphrastic future encodes doubt (5b).

(5)   a. *On devrait, en bonne logique, ne l'employer [SF] que lorsqu'on est sûr de son fait.*

(Frontier 1997:533, cited in Poplack & Dion 2009:566)

b. *[PF] présente la réalisation du procès comme plus assurée et sa réalité comme plus certaine que le futur [SF] qui laisse subsister un doute.*

(Riegel et al. 1998:315, cited in Poplack & Dion 2009:566)

Mathematical reasoning and argumentation remain a domain in which there is a consensus that Type 2 reasoning dominates. Even Mercier & Sperber, whose *Argumentative Theory of Reasoning* emphasizes the prevalence of Type 1 decision making and the social function of argumentation, identify mathematicians as a special class. They say (2017: 324), "Of all the scientific communities, mathematicians are those who are most likely to recognize the same facts and to be convinced by the same arguments – they share the same axioms, the same body of already established theorems, and the arguments they are aiming at are proofs. [...] In mathematics and logic, the formal and sociological notions of proof tend to be coextensive." Our preliminary studies in mathematical hygiene (Arana & Burnett 2023) show that the tendency described by Mercier & Sperber is only that: the sociological aspects of a proof do often go beyond its formal aspects. This raises the question of whether mathematicians are really so different from other people, and whether they too use rationalization in their practices. Therefore, in years 2-3 of the MATHY project, collaborators **Burnett (CNRS-UPC), Arana (U.Lorraine)** and **Noveck (CNRS-UPC)** will hire a **psychologist postdoc on a two year contract at UPC** to experimentally test the hypothesis that verbal and/or mathematical hygiene involves rationalization. In order to do so, we will use an experimental paradigm that is commonly used to study rationalizations: the *choice blindness paradigm* (Johansson et al. 2005). Finding evidence that verbal hygiene, mathematical hygiene or both involve rationalizations would have important consequences for both theories of reasoning and guidelines for best mathematical/linguistic practice. Firstly, these results would argue in favor of models of human decision making in which rational explicit reasoning is very limited, including but not limited to the *Argumentative Theory*. Secondly, understanding that grammarians, linguists and possibly even mathematicians may be susceptible to employing Type 1 processes in their work would argue in favor of developing new practices within the fields of language policy, linguistics and mathematics to promote more rational, explicit Type 2 thinking. Indeed, while the psychology of reasoning is famous for revealing to what extent individual human decision making can be too quick and even logically flawed, this field has also discovered how much more successful

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

people are at logical reasoning when they engage in collective interactive decision making, i.e. arguing with other people (Resnick 1993, see Kerr & Tindale 2004 for a review). The results of Axe 2, WP2 of MATHY could therefore highlight the importance of interactive social media (such as Twitter, Stack Exchange, MathOverflow) for reasoning about language and reasoning about mathematics. In order to engage with the psychological and mathematical reasoning communities, we will hold a **workshop on cognitive approaches to linguistic and mathematical reasoning in Year 3.**

b. Position of the project as it relates to the state of the art

The MATHY project innovates with respect to the state of the art in that it defines a whole new area of academic inquiry (mathematical hygiene), which has not been investigated before. The domain of mathematical hygiene is positioned at the center of the humanities (history, philosophy), the natural sciences (mathematics), the social sciences (sociolinguistics, sociology), and the cognitive sciences (psychology), making it fundamentally interdisciplinary. This interdisciplinarity can be further seen in the profiles of the different partners and collaborators: the two partner labs are attached to different CNRS sections, section 35 (humanities) for the *Archives Poincaré* and section 34 (language sciences) for *LLF*, and the collaborators come from three different sections across two institutes: 34, 35 (INSHS) and 26 (psychology, INSB).

