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How Schrödinger's Cat Became a Zombie: On the Epidemiology of Science-Based Representations in Popular and Religious Contexts

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Abstract:

Research on cultural transfers between science and religion has not paid enough attention to popular science. This article develops models that grasp the complexities of the epidemiology of science-based representations in non-scientific contexts by combining tools from the cognitive science of religion, the history, sociology, and philosophy of science, and the study of new religious movements. The popularization of science is conceptualized as a process of cognitive optimization, which starts with the communication efforts of scientists in science-internal forums and accelerates in popular science. The popularization process narrows the range of scientific representations that reach the public domain in structured ways: it attracts minimally counterintuitive representations, minimizes the massively counterintuitive, and re-represents (or translates) hard-to-process concepts in inferentially rich metaphors. This filtered sample trigger new processes of meaning-making as they are picked up and re-embedded in new cultural contexts.

Keywords: popular science; religion and science; epidemiology of representations; cognitive optimization; thought experiments; cultic milieu.

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Introduction

Despite their reputation for opposition, religions are often deeply fascinated by science (Hammer and Lewis eds. 2010; von Stuckrad 2014). This is especially the case with new religious movements (NRMs) and entrepreneurs in the "cultic milieu" (Campbell 1972), who often draw upon scientific representations and scientific-sounding nomenclature in their quest for legitimation (Hammer 2001). We see this both in the loosely organized publishing networks associated with the "New Age" (Hanegraaff 1996) and in a host of institutionalized NRMs, from Theosophy and Christian Science to Scientology and Aum Shinrikio. The interest in science is, however, deeply selective: scientific themes referenced in New Age literature constitute a very limited subset of the full range of issues treated in the scientific literature. There is much talk about quantum mechanics and string theory, considerably less about behavioral economics. Moreover, scientific representations are rendered in ways that tend to diverge from those in peer-reviewed journals.

These observations may appear obvious at first sight, but they conceal a worthy and little studied intellectual problem: how do we account for the selectivity, and how do we explain the variations across cultural domains? Much of the religious studies scholarship on science in NRMs has evaded these problems by focusing on processes of legitimization and strategic appropriation of scientific ideas (see review in Asprem 2015; cf. Hammer and Lewis eds. 2010).

These critical approaches are no doubt important, but they leave an explanatory gap that can only be covered by a much broader interdisciplinary approach.

The present article outlines a new interdisciplinary framework. I begin by arguing that the *popularization* of science constitutes a missing link in studies of religion and science. Important insights can be gained from studying the translation processes that link the activity of scientists in laboratories with the publication of research results and the popularization of those results to a broader audience. I draw on tools from the cognitive science of religion (CSR), the sociology of science and the study of NRMs in order to theorize these translation processes. Embedding the communication of science in a broader epidemiology of cultural representations (Sperber 1996) is central to this undertaking, and allows us to build bridges between the study of religion, the study of science, and the study of popular culture. This particular interest in epidemiology leads me to focus primarily on how popular science mediates between professional science and the relatively unorganized networks associated with the cultic milieu. I shall have less to say about the uses of science in full-blown, institutionalized NRMs. I will, however, suggest that the model introduced here produces specific predictions about the range of scientific representations that can be found in established NRMs, and conclude the article with a series of proposals for future research to test them.

The first part of the article takes Robert McCauley's (2011) recent comparison of science and religion on cognitive terms as a starting point for engaging with relevant CSR tools. Highlighting some problematic shortcomings, I proceed to show how we can break open McCauley's model in order to think about more dynamic processes of translation from "professional" to "popular" science, which involve activating inference systems that are at odds with those utilized in the original scientific process. This part of the argument draws on conceptual blending theory to demonstrate how the normal communication of science by scientists already shapes science-based representations in ways that invite "representational incorrectness". In the second part, I move on to suggest a model for the transmission and mutation of scientific representations from scientific institutions to other socio-cultural formations (religion, spirituality, esotericism), funneled through a representationally narrower popular science domain. This "mirror funnel model" suggests that popularization can be understood as a process of *cognitive optimization* that attracts particularly attention-grabbing and inferentially rich representations.

