Investigating journal peer review as *scientific* object of study: unabridged version – Part I

Joanne Gaudet[1]
[1]Department of Sociology, University of Ottawa, Ottawa ON K1N 6N5

AUTHOR'S NOTE: This sociological preprint is Part I (of II), an unabridged version of an earlier abridged preprint I proposed: "Investigating journal peer review as scientific object of study" (http://hdl.handle.net/10393/31161). The main target audience is natural science and medical researchers, publishers, and policymakers and a secondary audience is social scientists with an interest in natural science and medical journal peer review. This preprint is one of a series in which I explore ignorance (re)production in journal peer review and journal peer review dynamics more generally.

Abstract

The main goal of this paper is to construct journal peer review as a scientific object of study based on historical research into its shaping. This paper is a first in a two-part series. Journal peer review performed in the natural sciences has been an object of study since at least 1830. Researchers mostly implicitly frame it as a rational system with expectations of rational decision-making. This in spite of research debunking rationality where journal peer review can yield low inter-rater reliability, be purportedly biased and conservative, and cannot readily detect fraud or misconduct. Furthermore, journal peer review is consistently presented as a process started in 1665 at the first journals and as holding a gatekeeper function for quality science. In contrast, socio-historical research portrays journal peer review as emulating previous social processes regulating what is to be considered as scientific knowledge (or not) (cf., inquisition, censorship) and early learned societies as engaged in peer review with a legal obligation under censorship. However, to date few researchers have sought to investigate journal peer review beyond a pre-constructed process or self-evident object of study based on common experience. Here I construct journal peer review as a scientific object of study with key analytical dimensions based on its structural properties. I use the theoretical concept of social form to capture how individuals relate around a particular content. For the social form of 'boundary judgement' (i.e., journal peer review), content refers to decisions from the judgement of scientific written texts held to account to an overarching knowledge system. Given its roots in censorship with its function of bounding science, I frame journal peer review as following precursor boundary judgement forms of inquisition and censorship. Constructing journal peer review as a scientific object of study contributes to improving it based on *scientific* understanding.

Introduction

The main goal of this paper is to construct journal peer review as a scientific object of study based on historical research into its shaping, going back to the twelfth century at the start of universities. The paper draws from, and contributes to, historical scholarship on peer review (Gould, 2012, 2013; Rip 1985; Spier, 2002) and journal peer review scholarship more generally (Hirschauer, 2010; Zuckerman and Merton, 1973; Biagioli, 2002). The main argument is that historical social conditions, dynamics,

processes, and contexts that (re)structured the ensembles of practices, meanings, and relations that led to journal peer review are mostly neglected in existing scholarship. The paper is a first of a two-part series, where in the second part I look more closely at the shaping of relations and actors in journal peer review and its predecessors.

To start, in the 17th century Bacon referred to pre-constructed objects of study (objects) as 'prenotions' or 'vulgar notions' (Bacon, 1620) based on a failure to go beneath the surface to construct an object scientifically. The use of pre-constructed objects in alchemy and astrology, for example, created a boundary between these non-scientific activities from chemistry and astronomy that purposefully and painstakingly constructed scientific objects (Bacon, 1620). Moreover, Leibniz advanced that a mathematician could build an equation reflecting the curb of a series of points that make up the contour of a face, but that such a construction would not go beyond the perception of the object, and would only reify common perception instead of challenging it (Bourdieu et al, 1968:83). In contemporary science, pre-constructed objects persist.

Einstein lay bare such a pre-constructed notion, for example, when he overturned the absolute nature of simultaneity for time (Rovelli, 2007:117-118). Since Kant, the self-evident understanding of time with absolute simultaneity had been assumed as an a priori condition of knowledge (2007:118). In doing away with time as a self-evident, Einstein paved the way for his theory of special relativity.

While trying to elucidate a cause for peptic ulcers, in another example, a long-standing biopsychosocial understanding proposing that stress was one of the main factors that caused these ulcers (Davey Smith, 2005:81-85) was at least in part owing to peptic ulcers viewed as a pre-constructed object. As pre-constructed, it was generally self-evident that bacteria could not live in the highly acidic human stomach (Robbins, 2012) and that bacteria therefore could not be the cause of peptic ulcers. Even if randomized controlled trials did not support the stress model (Davey Smith, 2005:84-85) and if antibiotic treatments appeared to work (Davey Smith, 2005:84; Robbins, 2012), peptic ulcers as a pre-constructed object long prevailed. Marshall and Warren encountered resistance to their Nobel Prize winning work that challenged the pre-construction by proposing the H. pylori bacterium as a cause for peptic ulcers (Robins, 2012).

Furthermore, in the social sciences 'spontaneous sociology' (Bourdieu et al., 1968) tends to investigate pre-constructed objects such as communication, leisure (1968: 60-61), 'natural' disasters, and climate change using common experience criteria where it fails to properly construct scientific objects. It is not sufficient to use a scientific approach to investigate an object in the social (or natural) sciences, the object itself must be meticulously constructed to gain scientific status (1968: 83). To properly construct a social object such as journal peer review, therefore, is to go beyond its operational character and common experience definitions as process. In addition to tending to the scientific construction of the object itself, like natural scientists, social scientists must tend to how an object is shaped (1968; Durkheim, [1894]1988:182-184) in order not to perpetuate the apparent naturalness of a pre-constructed object.

Since at least 1830 (Granville, 1830) therefore, research on (natural) scientific and medical journal peer review that focuses on process and neglects shaping has failed to construct the object scientifically beyond its common sense pre-construction. As with the peptic ulcer object of study above, using rigorous scientific method (i.e., modelling (Park et al., 2014) or randomised controlled trials (Godlee, 2002) on a poorly constructed object

such as journal peer review as common experience process, with assumptions reflecting the apparent self-evidence and naturalness of traditional journal peer review, undoubtedly yields questionable scientific insights.

Moreover, researchers mostly implicitly frame journal peer review as a rational system with expectations of rational decision-making (Biagioli, 2002; Hirschauer, 2010). Such a normative framing further contributes to an ill-constructed object and might help explain why research on journal peer review reveals purported low inter-rater reliability (Bornmann et al., 2010), bias (Smith, 2011), conservatism (Campanario, 2009), and an inability to detect fraud or misconduct (Smith, 2011; Ioannidis, 2005).

Ill-constructed journal peer review might also explain why researchers tend to attribute 'failings' of peer review to psychological, philosophical, and social causes such as bias, gender, age, epistemic conservatism, epistemic path dependence, and professional rank (i.e., Smith, 2011; Fang, 2014; Horrobin, 1990). By attributing failings to causes external to peer review, researchers are engaging in 'asymmetrical accounting for error' (Mulkay and Gilbert, 1982) to account for discrepancies between expected rationality (cf., non-problematic decisions as rational) and empirically investigated non-rationality. In contrast, when a journal peer review decision is deemed as non-problematic, it is assumed that a rational process led to the decision. A knowledge gap here is a need to produce understanding for journal peer review itself without resorting to external explanations and rationality.