This being said, the MATHY project also situates itself within existing open questions in the current state of the art. Its central hypothesis, which is outlined in the preliminary results presented in Arana & Burnett (2023), is that there are non-trivial parallels between mathematical and verbal hygiene. This clearly bears on a long line of inquiry in mathematics, philosophy and cognitive science which studies the relationship between language and mathematics. While comparing the normative discourses on mathematics with those on another practice (art, sport etc.) would certainly be possible and probably interesting, language is a natural starting point since it is a common view in the philosophy of mathematics, among nominalists for instance, that mathematical knowledge is knowledge of language.

c. Methodology and risk management

c1. Methodologies

As discussed above, the MATHY project is innovative in that it brings together research and methodologies from the history and philosophy of mathematics, sociolinguistics, and the psychology of reasoning.

Historical and philosophical studies: Axe 1 involves the detailed historical comparison of mathematical and verbal hygiene in 17th and early 20th century France. The historical and philosophical analysis of case studies from the history of mathematics is crucial to the project in two ways. Firstly, the history of mathematics provides illuminating case studies of mathematical hygiene. The history of algebraic geometry in the 17th century provides a classic example, as the subject began with distinctive ideologies at play, and its continued development involved ongoing critical reflection on these ideologies. The history of Bourbaki in the period of WP2 is one instance of this continuation. Secondly, these case studies promise rich comparisons with verbal hygiene in the same periods, enabling us to do the analytic work on the relationship between mathematical and verbal hygiene. Thus the methodology of research for this axe involves philosophical reflection, carried out either individually or by means of common discussion (seminars, workshops, conferences).

Corpus construction: Axe 2, WP1 involves the construction of two subcorpora of verbal and mathematical hygiene. As described above, we will collect selections of text from academic articles, books, blog posts, fora (Stack Exchange, MathOverflow etc.), Twitter (obtained using the Twitter API), and transcripts of podcasts, YouTube and TikTok videos. Where available, we will take audio or video

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

transcripts provided by the content creator. Otherwise, we will use automatically generated transcripts from closed-captioning or free speech to text programs (like Google Docs). The format of the corpus will be .txt, to allow for both ease of reading and of processing with computational tools. The portions of the corpus that are not under copyright and which can be fully anonymized will be cleaned and uploaded to *Ortolang*, a French **open science** corpus platform (https://www.ortolang.fr/en/home/), as the MATHY corpus.

Corpus analysis: In the philosophy of mathematics, as in sociolinguistics, one of the most commonly used methodologies for analyzing corpora is **critical discourse analysis (CDA)**. CDA involves "(a) finding a regular pattern in a particular text or set of texts [...] and then (b) proposing an interpretation of the pattern, an account of its meaning and ideological significance" (Cameron 2001: 137). As is standard, the analyses will be done manually in Axe 1, WP1 and WP2, and in Axe 2, WP1. However, in Axe 2, WP1, we will combine qualitative discourse analysis with **quantitative analyses of variation** in the kinds of justifications that are provided for the choice of sociolinguistic variable. Using **mixed effects multinomial regression** (see Levshina 2015 for linguistic applications)**,** we will identify which factors, such as source type, time period, or hygenists' expert status, among others, condition the production of which kind of justification (legalistic, moral or functional) in our mathematical hygiene and verbal hygiene corpora.

Psychological experiments: We will obtain **ethics approval** from the *Comité d'éthique de la recherche* at UPC for our experiments, and approval for our **data management** plan from UPC's *Déléguée à la protection des données*. For the verbal hygiene experiment, we plan to recruit around 150 participants. Around 75 will be "non-experts", i.e. not language professionals, which we will recruit from the French participants on the Prolific online platform. Around 75 will be "experts": language professionals (grammarians, teachers, linguists), which we will recruit from relevant social media and academic mailing lists. For the mathematical hygiene experiment, given that a certain amount of mathematical maturity is required to even understand the options, we expect to have fewer participants, around 100. For our around 50 "non-experts", we will recruit master's level students in mathematics using social media and student life mailing lists. The around 50 "experts" will be professional mathematicians (professors), likewise recruited through social media and academic mailing lists. Participants will be paid the equivalent of 10 euros per hour, which is the standard given by Prolific.