In the final part I illustrate the mirror funnel model by way of a specific historical case study: the popularization of problems in quantum mechanics through the "Schrödinger's cat" thought experiment. Thought experiments are an integral part of scientific communication, but also a starting-point for popular dissemination; unpacking this point I aim to show how we can map the generation, transmission, transformation and reinterpretation of science-based representations through distinct morphological stages where different social, cultural, and cognitive factors come into play. The model allows us to map the processes of transmission in six distinct stages, affording specific predictions about the distribution of differently shaped science-based representations along the way.

I. Natural Religion, Unnatural Science? On the Processing of Popular Science

A. Some Shortcomings in McCauley's Comparison of Religion and Science

In *Why Religion Is Natural and Science Is Not* (2011), Robert McCauley borrows from evolutionary and developmental psychology in order to encourage a new style of comparison of "science" and "religion". The result is a set of contrasts summed up in a fourfold table (Figure 1), produced by two sets of distinctions based on influential models of information processing and folk-explanations. McCauley's classification is entirely in keeping with the CSR "standard model". The first distinction is borrowed from dual processing theories of cognition, and separates quick, intuitive, "System 1"-type processing from slow, reflective, "System 2"-type processing (e.g. Kahneman 2011; cf. Oviedo 2013). McCauley renames the first system "natural" and the second "unnatural", and continues to subdivide the natural into a "practiced" and a "maturational" type: Some quick processing is based on cognitive modules that all normally functioning humans, irrespective of culture or schooling, develop through childhood (e.g., speech, face recognition), whereas other forms may *become* quick through costly learning efforts (e.g. reading, arithmetic). This latter sort of "second nature" is of lesser interest to McCauley, who focuses exclusively on the former, maturational naturalness in his discussion of religion.

McCauley' second distinction is between agent- and cause explanations (McCauley 2011: 230-237), where one draws on the inferences of intuitive physics and the other on those of intuitive psychology. This distinction builds on CSR's long-standing interest in theorizing "god concepts" in terms of Theory of Mind (ToM) and the Hyperactive Agent Detection Device (HADD). In line with much of CSR, then, a profusion of agent explanations marks the religious domain, while the scientific domain – both "professional" (reflective) and "folk" (quick processing) – tends toward cause explanations.

	Agency explanations	**Cause explanations**
Slow processing (reflective)	THEOLOGY	SCIENCE
Quick processing (intuitive)	POPULAR RELIGION	COMMONSENSE EXPLANATIONS

Figure 1: McCauley's typology (2011: 231).

Professional science and theology come out as cognitively similar in this comparison, as they both rely on cumbersome reflective processing, while a diametric contrast emerges between professional science and popular religion. It is this contrast that McCauley focuses on in his book. "Religion," to him, means *popular* religion, whereas "science" refers strictly to *professional* science.

McCauley's typology and the comparisons it invites have already attracted criticism (e.g. Cho 2013; Talmont-Kalminski 2013; cf. Xygalatas 2013; McCauley 2013).[1] I will only expand on a couple of relevant points. First, construing the

[1] See the review symposium in *Religion, Brain and Behavior* vol. 3, no. 2 (2013), and the upcoming symposium in *Zygon* (2015).