One researcher who avoided journal peer review pre-constructed as process, Hirschauer (2010), proposed that contemporary peer review can be understood as reciprocal accountability of judgements among peers (2010). Reciprocity means that authors and editorial readers are actively engaged in a process of mutual relations of accountability where the author is not unilaterally submitted to peer review (2010). Hirschauer's (2010) conceptualization, though robust, was based on empirical research from the social sciences; it therefore appears to lack sensitivity to relations for journal peer review in the natural sciences. This knowledge gap on relations includes a pronounced relation of accountability to empiricism and relations of accountability to multiple actors with sometimes conflicting goals for authors, referees, and editors (i.e., to funders, journal publishers, and advertisers).

Related, and fundamental for this paper, is that researchers take journal peer review as a self-evident object started at the first journals in 1665 without tending to its shaping (i.e., Bornmann et al., 2010; Campanario, 2009; Ioannidis, 2005; Godlee, 2002). This assumes journal peer review as a purely rational process borne of a need for rationality that is disembodied from the social conditions, the dynamics, the processes, and the contexts that contributed to its shaping.

In contrast, historical research gives a glimpse into early journals that from their start held to account to sacred texts, the Church, and the State and maintained a legal obligation to perform censorship on scientific texts (Biagioli, 2002; Gould, 2012, 2013; Johns, 1998). Gould brought attention to potential roots of peer review in the early twelfth century at the start of inquisition and into censorship at the beginning of the printing press where scholarly inquisitors and censors performed 'peer' review (Gould, 2013). Rip (1985) and Spier (2002) proposed historical footing for journal peer review in inquisition and its censorship function. I therefore enlist these researchers that, to varying extents, challenged pre-construction for the object of study.

Rip (1985) refers to the use of The Royal Society of London's (the Royal Society) *Philosophical Transactions* as a starting point in the history of peer review as a "founding myth in science" (1985:84). He proposed that "[a]s to peer review in general, one could ask why the Jesuit astronomers of the Collegium Romanum, who critically evaluated Galileo's claims, and the mathematicians who advised about the imprimatur of his books, are never mentioned as the fathers of peer review" (1985:84). Rip's (1985) questioning of the start of peer review (as myth), and his conceptualization of first peers as mathematicians engaged in the censorship of Galileo's books and those who evaluated claims during his inquisitional trial, break free from the pre-construction of journal peer review in early journals in 1665.

However, I advance that Rip (1985) appears to have himself been taken in by another founding myth; that Galileo signalled the beginnings of modern science and therefore should signal the beginning of not only journal peer review, but of 'peer review in general' as Rip put it (see Galileo (1564-1642) as martyr in the 'martyrology of science' in Peters, 1988:242-254). I advance that if scholars engaged in censorship of Galileo's books and in evaluating his claims at his inquisitional trial can be conceptualized as engaged in 'peer review', then it is perhaps a sociological slip to limit the conceptualization to one – martyred case – of inquisition and censorship as 'peer review'. Should understanding not be extended to censorship and inquisition as a whole?

A second exception to dominant cultural meanings for journal peer review is Spier (2002), a natural scientist, who constructed a history of 'peer review' including examples of censorship and inquisition (2002:357). Once more, this conceptualizes censorship and inquisition as 'peer review' before early journals in 1665.

Furthermore, Biagioli (2002) painstakingly documented, historically and sociologically, an apparent transition from book censorship practices to nascent journal peer review practices in the mid-seventeenth century. Biagioli (2002) proposed that because "…peer review developed within the logic of royal censorship, its protocols were not significantly different from traditional book licensing" (2002:17). This included ensuring that texts did not make unacceptable claims as opposed to ensuring or certifying claims (2002:23). Conceptualized this way, early journal peer review would have emulated royal censorship book licensing. Although Biagioli's (2002) work on what he conceptualizes as a transition from book licensing to the broader concept of 'academic peer review' is insightful, it raises a question.

With regard to the historical framing of peer review, Biagioli (2002) advanced that it "…is clear […] that peer review was a 17th-century development tied almost exclusively to the emergence of a new kind of institution: the royal academy" (2002:14, note 10. 36-37). He also opposed 'scientific peer review' to 'traditional religious censorship' (2002:37). However, practices of review of scientific texts (as precursors to journal peer review) with 'peers', by analogy, can be understood to institutionally date back to at least the start of universities and the rise of inquisition in early twelfth century (see Hannam, 2010; Hamilton, 1981). Censorship was itself a function within inquisition and censorship at learned societies included an accountability relation to the Church (and State). Extending 'peer review' to the twelfth century is also in keeping with work by Gould (2012; 2013) who probed into the role of the Church in the 'peer review' of scientific writing in the Middle Ages.

That written work should not be making 'unacceptable' claims for journal peer

review therefore did not only reflect book licensing protocol, but was already incorporated in inquisition (see Hamilton, 1981:38-59), even before inquisition added a censorship function. A core element of journal peer review as object of study is therefore the review of scientific texts against overarching dominant knowledge[1] practices that shaped, through decisions, what was, or not, as 'scientific'. For example, inquisition and censorship brought together actors in roles to review scientific texts and construct judgements on what was deemed acceptable or unacceptable scientific knowledge in those contexts. By clinging to a 'scientific'/'traditional religious censorship' dichotomy, Biagioli (2002:37) appears to be framing 'science' as distinct from religion – although from at least the twelfth century, religion was central to science (Gaukroger, 2006).

I enlist Gould (2012; 2013), with his extensive investigation into 'peer review' starting in the Middle Ages with religious oversight of scientific communication, including inquisition and censorship. This therefore questions and extends Rip's (1985), Spier's (2002), and Biagioli's (2002) historical understandings of 'peer review'. In accordance with Gould (2012; 2013), conceptualizing inquisition and censorship as early 'peer review' (2012; 2013) should extend to the beginnings of these practices. This helps me to address a logical gap in Rip (1985) and Spier's (2002) work whereby they propose temporally bound *examples* as related with peer review (cf., 'peers' in Galileo's inquisitional trial and book censorship) instead of looking to inquisition[2] and its later censorship function *per se* as precursors to 'peer review'.

Furthermore, conceptually I advance that it is tenuous to establish a historical linkage among 'peer review' practices without tending to broader questions of how to construct an object of study. Researchers above appear to have failed to construct a robust object owing in great part to a focus on superficial and self-evident commonalities instead of constructing a deeper analogy (see Bourdieu et al., 1968:83) among inquisition, censorship, and journal peer review. Early learned societies were engaged in censorship practices that, conceptually, shared structural properties with censorship such as an overarching knowledge system bounding science – with decisions as to what could be considered scientific, or not. A core knowledge gap, therefore, is one of constructing an underlying analogy among inquisition, censorship, and journal peer review. To do so means carefully constructing journal peer review as an object of study. To perform this task, I adopt a social form theoretical approach.

The paper proceeds in three phases. First, I elaborate on how I harness the concept of social form (Simmel, [1971]1907; Medam, 1998; see relational sociology in Donati, 2011) to tend to the linkage among inquisition, censorship, and journal peer review and their interaction with scientific exchange. Second, I refine my use of science as culture. Finally, I tend to shaping of journal peer review from inquisition and censorship since the twelfth century, to early journal peer review. In conclusion, historical social conditions, dynamics, processes, and contexts shaped precursors to journal peer review, journal peer review itself, and the exchange of scientific knowledge, including a critical new dynamic in early journal peer review: the contingency it created on scientific exchange.