The main paradigm used in the experiments in Axe 2, WP2 is the *choice blindness* paradigm (Johansson et al. 2005). This paradigm has been widely used in the decision-making literature to show that the reasons that individuals provide to justify their choices are often rationalizations; that is, the argument justifying the choice is arrived at after the choice was made rather than being what drove the choice in the first place. Choice blindness experiments have been used to show that rationalizations can be at play when people choose who they find attractive (Johansson et al. 2005), how they evaluate syllogisms (Trouche et al. 2016), and even how they defend moral choices (Hall et al. 2012). A choice blindness task has two stages: first, participants are asked to provide a preference among two or more options (e.g. about two different faces or four potential deductions). Second, they are (occasionally) asked to provide a justification for their choice. It is at this point that the paradigm uses misdirection because – among a subset of the to-be-justified cases – participants are shown their rejected option so they are actually being asked to justify their non-preferred choice. Remarkably, very few participants actually notice the switch. As far as our experiments are concerned, we plan on closely following the seminal procedure as described in Johansson et al. (2014): In stage 1, we will present 15 items (each comprising of a pair of options about a participant's preferred choice of verbal expression) and, for each, participants will be asked to show a preference. For six of those items, participants will be asked to justify their choice and among three of these, we will introduce the choice-blindness manipulation. Pre-testing will determine whether it is optimal to have participants make their six

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

justifications (with three being manipulated) during the presentation of the 15 items or to first present all 15 items before choosing six for justifications.

To appreciate a manipulated choice blindness item, consider the example on verbal hygiene in (6) below and suppose that a participant chose (b); the follow-up in (7) represents the experimental misdirection (note that the studies will be run in French).

(6)   *Here are two ways of writing the same thing. Which of the following is the best option?*

    a.   *Les directeurs et directrices écriront le rapport final.*
    b.   *Les directeur.ice.s écriront le rapport final.*

(7)   *You answered that the best option was:*

    a.   *Les directeurs et directrices écriront le rapport final.*

    Please briefly explain why you chose this option:_____

Again, out of 15 items, participants are simply asked to provide their choice without justification (9 items) or else to provide their choice with later justification (6 items, three for which the explicit choice is manipulated). In previous choice blindness studies, a small percentage of participants in the manipulation condition do realize that the option presented was not their choice, but the majority do not and proceed to give a rationalization for why they chose the option that they did not in fact choose. We hypothesize that participants in our verbal hygiene experiment will likewise provide rationalizations for their supposed choices. To find those who detect the manipulation, we will have participants fill in a short questionnaire at the end of the experiment asking about their demographic properties, their "expert" status with respect to language (language professional vs non-professional), and incidentally whether they noticed something odd about the experiment. At no time will it be possible to identify a particular participant based on the data in this online questionnaire. We will then analyze the experimental results using mixed effects binomial and multinomial logistic regression in order to determine whether demographic properties or expert status conditions whether or not participants notice the manipulation and, for those who do not, what kind of rationalizations they provide (legalistic, moral or functional). We hypothesize that non-experts will be less likely to notice the manipulation than experts, but that the range of rationalizations provided will not differ greatly between groups.

Our plan for the mathematical hygiene scenario is similar to the one for verbal hygiene above. The mathematical hygiene choice blindness experiment will have exactly the same procedure as the verbal hygiene experiment: in stage 1, participants will see 15 items in which they have to choose between two proof methods. An example of one such item is shown in (8).

(8)   *Here are two ways of proving the infinitude of the prime numbers. Which of the following is the best option?*

    a.   **By Euclid's method:** *for any finite list of primes, the product of those primes, plus one, has a prime divisor that isn't any of the primes listed.*
    b.   **By Euler's method:** *the product of 1/(1-(1/p)) over all prime numbers is equal to the sum of the harmonic series for all natural numbers. But since the harmonic series diverges, there cannot be only finitely many primes, since otherwise the product on the left would converge.*

After stage 1 is over, they move to stage 2 in which they see 6 items where they give a justification for a choice made in stage 1 (as in (9) below). Once again, for each participant, 3 of the 6 items will be non-manipulated; whereas, 3 will be manipulated.