crucial difference between theologies and sciences in terms of the agency/causality distinction is much too simple. Historically, theologies have not been too fond of "unrestricted agent explanations"; we need only think of Weber's thesis that processes of rationalization and disenchantment – that is, of ridding the world of "mysterious and incalculable powers" – began as *theological* process that restricted the agency of "magical" powers while emphasizing increasingly transcendent conceptions of the divine (Weber 1917; cf. Asprem 2014b). The reflective theorizing of theology has historically been associated with a gradual, though seldom complete, restriction of agency explanations, rather than an "unrestrictive" attribution of agency. Similarly, the history of modern science can easily be construed as moving towards fewer agent explanations (just like theology can), but that process has never been completed, and perhaps for good (cognitive) reasons. The restriction of agent explanations has frequently been interrupted by phases of opposition – such as in the multiple revivals of vitalistic theories of life, teleological understandings of evolution, or the opposition to behaviorism in psychology (cf. Asprem 2014b). But we should also take seriously the continued emphasis on methodological individualism (e.g. Schumpeter 1908; Elster 1982) in the social sciences, which *operationalizes* the intuitive assumption that people possess minds and act as intentional agents – hence reserving a place for folk-psychological agent explanations in the scientific explanatory scheme. Complicating the picture further, work on the cognitive mechanisms at play in scientific reasoning demonstrate that here, too, intuitive ontologies (De Cruz and De Smedt 2007), structured imagination (De Cruz and De Smedt 2010) and other evolved, "maturationally natural" cognitive biases and heuristics (De Cruz and De Smedt 2012; Mercier and Heintz 2013; Rozenblit and

Keil 2002; Keil 2003) constrain scientific creativity. There is even some compelling evidence that heuristics for discovery tend to determine the shape of scientific theories (Gigerenzer 1991). On this view, scientific reasoning may be "heuristics all the way up" (Wimsatt 2007: 11; cf. Gigerenzer 2010).

Theorizing the articulation, communication, understanding and use of science *outside* the institutionalized reflective context of laboratories and peer-review will require us to redirect the tools that McCauley uses and amend them with sociological considerations on the one hand, and additional cognitive ones on the other. Borrowing a distinction from the sociology of science (Collins and Pinch 1979), a focus on science in its "constitutive forums" (theorizing, experiments, peer-review) should be accompanied by an analysis of the important negotiations and articulations of science that take place in "contingent forums" (conferences, journalism, popular lectures, interviews, correspondence). This is in line with Sperberian epidemiology, which emphasizes the role of ecological cultural factors in explaining different representational attractor positions (Sperber 1996: 84-85, 113-118). By neglecting contingent networks in general and popular science in particular, previous research has missed an opportunity at predicting which scientific representations will be most successfully communicated from one domain to another, what sort of conceptual mutations will tend to occur in the process, and why.

B. From Typology to Dynamic Model of Translation: An Attempted Adjustment

McCauley's framework can be altered to better accommodate the dynamic processes of cultural production. If we break open the typology and instead conceive of it as a field that is bounded by an *intuitive/reflective processing* axis and an *agency/no-agency* axis, we are better equipped to map out the complex relations that obtain within and between different knowledge domains. Doing this, we can identify a dynamic popular science-system at work behind the overly polished types of McCauley's framework (Figure 2).

The popular science system consists of a "professional science" *input space* (reflective processing, no agency), two *translation spaces* in the intuitive processing spectrum – one in the domain of intuitive psychology (agency explanations), the other in intuitive physics (cause explanations) – and a popular science "blended space". The blended space is produced by *translating* input-science into natural language, rendering concepts linguistically effective through metaphor, allegory, and conceptual adjustments that create a better fit with what McCauley would call maturationally natural inference systems.[2] These correspond to the default intuitive inferences belonging to basic-level categories such as ontological domains (see e.g. Boyer 2001).

[2] The association to standard conceptual blending diagrams is merely suggestive: The input-, translation- and blended spaces in Figure 2 should not be confused with the basic mental spaces involved in the processes of conceptual blending on the individual level. The level of analysis here is much less basic than that of Fauconnier and Turner (2002).