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[1] In this paper, where I refer to scientific knowledge I include scientific ignorance as the borders and the limits of knowledge (Gross, 2010).

[2] See historical research on the heterogeneous and locally-varying practices of inquisition in the Middle Ages in Hamilton (1981), from the Middle Ages onward in Hannam (2010), and Peters (1988).

Phase I - Enlisting Social Forms

This section lays the foundation for journal peer review and precursor inquisition and censorship as social forms of boundary judgement. Understanding anchors and builds on social form as a long-standing sociological theoretical concept.

I understand a social form as structured by, and structuring, informal to institutionalized relations and dynamics among actors that constructs sense around a particular type of content (see Levine, 1971:24). To characterize a social form is to characterize its structural properties and its content. By structural properties of a social form, I refer to elements that contribute to shaping relations in a form around a particular type of content. For boundary judgement, the main content is editorial decisions on whether the content of a manuscript is scientific, or not.

To grasp social forms from a sociological perspective is to "…identify and classify the different forms of social interaction; […] to study the conditions under which they emerge, develop, flourish, and dissolve; and to investigate their structural properties" (Levine, 1971:xxvii-xxviii). In this first paper of a two-part series, I focus on the emergence, development, flourishing and dissolution of social forms. In the second part (Gaudet, 2014a), I focus on investigating structural properties for the social forms.

The two main social forms I investigate are scientific exchange and boundary judgement. In principle, the first could be classified as a subtype of the social form of 'exchange' as conceived by Simmel (see economic exchange as subtype of exchange in [1971]1907), and the form of boundary judgement can be classified as having three subtypes. In this work however, I refer to all forms as 'social forms' doing away with hierarchical delineations (see Donati, 2011:13, 178, 181; Medam, 1998).

First, scientific exchange encapsulates relations where scientists communicate scientific knowledge, and more precisely in this work, written communication. Institutionalized relations increased in scientific exchange, for example, when scholars incorporated guilds or *universitas* starting in the early twelfth century (see Hannam, 2010:74) and later exchanged knowledge institutionally through learned society meetings and journals (see Johns, 2000; Biagioli, 2002).

Second, boundary judgement encapsulates relations where the content of scientific exchange is evaluated against an overarching knowledge system. Before self-regulation in science, the Church held dominant knowledge practices with relations of power over the content of scientific exchange. The three of interest here are: inquisition and censorship under mostly religious (with some state/crown) relations of power and journal peer review that eventually mutated to relations of scientific self-regulation.

Finally, constructing social forms as a social scientific endeavour means that I cannot *arbitrarily* construct new forms. I therefore ensure that I look to elements that differentiate among, and connect, the social forms of boundary judgement (see Donati, 2011:178). This entails considering not only emergence and development but also meanings that actors attribute to the forms, and structural elements that are differentiating or connecting for the forms (Donati, 2011:178). To be sure, the forms I propose, inquisition, censorship, and journal peer review are quasi-ideal type forms. By this I acknowledge that there were and remain heterogeneity in forms and that I attempt to retain the highest number of properties in a quasi-ideal type form (Bourdieu et al., 1968:79-80) – without necessarily reflecting 'real-life' historic or contemporary forms.

Phase II – Science as Culture

I understand science *as culture* (Stengers, 1998; Franklin, 1995; Hess, 2012; Knorr Cetina, 1999). At one level, to understand science as culture means that I am attentive to science contributing to, and reflecting, wider cultural, political, and historical dynamics. At another level, it means looking at science as "…pursued by groupings of specialists who are separated from other experts by institutional boundaries deeply entrenched in all levels of education, in most research organizations, in career choice, in our general systems of classification" (Knorr Cetina, 1999:2). Here cultural therefore "…refers to the broad systems of meanings that structure and are structured by discourse and practice" (Hess, 2012:1). Practice encompasses discursive and material dynamics (Wehling, 2006) that reflect place.

Furthermore, local to global science practice and discourse (re)produce unevenly distributed norms and values (Hess, 2012; Franklin, 1995) and processes that enforce boundaries between what is considered as science and what is not. Before I turn to the shaping of boundary judgement and scientific exchange, I must tend to more fundamental considerations: the concept of science and how I frame scientific exchange.

The concept of science and framing scientific exchange in science as culture

The concept of 'science' and the institutionalization of its discourses and practices originate in the early twelfth century in the Middle Ages[3] (mostly in the then 'new' universities). From medieval Latin *scientia* (Grant, 2004:21), science is in the etymological family of *scire* (knowledge, to know) (Robert, 2009: 2327; Hannam, 2010:6) therefore revealing its epistemological roots. By this, I mean that the concept of science is conceptually one that in the Middle Ages (through today) embodied knowledge practices. In medieval France, for example, science (alternatively as *escience*) in 1119 stood for "*savoir, connaissance compréhensive acquise par l'étude et la réflexion*" and in 1174-1176 "*le savoir humain (opposé ici aux préoccupations religieuses)*" (CNRTL, 2012). The implied differentiation between scientific and religious knowledge is relevant to understanding early editorial practices. Furthermore, the emphasis on reflection in early definitions of *scientia* emphasized it as "…a form of wisdom that derives from the systematic organization of material" (Gaukroger, 2006:2). This differentiates it from later (to contemporary) cultural meanings of professional organization embodied in the concept of science (2006:2).

To this discussion, I add two further clarifications on the use of 'science' that I hope to heed. First, Anstey and Shuster (2005) warned of the potential misuse of the concept of science as an *overarching* label for natural philosophising (2005:2). Dear

[3] By using the coining of the concept of science as a starting point, I do not negate previous historical contributions to science. Rather, I suggest that science 'as culture' relevant for a study of peer review (and its practices) coincides with the coinage of the term and the establishment of universities where science was in at least in part institutionalized (followed by courts and learned societies). See Biagioli (1993) for an analysis of courtly patronage based on Galileo Galilei as honorary courtier in Florence (1993:160). Biagioli (1993) recounts how Galileo was encouraged to move away from oral disputes (seen at least partly as forms of entertainment (1993:165)) and towards putting his views in writing. In one such instance, Galileo employed a rhetorical strategy that "…switch[ed] from an ad hominem style of argumentation to a more polite and systematic one" [that] "also allowed him to define his audience and, therefore, whose questions to answer and whose to ignore" (1993:179). I highlight this passage as an example of the author actively shaping the text as actor *itself* in a dispute.

(2012) for his part, proposed that "[t]he reality of what science truly is resides less in essential similarities between its assorted branches than it does in the ideology that binds them. This ideology presents the appearance of unity where none truly exists. A broader vision of the development of this ideology, integrated with some of the more signal examples of the knowledge activities and practices that have come to constitute it, may help to exorcise the totalizing ghost of "science" while still telling us what it is." (2012:38-39). Investigating peer review as one of the central knowledge practices in 'science' can therefore (hopefully) provide insights into what science *is,* without rendering it totalizing. In this way, the apparent contemporary unity of peer review *practices* contributes to an ideology of science that is set apart from other valuing mechanisms; scientific knowledge gain value through peer review (see Biagioli, 2002:11). I will look to historical analysis to explore (dis)unity of peer review.