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

(9)   *Earlier, you answered that the best option was:*

a. **By Euclid's method:** *for any finite list of primes, the product of those primes, plus one, has a prime divisor that isn't any of the primes listed*

Please briefly explain why you chose this option: _____

As with the verbal hygiene experiment above, participants will complete a questionnaire at the end of the experiment asking about their demographic properties, their "expert" status with respect to mathematics (mathematics professor vs master's student), and whether they noticed something odd about the experiment. Again, we hypothesize that experts will be less likely to notice the manipulation than non-experts. Furthermore, comparing between the verbal and mathematical experiments, in line with Mercier & Sperber's claims, we predict that the mathematicians will have a higher rate of noticing the manipulations than the participants in the verbal experiment.

Summary of the MATHY project (Gantt chart)

	Year 1	Year 2	Year 3	Year 4
Axe 1: Mathematical/verbal hygiene in a diachronic perspective				
Personnel	PhD student (20thC France, years 1-3)			
	Postdoc 1 (17thC France, years 1-2)			
Outcomes: events		Conference 1 (17th century)	Conference 2 (20th century)	
Outcomes: publications		Philosophia Mathematica,, Historia Mathematica (WP1)	Mind, Synthese (WP2)	Philosophical Review, Linguistics & Philosophy (WP1/2)
Axe 2: Mathematical/verbal hygiene in a synchronic perspective				
Personnel	MA student 1 (Verbal) MA student 2 (Math)			
		Postdoc 2 (Psych. experiments, years 2-3)		
Outcomes: events	Workshop 1 (verbal hygiene)		Workshop 2 (psych. of reasoning)	
Outcomes: publications		J. French language studies (WP1) Science in Context, Mind & Language (WP2)		Language in Society, Cognitive Science (WP2)
Outcomes: resources	MATHY Corpus			

b.   Risk assessment and management

The MATHY project is one with very few risks. The profiles of the main personnel we plan to hire (philosophy of mathematics with an interest in language (Postdoc 1 and PhD student 1); psychology of language/reasoning with an interest in mathematics (Postdoc 2)) are common. Our data collection is straightforward, and our methods of analysis are standard in philosophy, linguistics and psychology. Although our experiments involve recruitment of expert participants, the fields of mathematics and language are enormous in France, so we do not anticipate having problems finding around 50 mathematicians and 75 language professionals. Throughout this proposal, some our research

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

questions have been motivated by suggestive parallels between verbal hygiene and mathematical hygiene; however, if, after careful empirical study, we conclude that verbal and mathematical hygiene are different in a principled way, this would not be a failure of the project, but rather one of its important results.

II. Organisation and implementation of the project
a. Scientific coordinator and its consortium / its team

The MATHY project is a partnership between the *Archives Henri-Poincaré* (AHP-PReST, UMR 7117), specialists in the history and philosophy of mathematics, and the *Laboratoire de Linguistique Formelle* (LLF, UMR7110), specialists in French grammar and experimental linguistics.

Team from *Archives Poincaré:* Andrew Arana (PR, Département de Philosophie, Université de Lorraine, 75% implication) is a philosopher of mathematics who has worked extensively on normativity in mathematics, in particular on purity of methods and mathematical depth. His first book on purity in mathematics will appear in 2023 with CUP. Christophe Eckes (MCF, math., UL, 15%) is a historian of mathematics specializing in the scientific and mathematical relations between France and Germany during the 1930s and 1940s, and in the history of Nicolas Bourbaki. Baptiste Mélès (CR, CNRS, 10%) is a philosopher of logic, mathematics and informatics, with an active research program on 20th century philosophy of mathematics in France.