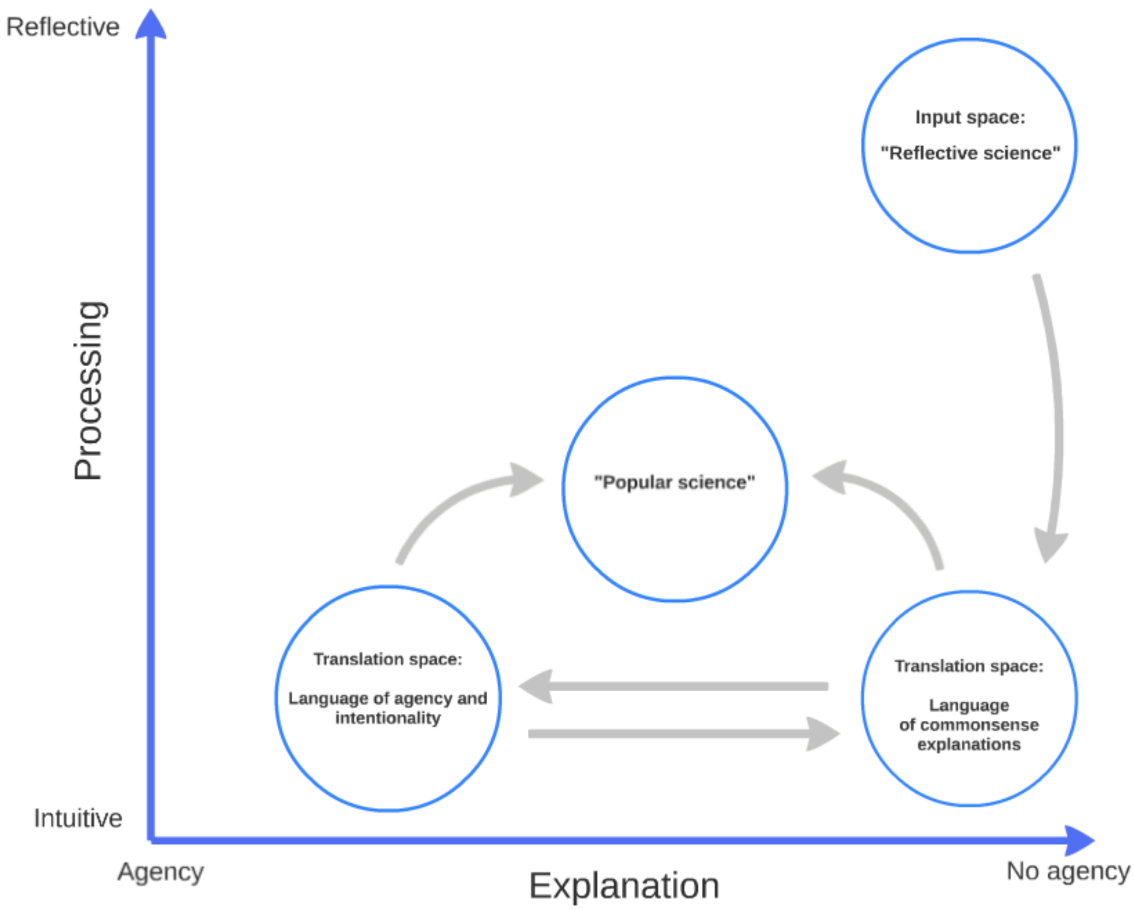

Figure 2: Popular Science as a Translation System

The input could be any hard-to-process, non-agency based product of professional science. The translation spaces come into effect whenever this science is being communicated – not only in the popular or contingent forums, but in constitutive ones as well. To illustrate the process by way of an example, we can consider the popularization of gene-centered theories of evolution – i.e., theories that see "genes", however defined (Wieben 2003), as the unit of selection in evolution (e.g. Williams 1966; Dawkins 1976). These are not only difficult-to-process theories that require the understanding of molecular biology, selection pressures and adaptation in complex environments – they also illustrate McCauley's science type in that they develop a complexity of microlevel cause explanations in a field where we are particularly prone to agent explanations. Contrary to how it seems to us, it is not *intentional agents* that are at work in evolution (i.e., organisms capable of intentional action), but rather the complex mechanical interplay of regions of genomic sequence in DNA and RNA molecules.