My use of the concept of science will hopefully respect and reflect the range of meanings it has held since *scientia* in the Middle Ages, without overly stretching the concept's scope. In this work, science is therefore ' "…used in a broad sense to refer to all forms of […] scholarship, rather than just to the natural sciences" (Whitley, 1984:7-8) deemed to be so by contemporaries. I concentrate on the natural sciences. In addition, I use the concept of 'scientist' (coined in 1833, Hannam, 2010:337-338) to designate individuals who engaged in scientific practice from 1833 onward. Before this date, I mostly refer to scholars.

To be clear, science today includes the natural sciences (e.g., biochemistry, biology, chemistry, and physics) and the social sciences (e.g., psychology, political science, and sociology). It reconstructs its boundaries when it discards, integrates, or modifies areas of scientific study. Following are three examples of boundary *re*construction. First, science discarded the study of eugenics (Kevles, 1992). Second, science integrated (at least in part) complementary and alternative medicine (see publication-related discussions in Caulfield and DeBow, 2005; Polich et al., 2010; Charlton, 2004). Third, the British Association for the Advancement of Science was reluctant to admit and sustain a statistical Section in the late nineteenth century. Reluctance involved the disadvantageous publication of statistical papers and omitting their political conclusions (Morrell and Thackray, 1981:291-296). In reconstructing boundaries, science also maintains boundaries of exclusion, such as for scientology and parapsychology (analysis of latter in Stengers, 1998). As I explore with historical insights below, the broad definition I adopt for science reflects science as culture with the potential for temporally dynamic boundaries. Journal peer review has played and continues to play an important role in boundary setting.

Finally, I frame elements of written scientific exchange as "…intrinsic dimensions of the performance of the cultural practices called 'science'" (Hirschauer, 2010:73). All scholarly science[4] engages in scientific exchange processes with most involving variations of journal peer review. Journal publication is pervasive in great part because contemporary scholarly reward systems privilege peer-reviewed publication (i.e., Morris et al., 2013:394). Rewards from publication for academic actors matter – promotions, awards, recognition, reputation – and are in large part related with peer-reviewed publications. This is in stark contrast with scholars who did not publish at all,

[4] This is not restricted to sciences as other scholarly disciplines in the humanities, business, management, and technology also engage in scientific exchange.

such as Leonardo da Vinci (1452-1519) who worked in secrecy (Hannam, 2010:7). To understand and to theoretically account for the stark contrast requires looking at history and the shaping of the social forms of scientific exchange and boundary judgement.

Phase III - Historical shaping of scientific exchange and boundary judgement

To shape the object of study in a broader historical lens, I look at science from the coinage of the concept of science in the Middle Ages to today[5]. This deceptively descriptive section helps me theoretically frame an understanding of the social conditions, the dynamics, the processes, and the contexts that helped shape the social forms of scientific exchange and boundary judgement.

To start, in the Middle Ages, science was "…all intellectual disciplines, including politics, theology and philosophy. [...] The study of nature as a separate subject was called 'natural philosophy'" (Hannam, 2010:6). *Mediae scientia* (middle sciences) referred to sciences between natural philosophy and mathematics that "…involved the application of mathematics to natural phenomena" (i.e., astronomy, optics, mechanics (Grant, 2004)). In addition, magic, astrology, and alchemy played important roles in medieval science (Hannam, 2010:6, 107, 134, 147), which bolsters a theoretical context of science as culture where science (through its members) constructs the boundaries of what is (or not) science. A first consideration is how scholars engaged in scientific exchange.

Early shaping of scientific exchange and boundary judgement

The "…widespread acceptance of reason as a valid tool for discovering the truth about our world" (as rational argument or the 'scholastic method', Hannam, 2010:7, 96; see recursive argument method in Beckwith, 2012[6]), is one of the era's (many) purported scientific practices that foreshadowed empirical practices and rational analysis. Scholars in this period would therefore have been held to account to rational argumentation in their written exchange much like scientists eventually became (and mostly remain) held to account to empiricism from the mid-seventeenth century onward.

Empiricism, an approach that emphasises that experience is the only way we can acquire knowledge (Misak, 1995:1) and construct concepts (Lipton, 2001:4481), was only burgeoning in the Middle Ages in comparison to its extensive construction in the seventeenth and eighteenth centuries (2001:4481). Thomas Aquinas (1225-1274) for example is believed to have proposed that "…there is nothing in the intellect which was not previously in the senses" (2001:4481). Scholarship also shed light on how the

[5] My goal here is not to develop a comprehensive history of science given that such a history reaches far earlier than the Middle Ages. It is instructive to note that when I consulted with scholars specializing in medieval texts about the etymology of Latin words in the Middle Ages, the first question they asked me was: for which region(s)? History (like sociology) is about context; but I cannot do it justice here. Rather, I focus primarily on key Western medieval and subsequent historical elements that help further understanding of contemporary peer review and ignorance (re)production. Brevity thwarted my ability to convey heterogeneity in practices and contexts. I do not doubt that this in turn over-simplified more complex historical events and dynamics. To compensate for this shortcoming, at least in part, I frequently reference historical texts with more comprehensive accounts.

[6] Beckwith (2012) chronicled the medieval science argument structure (the recursive argument method) from its Islamic roots. He argued that the contemporary use of hypotheses and experimentation "…is recursive and thus structurally related to the medieval recursive argument method, on which it seems in part to have been […] modeled" (2012:159).

rapprochement between medieval artisan-trained individuals and university-trained individuals contributed to the cultural acceptance and the shaping of empirical science (Long, 2011). Long investigated "...the interaction of artisans and humanists in trading zones bound by common interests and goals (and the blurring of the differences between them) that brought about profound changes in outlook, changes that favoured empirical approaches to investigating buildings, other artifacts, and eventually the natural world" (2011:129). Her research delved into areas of interaction that fostered cultural acceptance and provided opportunities to shape burgeoning empirical approaches such as painting, sculpting, pottery, alchemy (i.e., mining), and mixed mathematics (i.e., architecture and engineering). The role of universities thus appears pivotal in these changes.

Institutionalization shaping exchange and review

Universities developed in the Middle Ages[7], and from the start they harboured the development of science (Hannam, 2010:5, 193) and its practices. Early Western Europe *universitas* were 'corporations' (incorporated guilds) administratively mostly independent from royalty or the Church[8] (2010:74) (e.g., Bologna, Paris, and Oxford (Beckwith, 2012:43)). At the University of Paris, for example, the struggle between guild self-governance and the Church was wrestled from local ecclesiastic control and enforced by the papal bull of Gregory IX in 1231 (*Parens Scientarum, 'the Mother of Sciences'*) (Cobban, 1988:276). I advance that the self-regulating nature of the guilds no doubt contributed to science's eventual self-regulation practices (through to today).