Team from *LLF:* Heather Burnett (DR, CNRS, 25% implication) is a linguist specializing in sociolinguistics and formal semantics. She has written two books: one (2017, OUP) on reasoning with vague predicates and one (2023, CUP) on game-theoretic modeling of sociolinguistic variation. The more recent book outlines a research program that is the topic of an ERC Starting Grant (2020-2025). **Anne Abeillé** *(*PR, Linguistique, UParis, 10%) works on formal syntax and French grammar. She is the (co-)creator of many important resources for the French language, such as the *French Treebank* (2003) and *la Grande Grammaire du Français* (2021). **Ira Noveck** (DR, CNRS, 10%) is a psychologist working on language. His background is in the psychology of reasoning, and is one of the co-creators of the discipline of experimental pragmatics which uses experimental techniques to study linguistic meaning.

The collaborators on the project will be supported by an international network of scholars who will attend project meetings and give occasional feedback on the project's work. The network includes Wendy Ayres-Bennett (Cambridge, linguistics), Deborah Cameron (Oxford, linguistics), Valeria Giardino (ENS Paris, cog. sci. of math), Emmylou Haffner (ENS Paris, history of math.), Sébastien Maronne (Toulouse, history of math), Salvador Mascarenhas (ENS Paris, psychology of reasoning), and Hugo Mercier (ENS Paris, psychology of reasoning).

Implication of the scientific coordinator in on-going project(s)

Researcher	Person.month	Grant allocated	Project's title	Coordinator	Start-End
Heather Burnett	45	ERC Starting Grant	Formal models of social meaning & identity construction through language	Burnett	Feb 2020-Jan 2025

b.   Implemented and requested resources to reach the objectives

Partner 1: Université de Lorraine

Staff expenses The Archives Poincaré team consists of the coordinator, Andrew Arana (PR2, UL), who will work for 36 person.months (total cost: **144 990** €), Christophe Eckes (MCF CN, UL), who will work

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

on Axe 1, WP2 for 7.2 person.months (total: **26 485,20** €), & Baptiste Mélès (CR2, CNRS), who will work on Axe 1, WP2 for 4.8 person.months (total: **35 313,60** €). In addition, we will hire a postdoc in history & philosophy of mathematics (Postdoc 1, 0-2 years experience) on a two year contract, who will work on Axe 1, WP1 (total cost: **100 000** €). For Axe 1, WP2, we will hire a PhD student on a three year bourse (**117 576** €). For Axe 2, WP1, we will hire a M2 student on a nine month internship (**5 400** €).

Instruments and material costs We budget **14 000** € for computers for the PhD student and Postdoc 1 (2000 € each), and books related to Axe 1.

Building and ground costs None.

Outsourcing / subcontracting We budget **1 000 €** for software related to the archival work in Axe 1; **5 000 €** for translation costs related to the corpuses of Axes 1, as well as eventual costs for help with publishing our results in English; and **10 000 €** for publishing in open-access journals (though we hope to be able to keep those costs to a minimum).

Overhead costs We will hold two international conferences at the Université de Lorraine (19 175 € each; total 3**8 350** €). The funding for the conferences will cover 9 invited speakers (6 from Europe, 3 from outside Europe), lodging for speakers and for members of the Paris team, and meals and coffee breaks. We will also hold two one-day seminars for the Nancy & Paris teams in Nancy in the years we host no project conference in Nancy (1 250 € each, total **2 500 €**). The funding for these will cover transportation for Paris team members to Nancy, lunch and two coffee breaks. We budget **15 000 €** for travel to conferences to present the results of the project for the permanent members, the PhD student and Postdoc 1.

Partner 2: Université Paris Cité

Staff expenses The LLF team consists of the coordinator, Heather Burnett (DR2, CNRS), who will work for 12 person.months (total cost: **84 000** €), Anne Abeillé (PRCE, UPC), who will work on Axe 2, WP1 for 4.8 person.months (total: **16 161,60**€), and Ira Noveck (DR1, CNRS), who will work on Axe 2, WP2 for 4.8 person.months (total: **38 400** €). In addition, we will hire a postdoc in psychology/cognitive science (3-5 years experience) on a two year contract, working on Axe 2, WP2 (total cost: **119 040**€). For Axe 2, WP1, we will hire a M2 student on a 9 month internship (**5 409** €).