The first step in popularizing the theory is to *translate* the science into everyday language, using metaphors that exploit intuitive inference systems. This, however, means that the constraints of "folk science" will determine the level of complexity and the depiction of causal chains in the translation. As work in the "cognitive science of science" (Thagard 2012) has shown, we tend to prefer some forms of causal explanations to others (cf. Rozenblit and Keil 2002; Keil 2003). The parsimonious notion of "one cause, many effects" appears particularly good to think with, while "interdependent causes, one effect" appear particularly hard to grasp. A predictable effect of popularization, then, is that multi-causal scientific theories are reduced to much simpler *monocausal* renderings – typically skipping all the explanatory mechanisms that bind causes together and creating representations that stress one initial cause leading to specified outcomes (cf. Keil 2003: 369-370). Thus, the complex theory of gene-centered evolution becomes genetic "folk determinism" on the popular level: Genes cause behaviors, and behaviors determine how long we live and how successfully we reproduce. If a person, or even a group, tends to do some particular task well or something else poorly, there is probably "a gene for it". All the original concerns of the theory, including the complexities in the definition of a "gene" to begin with,[3] the additional complexities of selection and adaptation to environments, the intricacies of epigenetics and so on are lost in translation.

Translation in terms of simpler – but essentially chimerical – causal chains might suffice for much popular science, but an additional translation is also commonly found. Conceptual blending with the domain of intuitive psychology enables mechanistic concepts to be rendered, by an operation of analogy, in the language of *intentionality*. Doing so may appear innocent enough at first glance, but the crucial point here is that the use of intentional language immediately activates intuitive inferences concerning mental states and goal-directed behavior. This is precisely why they are so effective for popularization – assuming, with Boyer (2001), that the activation of intuitive inference systems (e.g. psychological, physical, biological) makes a representation particularly salient and memorable, supporting relatively high-fidelity replication.

Blending the gene-centered view of evolution in metaphors involving intentional action allows popularizers to talk about "selfish genes," driving evolution because they "want" to replicate. Richard Dawkins was responsible for releasing this epidemiologically successful representation on the literate public. He has always insisted adamantly that it is *nothing more* than a metaphor, designed to form a clearer mental picture of the gene-centered view. It is not an actual attribution of psychological properties to molecular-level entities – or a

[3] Researchers in molecular biology have had to make do with heuristic working definitions in order to cover all the interrelated mechanisms involved with inheritance. One commonly cited definition sees a gene as a "locatable region of genomic sequence, corresponding to a unit of inheritance, which is associated with regulatory regions, transcribed regions and/or other functional sequence regions" (Pearson 2006: 401). Note the use of plurals and conjunctions.

reduction of psychological properties to molecular realities – and he trusts his readers to see the difference (e.g. Dawkins 2006 [1976]: 89, 123, 132, 196). Nevertheless, Dawkins opened a can of worms. The metaphor invites readers to process the science in ways that are antithetical to its theoretical content. This is a crucial paradox for science communicators in general. Popular science, together with the heuristics used to teach science to students and non-scientists, encourages people to think *intuitively* rather than *reflectively* about science. In doing so, they will frequently mix up and blend inferences across ontological domains and take shortcuts reverting to the relatively simple causal interactions of "folk physics". Paralleling one of McCauley's "surprising conclusions" about religion (2011: 237-244), then, *scientific incorrectness is inevitable*.