Of particular interest is that universities served to institutionalize practices of science from the Middle Ages onward. Relations within the already existing social form of scientific exchange included not only scholars, but also their students as potential future scholars (i.e., Hannam, 2010; Grendler, 1996). As I develop below however,

[7] There are competing historical claims about the development of universities that I do not wish to detail, but do acknowledge given their relevance for the religion-science relationship. A first claim asserts that universities developed mostly out of cathedral schools (i.e., Vickery, 2000:46; Grant, 1996:34-35). Others dispute this Eurocentric view however, and have chronicled the development of colleges (as all-inclusive academic institutions with permanent endowment) from Islamic and Asian traditions (e.g., la Sorbonne in France and Merton College in England) merging with Western Europe medieval *universitas* (incorporated scholar guilds without institutional purpose or functions) to yield modern universities (i.e., Beckwith, 2012). Regardless of the path, the resulting universities are to this day a 'permanent' medieval Western European institutional contribution (Grant, 1996:38) that has maintained a relationship with science (from teaching to research during different periods), but has now mostly abandoned its relationship with the Church.

[8] *Universitas* in Latin "…means a legally defined corporation" (Gaukroger, 2006:67). Self-regulating guilds (i.e., masters' guilds made up of scholars or craft guilds made up of craftsmen) in the Middle Ages recognized only their members as professionally qualified to engage in governance (Cobban, 1999:213-217). For a discussion of variations of, and fluctuations in, relationships among incorporated masters' guilds and universities (as autonomous legal entity), the Church, and the Crown primarily in England but also with comparisons to France, see Cobban (1999:213-235;1988:274-299). For example, Cobban (11999) proposed that "[b]efore the sixteenth century […] the master's guilds, led by their elected chancellors, assumed full responsibility for university government and for the setting and maintenance of academic standards. […] Self-regulation and internal policing were the means by which the university authority sought to control their regimes" (1999:216). It was following the sixteenth century that the then Tudor government "…began to treat Oxford and Cambridge as an arm of the state and expected compliance to the royal will" (1999:216). The latter highlights a shifting accountability to State/Royal governance of universities and their evaluation that persists to this day.

starting in the seventeenth century, learned societies began to play an important role in science research (experimentalism, exchange, and review). In this later period, universities mostly fulfilled the role of teaching science (Manten, 1980:9) before regaining a stronghold on research that has persisted with varying degrees to this day.

What is more, actors within the Church engaged in diverse relations and interactions in scientific exchange. For example, the Church served as patron (and sponsor) to scientific work (not necessarily over the incorporated guilds *per se*) and natural philosophy held "…protected status in the universities because it was a prerequisite for the study of theology" (Hannam, 2010:89). The Church oversaw much of Middle Age intellectual undertakings (2010:7, 193; Gould, 2013; Burke, 2000:21), and also actively engaged in scientific practice (Vickery, 2000; Hannam, 2010; Grant, 2004; Shapin 1996126). Medieval theologian-natural philosophers, for example, "…were significant contributors to both natural philosophy and science, and most of them lectured and wrote on these subjects" (Grant, 1996:175). The context of relations of dominant religious ensemble of knowledge practices over science changed, however, and led to a need to suppress error openly in scientific exchange, through inquisition.

Shaping inquisition as social form for the suppression of 'error' in exchange

It is not surprising therefore, that *scholarly* members of the Church engaged in the investigation of heresy (cf., espousing beliefs that went counter to those of the Church or heterodoxy) through inquisition for manuscript[9] books (later printed books) and shorter written texts (Hannam, 2010:191; general discussion in Gould, 2012, 2013). Although heresy had been common before the Middle Ages, the Church intervened by constructing the legal process of inquisition during the Middle Ages in order to deal with the growing number of heretics and increasing violent actions of "…common people taking matters into their own hands" (Hannam, 2010:83-84).

The emergence of a legally-binding social form (including oral and written boundary judgement) had a goal of giving heretics an opportunity to repent and "return to the faith" (2010:84), that for scholars translated into espousing dominant Latin Christian-sanctioned scientific knowledge. Heretics were problematic for the Latin Christian Church that tried to prevent the spread of 'error'[10] and preserve orthodox religious beliefs (Hamilton, 1981:13, 38; Peter, 1988:1). Here I concentrate on the written boundary judgement element of inquisition that I construct as a social form in its own right.

The context of emergence of the social form of inquisition (as boundary judgement) was therefore one where scholars and religious scholars and non-scholars were already in relation, but where relations changed in response to growing popular tension and violence towards heretics. The change in relations included religious actors

[9] This is one of the rare instances where 'manuscript' means written by hand in contrast to contemporary use where manuscript refers to an unpublished work (no longer handwritten).

[10] That I concentrate on accountability to sacred texts for the Church does not exclude related dynamics (i.e., social and political) in inquisition and censorship. Hannam (2010) for example, advanced that "[a]cademic historians are now convinced that [the trial of Galileo Galilei in 1663] had as much to do with politics and the Pope's self-esteem as it did with science" (2010:3). Biagioli's (1993) analysis of Galileo's trial through the lens of patronage lends credence to this type of analysis by adding understanding for patronage dynamics involving an absolute Prince as Galileo's patron. For Galileo's *Dialogue* (book) trial, intersecting accountabilities would have included State/Crown and Papal prerogatives, in addition to sacred texts.

holding explicit dominating relations of power over texts and scholars accused of heresy.

In effect, the social form of inquisition helped reproduce boundaries for scholarly practice – scholars who returned to the faith would thus abandon 'heretic' knowledge deemed as 'non-scientific' in that context. The social form of inquisition thus exerted review over texts *after* scientific exchange had taken place.

Gaukroger (2006) went one step further where his comparison of science in the West with that in China "…made [him] realize that the success of science in the West in the early-modern era might be due to its close association with religion, rather than any attempt to dissociate itself from religion" (2006:5). Dominating religious knowledge practices over scientific exchange from religious insiders might therefore have helped cultivate a meaning of *absolute* knowledge in science and boundary judgement that necessarily excluded other ways of knowing – thus eventually leading to a meaning of scientific dominance.

Furthermore, that the Catholic Church insisted on maintaining clear demarcations between nature and metaphysics, combined with a sustained involvement in science practices, is proposed to have contributed to the construction of 'modern'[11] natural sciences focused on nature (Hannam, 2010:2, 104) because natural philosophy was able to hold its own as an independent science (Grant, 2004:187). To start, William of Conches (1085-c1154, a natural philosopher) "…could see that for natural philosophy to be worthwhile, nature had to enjoy autonomy" from a Christian God. Of Conches and his contemporaries therefore constructed a way to reconcile the difficulty of distinguishing "…between something that is a result of the laws of science and something that occurs due to the direct actions of God" (Hannam, 2010:63, 64). Furthermore, in 1323 the Church amended the 1277 condemnations to accommodate the (previously banned) notions of the now canonised Thomas Aquinas (2010:104). According to Hannam (2010), this allowed natural philosophers to "…get on with the study of nature without being tempted to indulge in illicit metaphysical speculation" (2010:104).

Hannam (2010) proposed a vivid metaphor to capture the split. He likened natural philosophy to a country with new and well delineated borders within which natural philosophers could engage in their tasks with *less* fear of recrimination (2010:105) through the then accountability processes for scholars. I emphasize 'less' as it conveys the ever-present editorial (and oral) review process of inquisition and its legally-binding accountability to knowledge in religious texts.