Instruments and material costs We budget **3000** € for a computer for Postdoc 2 and books.

Building and ground costs and Outsourcing / subcontracting None.

Overheads costs We will hold two workshops at Université Paris Cité (4 000€ each; total **8 000**€). The funding for the workshops will cover inviting speakers and refreshments. We budget **18 000**€ for travel to conferences to present the results of the project for the permanent members and Postdoc 2, as well as to invite members of our panel to annual project meetings in Paris. We also budget **2000**€ to pay participants in our mathematical and verbal hygiene and choice blindness experiments. We will publish our articles open access, either in green open access journals or in journals published by publishers for whom the CNRS has paid for open access (Cambridge, Wiley etc.), so the open access budget is 0 €.

Requested means by item of expenditure and by partner

	U. Lorraine	U. Paris Cité
Staff expenses	206 788,80 € (permanents) 222 976,00 € (nonpermanents)	138 561,60 € (permanents) 124 449,00 € (non permanents)
Instruments and material costs	14 000 €	3 000 €

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

Building and ground costs	0 €	0 €
Outsourcing / subcontracting	16 000 €	0 €
Overheads costs	55 850,00 €	28 000,00 €
Administrative magt & structure costs	41 691,51 €	20 895,62 €
Sub-total	350 517,51 €	176 434,62 €
Requested funding	526 952,13 €	

III   Impact and benefits of the project

The MATHY project will have a number of benefits and impact a number of areas in the short, medium and long term. In the **short term**, the investigations of the members of the project will result in the publication of journal articles, book chapters and/or conference proceedings. At the moment, we plan on publishing at least six articles based on the research undertaken in Axe 1, in specialist journals in history and philosophy of mathematics such as *Philosophia Mathematica* and *Historia Mathematica*; and in generalist philosophical journals such as *Mind*, *Synthese*, and *Philosophical Review*. Based on Axe 2, we plan to publish at least an article on current day French verbal hygiene (WP1) in the *Journal of French Language Studies* or similar, and an article on mathematical hygiene and social media (WP1) in a history/philosophy of science, such as *Science in Context*. For WP2, we aim to publish at least one article on the linguistic choice blindness experiments in a sociolinguistics journal, such as *Language in Society*, and one article on combining the mathematical and linguistic choice blindness experiments in a cognitive science journal, such as *Cognitive Science.* The short-term benefits of the project also include the creation of resources, in particular, the MATHY corpus (Axe 2, WP1), which will be made available to the academic community, giving it potential for **medium-term** impact for sociolinguistics and the sociology of mathematics. Other potential **medium-term** benefits of MATHY involve a new understanding of the social aspects of the practice of mathematics and a more detailed theory of how language and math are (or are not) related at both a cognitive and social level. Depending on the results of Axe 2, WP2, the project could provide arguments for the adoption of new more collaborative practices in both academic mathematics and in language policy formation.

Finally, the MATHY project has the potential for significant **long-term** academic impact. We propose the creation of a whole new academic subfield that lies at the center of linguistics, mathematics, philosophy and psychology. The proposed four years will give us time to discover whether the subfield is deep enough to merit a deeper and wider scale investigation. If so, this would open the door to further actions such as the creation of an annual conference on "hygienes" of various sorts (verbal, mathematical, artistic, political, along with an academic journal.

IV   References related to the project

Abbou, J., Arnold, A., Candea, M., & Marignier, N. (2018). Qui a peur de l'écriture inclusive? Entre délire eschatologique et peur d'émasculation Entretien. *Semen.* 44.

Arana, A. & H. Burnett (2023). "Mathematical Hygiene". In revision for *Synthese.*

Arana, A. (2015). On the depth of Szemerédi's Theorem. *Philosophia Mathematica*, 23(2).

Arana, A. (2017). On the alleged simplicity of impure proof. In R. Kossak and P. Ording, eds., *Simplicity: Ideals of Practice in Mathematics and the Arts*, pages 207–226. Springer, Cham.