II. The Popularization of Science as Cognitive Optimization

A. Cognitive Optimization

McCauley's "popular religion" is equivalent to what other scholars have called *cognitively optimal* religiosity (Whitehouse 2004: 29-47; Hammer 2013; cf. McCauley 2011: 145-221). The notion that some representations are optimally calibrated for salience and memorability, and hence more likely to be communicated and reproduce across minds, has been central to research on the epidemiology of religious concepts (Sperber 1996; Barrett 2000; Boyer 2001). Thus, Harvey Whitehouse (2004) distinguishes between cognitively optimal and cognitively costly religion, arguing that the standard epidemiological approach only covers the first of these two. Most historical and contemporary religions, however, also involve costly representations that need elaborate social formations to survive. The transmission of these representations through institutionalized practices that mobilize semantic and episodic memory systems in diverging ways gives rise to Whitehouse's "imagistic" and "doctrinal" modes of religiosity (Whitehouse 2004; cf. Whitehouse and Martin eds. 2004).

None of the cognitive processes that determine the optimality of religious representations are *specific* to the religious domain – they are generic and apply to all of culture. To the extent that popular scientific notions are successfully transmitted in a population, we should expect these to likewise converge on a cognitive optimum. Since professional science, like much of institutionalized religious doctrine, is cognitively costly and awkward, the popularization of science must involve a process of *cognitive optimization*. This process selects and shapes scientific concepts in specific ways, making them salient and memorable in ways comparable to popular religious concepts.

The elements of the cognitive optimization of cultural representations have been studied meticulously in CSR, and the effects observed in that context are transferable to the transmission of popular-scientific concepts. This point leads me to propose two interconnected theses about the transmission of professional science into popular science: it (1) tends to generate science-based MCI concepts, and (2) introduces scientific incorrectness. Together, these steps prepare the ground for further adoptions and adaptations of the representations in new, non-scientific contexts.

B. A Note on Minimal Counterintuitiveness (MCI)

As part of an explanation for the epidemiology of cultural concepts, Boyer (2001: 51-92) proposed that the degree to witch a representation or concept breaks with intuitive domain-specific inferences ("ontological intuitions") is significant for determining how attention-grabbing and memorable it is and therefore how successfully it will be reproduced. In addition, Boyer theorized that the *inferential potential* of the resulting MCI concept would be relevant for its cultural success: fit concepts "produce the richest set of inferences with the least cognitive effort" (Boyer 2001: 164). The MCI theory has generated a steady stream of research. However, recent results suggest that the role of MCI concepts is more complex than first thought (Barrett 2013). Coding and quantification of real-life (and hence naturalistically successful) narratives encoded in folktales (e.g. Barrett, Burdett, and Porter, 2009) *supports* the predictions of Boyer's original MCI theory, but experimental findings produced in controlled laboratory conditions are much more ambiguous (e.g. Gregory and Barrett 2009). This may suggest that it is the way MCIs get embedded in broader narrative structures that is the key factor for recall (suggestive computational evidence is now available in Stubbersfield and Tehrani 2013), or, in line with Boyer's initial theorizing, that the concept's inferential potential is more important than its counterintuitive qualities alone. The model of transmission of science-based MCI concepts that I will present here is designed to agree with Boyer's original focus on the inferential richness of concepts rather than MCI as a standalone factor.

C. Representational Incorrectness

"Theological incorrectness" is a robustly documented and predictable result of the optimization of cognitively costly theological representations in online reasoning (Slone 2004; Barrett and Keil 1996; Cohen 2007; Cohen and Barrett 2008a; Cohen and Barrett 2008b; cf. Boyer 2001: 283-285). However, we should remove the qualifier "theological" and talk about a generic *representational* *incorrectness*. This is a necessary step for being able to compare basic processes without confusing these with the complex cultural concepts that belong to the level of socio-cultural formations (cf. Taves 2015). Mutated renderings of scientific concepts belong to this generic category, along with similar effects from any other form of semantic system where some sort of "orthodoxy checks" are in place (cf. Whitehouse 2004: 65-70). Against this backdrop, popular science produces scientific incorrectness in exactly the same sense as popular religion produces theological incorrectness. It may do this by generating MCI concepts, either by simplifying the *massively* counterintuitive, or by transferring properties across domains by way of metaphors. Both features were illustrated in the case of the selfish gene.