The nature/metaphysics cleavage also appears to have paved the way for two fundamental and interrelated changes in science practice. First, this nurtured the foundations for science to develop empirical knowledge practices as separate from ecclesiastic knowledge practices (also see Long, 2011 above). Second, and related, this also prepared for a change in accountability for scientific texts. I deem that two additional important elements helped shape the context of scientific exchange for scholars.

<u>A shared language and 'free' movement shaping exchange</u>

Two additional elements of medieval science as culture are relevant. First, the domination of the Latin language for communication fostered 'cross-pollination' of

[11] As I understand science as culture, I purposely do not differentiate between eras of science. From this point forward I generally do not refer to 'modern' or 'new' science, and instead contextualize my use of concepts with dates (where possible and relevant).

Church-sponsored (or Emperor-protected if they fell out with the Pope) scholars. Second, these actors had mostly free movement across the then western world, in spite of political divisions (Hannam, 2010:136, 155; including a 'republic of letters' in the Middle Ages, 2010:189). These dynamics fostered scientific exchange relations in a wider scientific community mostly immune to political upheaval. With the advent of print however, came more radical changes to the social forms of scientific exchange and boundary judgement.

The advent of print culture in science and the emergence of the social form of censorship

The historical analysis to this point has shed some light on the social conditions, the dynamics, the processes, and the contexts that have helped shape scientific exchange and boundary judgement. The advent of the printing press toward the end of the Middle Ages, however, radically altered scientific exchange practices and boundary judgement. This included increased potential for scientific written text availability, quality, and distribution. Johns (1998) warned, however, not to see the advent of printing as one that immediately led to fixity in printed knowledge. To the contrary, he dispelled this monolithic view of print and contextualized its localized meanings – including piracy, fears of destabilization, and problems with replication and distribution.

From early on, the Church and State sought to contain the spread of 'error' and 'sedition' (Knight, 1980:27) through printing censorship with a main goal of not destabilizing the Church and state (Biagioli, 2002:19; Farge, 1996:75). For the Church, censorship as a new boundary judgement extended the reach of inquisition.

In keeping with inquisition, 'error' for science included deviating from a relation of accountability to sacred texts and/or State/Crown prerogatives. In the emerging social form of censorship, the processes that enabled the Church and State/Crown to gain power over printing included various systems of licensing with proper authority across Europe that restricted (or not) what could be printed (1980:27; Johns, 1998; The Royal Society, 1912:66-67, 141, 162). The censorship social form therefore had many variants, but a constant was new interactions and relations of power the Church and State constructed over printed scientific exchange *before* publication.

Academics and intellectuals voiced their criticism of censorship functions, especially in response to the Spanish Inquisition in the seventeenth century. At the time, "[i]nfluencing such criticism was the belief that the censorship functions of the Inquisition were an attack, not exclusively upon doctrinal error, but on the expression of ideas itself" (Peters, 1988:164). The meaning given to the censorship function of inquisition here was one of gatekeeping scientific ideas (cf., inhibiting the expression of ideas). To be sure, scientific exchange does not appear to have been consistently contingent on censorship (see Peters, 1988), yet nuances of frequency or consistency of contingency are not necessarily reflected in the meaning attributed to censorship by actors involved.

In France (and in other countries), books proposing 'erroneous' knowledge claims could nonetheless still circulate in the form of manuscript when they failed to pass censorship (Knight, 1980:27). An example[12] is that of Benoit de Maillet (1980:27) in

[12] Scientific exchange of manuscripts that did not pass censorship is similar to certain contemporary science exchange practices on the internet. These can involve exchanging peer review rejected (or *not* peer reviewed) papers on archival databases, university or institutional repositories, blogs, researcher websites, and other internet distribution venues.

France. Bypassing censorship (where he had not received permission to print), his circulating manuscript proposed new knowledge (and ignorance) of a naturalistic and materialistic mechanism in his geological theory. This was counter to Genesis (in sacred texts). More generally, Farge (1996) proposed that even books that *had* been censured "…were certainly in circulation enough to keep the authorities alert and worried" (1996:89-90). These examples highlight the scientific exchange options exercised by and relations scholars engaged in attempts to maintain a separation between the social forms of scientific exchange and boundary judgement. The rise of experimentalism further shaped the social forms.

New experimentalism shaping exchange and review

With experimentalism came more change. Following what is commonly (though now controversially) referred to as the scientific revolution[13] (roughly from 1450/1500-1700), science increasingly constructed itself to privilege the experimental method (cf., the turn to empiricism and the laboratory) by harnessing instrumentality with natural philosophy (discussion in Dear, 2012). Prior to empiricism as it is understood in contemporary science however, there was a period from the late 1650s to the early decades of the eighteenth century where experimentalism was only beginning to take shape in experimental natural philosophy (Anstey, 2005:216; Gaukroger, 2006:352).

The interplay among new experimentalism, new print culture, and scientific exchange: entangling exchange with boundary judgement

Johns (1998) argued that to understand the social construction of early experimentalism, contemporary scholars should take printing and reading processes seriously for experimental natural philosophers of the mid-seventeenth century (1998:542). This includes a migration from 'author-pays' scientific exchange in essays, books, pamphlets, and letters to shorter journal texts in 'reader-pays' subscription-based journals (related in Johns, 2000; Lefanu, 1984:vii). Most 'author-pay' written exchange became contingent on censorship while later, reader-pay exchange content was contingent on journal peer review[14].

Therefore, toward the end of the seventeenth century, censorship of scientific books dovetailed burgeoning censorship practices for then new scientific journals at learned societies (commonly performed by the same scholars working for the censorship body and the learned society, McClellan, 1985:28; Biagioli, 2002:15). Given that those who performed science were generally not considered a censorship threat, some learned societies gained licensing privileges (2002:15) and therefore internal control over journal review and publication: This was the case for the Royal Society in England (in 1662) and

[13] The term 'scientific revolution' is contested, especially by researchers who are bringing previously negatively socially constructed medieval scholarship to light (i.e., Hannam, 2010; Long, 2011). Shapin (1996) not only proposes a sociological history of the period, but also offers an extensive bibliographic essay for further reading (1996:167-211).

[14] It was only in the early twentieth century however that scientific exchange practices led to an overwhelmingly greater use of journal papers as opposed to books (see physics in Bazerman, 1988:158; more generally in Gross and Harmon, 2014:5; Philosophical Transaction in Bryce et al., 1994:292; Lefanue, 1984:viii).

the *Académie Royale des Sciences* of Paris (in 1699[15]), (Biagioli, 2002:14; The Royal Society, 1912:162). Under these conditions, the new social form of journal peer review emerged with new relational dynamics and interactions among actors.

The social form of journal peer review, still entangled with the social form of censorship, was slowly and tenuously emerging with a new accountability to experimentalism (to become an accountability to empiricism). Thus, processes such as early 'journal peer review' (cf., as perusal) were as much products of, as producers of, early experimentalism (see Johns, 1998).