Aubin, D. (1997). "The withering immortality of Nicolas Bourbaki: A cultural connector at the confluence of mathematics, structuralism, and the Oulipo in France". *Science In Context* 10(2).

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

Avigad, J. (2008). Understanding Proofs. In P. Mancosu, ed., *The Philosophy of Mathematical Practice*. Oxford University Press.

Ayres-Bennett, W. (2020).From Haugen's codification to Thomas's purism. *Language Policy*, *19*.

Ayres-Bennett, W. (1987). *Vaugelas and the Development of the French Language* (Vol. 23). MHRA.

Bos, H. J. M. (2001). *Redefining Geometrical Exactness*. Springer.

Bourbaki, N. (1948). L'architecture des mathématiques. In F. L. Lionnais, ed., *Les grands courants de la pensée mathématique*. Éditions des Cahiers du Sud.

Briley, D. A., Morris, M. W., & Simonson, I. (2000). Reasons as carriers of culture: Dynamic versus dispositional models of cultural influence on decision making. *Journal of consumer research*, *27*(2).

Burnett, H., & Pozniak, C. (2021). Political dimensions of gender inclusive writing in Parisian universities. *Journal of Sociolinguistics*, *25*(5), 808-831.

Burnett, H. (2017). Sociolinguistic interaction and identity construction: The view from game-theoretic pragmatics. *Journal of Sociolinguistics*, *21*(2), 238-271.

Calcagni, S. (2013). *Éducation et enseignement sous le régime de Vichy: 1940-1944.* MA thesis. Laval.

Cameron, D. (2001). *Working with Spoken Discourse.* Sage Publications.

Cameron, D. (1995). *Verbal hygiene*. Routledge.

Carruthers, P. (2011). *The opacity of mind: An integrative theory of self-knowledge*. OUP Oxford.

Corry, L. (1996). *Modern Algebra and the Rise of Mathematical Structures*. Basel: Birkhäuser.

Cushman, F. (2020). Rationalization is rational. *Behavioral and Brain Sciences*, 43, e28.

Dehaene, S. (2011). *The number sense: How the mind creates mathematics*. Oxford University Press.

Descotes, D. (2005) Aspects littéraires de la Géométrie de Descartes. *Archives Internationales d'Histoire des Sciences*, 55(154).

Detlefsen, M. and A. Arana. (2011). Purity of methods. *Philosophers' Imprint*, 11(2).

Dieudonné, J. (1964). *Algèbre linéaire et géométrie élémentaire*. Paris: Hermann.

Dieudonné, J. (1982). The work of Bourbaki during the last thirty years. *Notices of the American Mathematical Society*, 29(7):618–623.

Dosse, F. (1991). *Histoire du structuralisme, Tome I : Le champ du signe, 1945- 1966*. La Découverte.

Eckes, C. (2018). Organiser le recrutement de recenseurs français pour le Zentralblatt à l'automne 1940 : une étude sur les premiers liens entre Harald Geppert, Helmut Hasse et Gaston Julia sous l'Occupation. *Revue d'Histoire des Mathématiques*, c24(Fascicule 2):259–329.

Eckes, C. (2020). Captivité et consécration scientifique. Reconsidérer la trajectoire académique du mathématicien prisonnier de guerre Jean Leray (1940-1947). *Genèses*, 121(4):31–51.

Force, J. (1999). Newton, the "ancients," and the "modems". In J. Force and R. Popkin, eds., *Newton and Religion*. Kluwer.

Granger, G.-G. (1968). *Essai d'une philosophie du style*. Armand.

Guicciardini, N. (2009). *Isaac Newton on Mathematical Certainty and Method*. MIT Press, Cambridge.

Hasse, H. (1930). Die moderne algebraische methode. *Jahresbericht der Deutschen Mathematiker-Vereinigung*, 39:22–33. Translated into English by A. Shenitzer as The modern algebraic method, *Mathematical Intelligencer*, 8(2):18–23, 1986.

Hutton, C. (2012). *Linguistics and the Third Reich.* Routledge.