Transition from natural philosophy to speculative and experimental natural philosophy: changing scientific exchange and epistemic practices

I examine the transition toward early experimentalism in more detail to gain understanding of how new relational dynamics shaped the social forms of scientific exchange and boundary judgement. Starting in the mid-seventeenth century, contemporary historians of science propose that philosophy went from two fairly distinct areas of inquiry, moral philosophy and natural philosophy, to three groupings when natural philosophy increasingly subdivided into two methods (among a range of methods). The first was *speculative* natural philosophy and the second *experimental* natural philosophy (Anstey, 2005; Gaukroger, 2006:354-355). Speculative natural philosophy, according to Anstey (2005) referred to the "…development of explanations of natural phenomena without prior recourse to systematic observation and experiment" (2005:215). The types of entities (ontological considerations) that were offered to support speculative natural philosophy explanations included "…inexplicable occult qualities, substantial forms, virtual extension, sympathies and antipathies" (2005:221). The speculative concept during this period of tension held (and I advance largely retains) a pejorative connotation (2005:220).

Experimental natural philosophy in contrast, referred to "…the collection and ordering of observations and experimental reports with a view to the development of explanations of natural phenomena based on these observations and experiments" (2005:215). For an experimental philosopher, this meant that "[s]cientific progress was possible even in the absence of a metaphysical account – however desirable this may be – of the underlying structure of the material world" (Dawes, 2011:5). Experimental natural philosophy privileged the acquisition of knowledge about nature through experimentation (with observations augmented through instruments, such a observation with telescopes or later microscopes, see Anstey, 2005:222; Knorr Cetina, 1999:94) that could be shown and witnessed (although some left room for 'imagined' experiments) (Johns, 1998:469, Dawes, 2011:3). Anstey (2005) and Gaukroger (2006) warned, however, that the distinctions and demarcation between these methods remained in flux during the seventeenth century (Anstey, 2005:220; Gaukroger, 2006:356). This included the tentative construction of concepts such as "…hypothesis, probability, induction, laws of nature, testimony, [and] experimental replication" (Anstey, 2005:220).

In addition, although experimental natural philosophy was in great part practiced by members of the Royal Society (and groups that proceeded it), it "…had an immediate

[15] In giving power over censorship and printing to a learned society, it appears the Crown in France was removing some powers from the universities (in theology) and expanding censorship to new areas (Hahn, 1971:60). This highlights institutional tensions with shifting accountability in science.

impact on many [of Secretary Oldenberg's] Continental correspondents" (2005:223). This included members of the *Académie Royale* in France (2005:223). New institutional relations and accountability relations thus shaped the social forms of boundary judgement and scientific exchange. Exploring why empiricism developed will help me contextualize the shaping of scientific exchange and journal boundary judgement social forms.

Contextualizing shaping under a dominant way of knowing

Briefly, delving deeper as to *why* the roots of empiricism were starting to take hold during this period, Bruner (1986) proposed that these changes were linked with the nascent idea of progress whereby through empiricism man could free himself from Fate (1986:137-138). He outlined a potential lineage for this notion of progress to Francis Bacon (1561-1620). Zavardeh and Morton (1991) further offered that those involved (i.e., members of the Royal Society and later scholars such as Thomas Hobbes, John Lock and David Hume) were "…attempting to dislodge the "authority" of Divine Rights and Divine Revelation by postulating Nature itself as the source of knowledge and that furthermore theorizes that access to Nature as direct, free, and open to all" (1991:67-68). Once secured however, the processes of power effectively shifted authority from Divine Right to Nature, suppressing freedom from other ways of knowing (1991:68).

The establishment of a single source of authority mirrors what Gaukroger (2006) framed as Christianity's goal in the third century, establishing Christian teaching as the only road to truth and the only source of authority to quash religious pluralism (2006:49). This framing informs understanding in this work. Processes of relational power for the social forms of boundary judgement (cf., inquisition and censorship) over scientific exchange first reproduced Christianity as single source of authority over science, then journal peer review over scientific exchange reproduced science as a single source of authority through experimentalism. Domination relational dynamics and experimental natural philosophy appear to be at the core of the shaping of then (to contemporary) social forms of scientific exchange and boundary judgement in science and medical science.

Experimental natural philosophy shaping scientific exchange and boundary judgement

Especially pertinent for this work in the wake of experimental natural philosophy are five (sometimes interrelated) elements. First, it appears that the newly established Royal Society was using the experimental versus speculative distinction to define itself, and distance itself from speculative natural philosophy (Anstey, 2005:221; Johns, 1998:468-469). In doing so, it instituted a new accountability for journal peer review, for scholars, and for editorial readers – to experimentalism. Following the works of empiricist scholars such as John Locke and Emmanuel Kant, accountability would be to empiricism *per se* (discussion on relation between experimental and speculative natural philosophy and empiricism and rationalism in Anstey, 2005:219).

Second, and linked with the first, is that by dissociating itself from speculative natural philosophy, the Royal Society was apparently demarcating itself from universities where the method prevailed with metaphysical speculations (2005:221-222; Gaukroger, 2006:352). This reveals institutional tension between universities and the new learned society that, through its founding Secretary, was establishing not only its role, but also its practices for the exchange of new experimentalism (for the latter see Johns, 1998:467-

472). That the new Royal Society, as a corporate body, could even entertain and attempt to establish its expertise in science is an example of a "…protected climate in which […] innovations could flourish" (Gaukroger, 2006:34) in multiple, decentralized, and autonomous corporate bodies (e.g., the Church and universities, 2006:34). Another then contemporary institution, the Royal Observatory (exerting expertise over navigation issues), also generated inter-institutional tension with the Royal Society and its dominating science exchange practices.

Exchange leads to the third element that is relevant for this work. I refer here to the practices and protocols (re)producing experimentalism, especially peer review at the then new scientific journal *Philosophical Transactions*.

Fourth, experimentalism also brought about new epistemic practices in science as culture – explicit interaction between knowledge and ignorance. In essence, experimentalism was based on the notion of not only demonstrating knowledge, but also of generating new ignorance from which new experiments could be undertaken (see Johns, 1998:470-471). Here a new meaning of science in practice was dominion over observable experimental phenomena with explicit epistemic practices conveyed through shorter and more frequent scientific exchange.

Finally, experimental natural philosophy crossed disciplinary boundaries. One example is the adoption of reforms by physicians in the late 1650s who proposed to focus their activities on observations and on experiments with hypotheses "…derived from the facts themselves" (Anstey, 2005:228) and not from "…unfounded hypotheses as 'castles in the air'" (Anstey, 2005:228) (including the construction of histories of diseases, Anstey, 2005:227-228).

Experimental natural philosopher Boyle for his part, "…exhort[ed] medical practitioners to look at the practices of midwives, barber surgeons, old women, American native Indians, and others: these [were seen as] a potential mine of information on the powers of medicines and how to use them, not least because of the large range of different circumstances in which they have been tried" (Boyle in Gaukroger, 2006:374). It would appear here that one of Boyle's goals was to construct medical scientific knowledge drawing from other ways of knowing (related in Laplante, 2014).