Johansson, P., Hall, L., Tärning, B., Sikström, S., & Chater, N. (2014). Choice blindness and preference change: You will like this paper better if you (believe you) chose to read it!. *Journal of Behavioral Decision Making*, *27*(3), 281-289.

Johansson, P., Hall, L., Sikström, S., & Olsson, A. (2005). Failure to Detect Mismatches Between Intention and Outcome in a Simple Decision Task. Science, 310, 116-119.

Kahneman, D. (2011). *Thinking Fast and Slow.* MacMillan.

Kitcher, P. (1989). Explanatory unification and the causal structure of the world. In P. Kitcher and W. Salmon, eds., *Scientific Explanation*, pp. 410–505, University of Minnesota Press.

Krömer, R. (2007). *Tool and Object: A History and Philosophy of Category Theory*. Birkhäuser.

Labov, W. (1972). *Language in the inner city: Studies in the Black English vernacular* (No. 3). University of Pennsylvania Press.

AAPG2023	**MATHY**		PRC
Coordinated by:	Andrew ARANA	48 months	526 952,13 €
Axe D.5 : Arts, langues, littératures, philosophies			

Lauwers, P. (2004). La description du français entre la tradition grammaticale et la modernité linguistique: étude historiographique et épistémologique de la grammaire française entre 1907 et 1948 (Vol. 24). Peeters Publishers.

Levi-Strauss, C. (1949). *Les structures élémentaires de la parenté, avec un appendice de A. Weil.* PUF.

Levshina, N. (2015). *How to do linguistics with R: Data exploration and statistical analysis*. John Benjamins Publishing Company.

Lodge, R. A. (1993). *French: From dialect to standard*. Routledge.

Mancosu, P. (2021). Mathematical Style. In E. N. Zalta, ed., *The Stanford Encyclopedia of Philosophy*.

Marquis, J.-P. (2022). The Structuralist Mathematical Style: Bourbaki as a Case Study. In G. Oliveri, C. Ternullo and S. Boscolo, eds., *Objects, Structures, and Logics: FilMat Studies in the Philosophy of Mathematics*. Springer.

Martel, P. (2014). *L'école française et l'occitan*. Presses univ. de la Méditerranée.

Mercier, H., & Sperber, D. (2017). *The enigma of reason*. Harvard University Press.

Mercier, H., & Sperber, D. (2011). Why do humans reason? Arguments for an argumentative theory. *Behavioral and brain sciences*, *34*(2), 57-74.

Milroy, J., & Milroy, L. (1999). *Authority in language: Investigating standard English*. Routledge.

Nathanson, M. (2000). *Elementary methods in number theory*. Springer.

Novaes, C. D. (2019). The Beauty (?) of Mathematical Proofs. In A. Aberdein and M. Inglis, eds., Advances in Experimental Philosophy of Logic and Mathematics. Bloomsbury.

Poplack, S., Jarmasz, L. G., Dion, N., & Rosen, N. (2015). Searching for standard French: The construction and mining of the Recueil historique des grammaires du français. *Journal of Historical Sociolinguistics*, *1*(1), 13-55.

Poplack, S., & Dion, N. (2009). Prescription vs. praxis: The evolution of future temporal reference in French. *Language*, 557-587.

Rabouin, D. (2017). Styles in mathematical practice. In K. Chemla and E. F. Keller, eds., *Cultures without culturalism: the making of scientific knowledge*. Duke University Press.

Segal, S. (2003). *Mathematicians Under the Nazis*. Princeton University Press.

Steiner, M. (1978). Mathematical explanation. *Philosophical Studies*, 34(2):135–151.

Tappenden, J. (2008). Mathematical concepts and definitions. In P. Mancosu, ed., The Philosophy of *Mathematical Practice.* Oxford University Press.

Toutain, A.-G. (2015). *La Problématique phonologique: Du structuralisme linguistique comme idéologie scientifique*. Classiques Garnier.

Trouche, E., Johansson, P., Hall, L., & Mercier, H. (2016). The selective laziness of reasoning. *Cognitive Science*, *40*(8), 2122-213.