Bernard ([1865]1966), a few centuries later, and in response to a rise of publications in medical science ([1865]1966:197), promoted a more sustained transition from empirical medical doctor to experimenter medical doctor ([1865]1966:193). An empirical medical doctor, according to Bernard, was in the empirical phase of experimental medicine where "…[il] agit plus ou moins aveuglément [mais] expérimente en définitive sur les phénomènes vitaux" ([1865]1966:182). An experimenter medical doctor, in contrast,

> "…fera usage de tous les moyens thérapeutiques que l'empirisme conseille ; seulement, au lieu de les employer, d'après une autorité quelconque, et avec une confiance qui tient de la superstition, il les administrera avec le doute philosophique qui convient au véritable expérimentateur ; il en contrôlera les effets par des expériences sur les animaux et par des observations comparatives sur l'homme, de manière à déterminer rigoureusement la part d'influence de la nature et du médicament dans la guérison de la maladie" ([1865]1966:193).

Bernard's ([1865]1966) conception of medical science and controlled experiments in medicine appears to have contributed to shaping the content of medical science exchange about such experiments ([1865]1966:183-184), relations of accountability, and Pickstone (2001) argued, shaped experimentalism (2001:144-145). Going back slightly in time however, increased secularization contributed to a further change – the dissolution of Church and (most) state-sanctioned inquisition and censorship.

Dissolving Church and (Most) State inquisition and censorship

Finally, towards the end of the eighteenth and early nineteenth centuries, the social forms of censorship and of inquisition gradually dissolved (see Biagioli, 2002:32; Peters, 1988:119) as "…increasing restrictions [were] placed upon the autonomy of Catholic churches by secular governments" (1988:120).

'Security' imperatives have historically revived (and continue to revive) State censorship of scientific exchange however. A first example is at the start of the Second World War. An announcement in journals such as *Nature* by the Royal Society's President stated that the Royal Society had "… undertaken the formation of a scientific panel to assist the [Press and Censorship Bureau] in arranging the censorship of papers in scientific journals" (Anonymous, 1940). A second example of seemingly ongoing State censorship is for science exchange of 'dual use' research (i.e., weaponisation of biological agents and legitimate research on emerging diseases) (The Royal Society, 2008:3-4). Ultimately, the dissolution of inquisition and censorship reflected a loss of dominant relations by the Church over scientific exchange.

Disentangling science from religion – towards self-regulation and mutating accountability relations in science

From approximately the end of the eighteenth and beginning of the nineteenth centuries, God has been excluded from science, in contrast to the Middle Ages where understanding of nature was as God's creation (Hannam, 2010:6, 64; see explanatory virtues and how scientific and religious explanations fare based on common criteria in Dawes, 2009). The metaphysics/nature split that grew more differentiated with the rise of experimental natural philosophy over speculative natural philosophy finally led to *empirical* accountability for journal peer review. The new accountability relation displaced the previously internal accountability to the Scholastic method and in the early nineteenth century also displaced external Church and State regulated accountabilities to *sacred texts* and state priorities (with the noted exception above for security imperatives).

Using a naturalistic[16] methodology (based on empirical data obtained from human sensory experience), instead of religious understanding, science has since professed explanatory and predictive success in the understanding of nature (Dawes, 2009:10). To sum up, Herschel's (1830) argument in the following passage captured the meaning of the transition *away* from accountability to sacred texts where "…it was foolish to make science bend to 'narrow interpretations of obscure and difficult passages in the sacred writings' " (Herschel, 1830:7-9 cited in Morrell and Thackray, 1981:226).

Moreover, boundary judgement at this turning point became a scientific practice

[16] Methodological Naturalism (MN) "…is science's universal *procedural* protocol requiring natural explanations for natural phenomena. [… MN requires a] commitment to an empirical methodology" (italics in original, Brauer et al., 2005:48).

free of legal status (as opposed to its legal obligations under inquisition (Gaukroger, 2006:66) and censorship) under science's new self-regulating practices (see Biagioli, 2002:13). With self-regulation, governance for science was (and remains) performed by those who engage in science, including its exchange, much like early masters' guilds engaged in self-regulation in universities. Finally mirroring the Middle Ages, scientific exchange continues to be shaped by a common language, and 'free' physical and new electronic movements.

A new shared language and 'free' movement continue to shape exchange

In parallel to medieval scholars who communicated in Latin, contemporary scientists still communicate in a common language – now English – that dominates scientific exchange. Scientists also retain (in great part) free movement that extends worldwide and features international collaborations for publication and enlistment in the role of referee. What is more, the rise of the Web[17] in the late 1980s has nurtured mutations in contemporary scientific exchange practices where scientific actors can more easily exchange electronic knowledge with scientific and non-scientific actors worldwide (Gaudet, 2014b). In conclusion, I give an overview of historical theoretical insights and implications from the insights.

Conclusion

The main goal of the paper was to construct journal peer review as a scientific object of study based on historical research into its shaping, going back to the twelfth century at the start of universities. Institutional actors shaping and being shaped by these social forms ranged from universities nascent in the twelfth century, the Church, the State/Crown, and later in the mid-seventeenth century, learned societies.

Of the social conditions, dynamics, processes, and contexts that (re)structured scientific exchange and boundary judgement, the emergence of inquisition in the Middle Ages, framed as a legal mechanism to combat heresy, was the first institutionally-led and single source of authority boundary judgement over scientific exchange as understood in this work. Review practices, however, were performed post-publication. Towards the end of the Middle Ages, the emerging context of print culture contributed to further mutations. Not only did it contribute to the eventual emergence of one of the most persistent forms of boundary judgement in the mid-seventeenth century, journal peer review, it also contributed to a critical mutation in scientific exchange. Not long after the rise of print culture, exchange became *contingent* on boundary judgement (first on censorship and then on journal peer review) where boundary judgement was mostly performed before publication. In addition, the rise of experimental natural philosophy saw the emergence of a new accountability to empiricism in scientific exchange and review. This mutation was linked with dissolution of internal accountability to the Scholastic method and dissolution of accountability relations to religious texts and State prerogatives mostly in the nineteenth century.

There are at least three implications from the above theoretical historical insights. First, the social form of inquisition appears to have helped shape the notion of institutional enforcement of boundaries for scholars. The social relations among heretic

[17] The World Wide Web (Web) is part of the internet (a network that also includes services such as e-mail, texting, tweeting, and file sharing).

scholars, the Church, the state, and inquisitors thus offered scholars an opportunity to relinquish heretic knowledge, and to "return to the faith" (Hannam, 2010:84). In this way, scientific exchange practices were shaped by an institutionalized understanding of absolute knowledge.

Second, framed in historical analysis, the contingency of scientific exchange on journal peer review is not immutable or inevitable– it is rather a historically situated mutation in boundary judgement practices.

Finally, processes of power in the social forms of boundary judgement over scientific exchange appear to have reproduced the domination of a single source of authority over scientific knowledge to the exclusion of other ways of knowing.

To understand journal peer review as a historically situated object of study can hopefully contribute to further contemporary research. More importantly, however, it can contribute to better understanding contemporary dynamics in a broader historical landscape. In the second paper of this two-part series, I delve deeper into an analysis of structural properties for inquisition, censorship, and early journal peer review.

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