III. Toward an Epidemiology of Science-Based Representations

A. Introducing the Mirror Funnel

So far, I have dealt with aspects of the cognitive optimization process involved with translating professional science into popular science. I have insinuated that these processes create affinities between popular science and popular religion, which may help us explain the preference for certain types of science-based representations in religious contexts. Popular science and popular religion, mobilizing the same cognitive mechanisms, tend to generate and/or attract similar types of representations. To get a full picture of the transmission, however, we need to correlate these cognitive factors with the socio-cultural infrastructure that allows representations to be articulated and distributed, from science's constitutive and contingent forums, through to the religious marketplace. The model presented in this section attempts to map the relation between these factors, providing a framework for "multilevel data mapping" (Paloutzian and Park, 2014: 58).

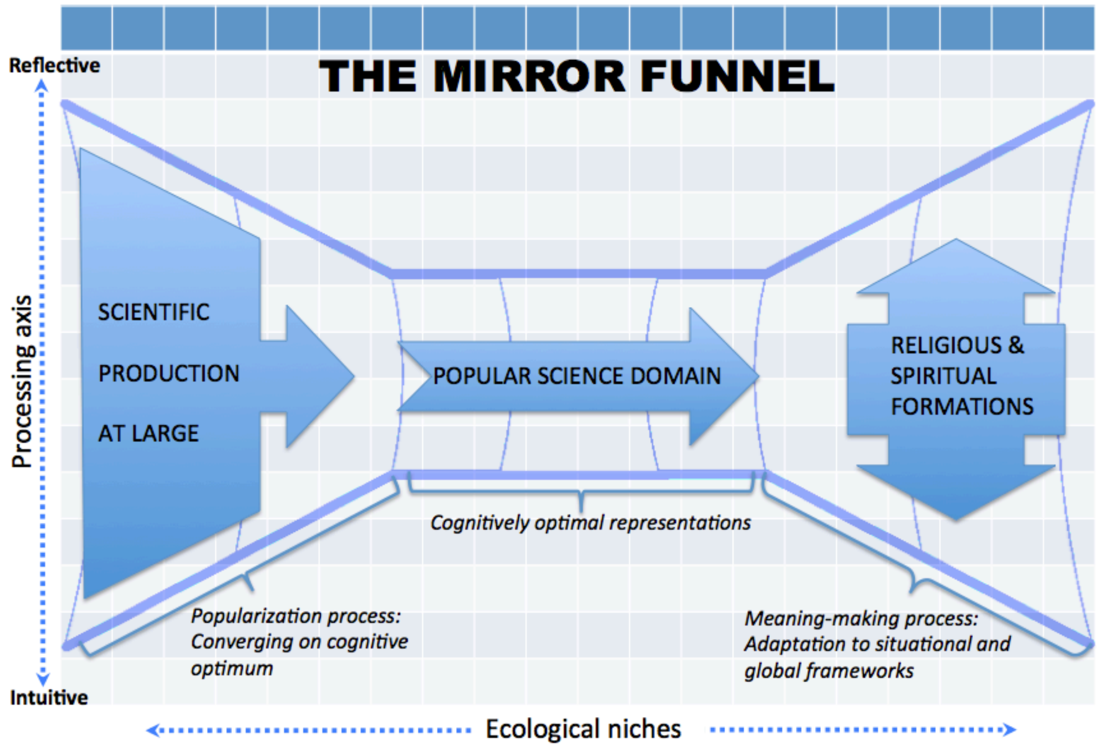

Figure 3: *The Mirror Funnel Model: Attractor Spaces for science-based representations along a processing axis (intuitive-reflective) and an ecological axis (scientific institutions-popular science-religious/spiritual formations).*

If we take the generalized framework of cognitive optimization as a starting point, we can model the transmission of representations from "science" to "religion" as two mirrored funnels connected by a narrow "popular science domain" (Figure 3). This should be understood as a map of *attractor spaces*. The vertical dimension represents cognitive processing constraints: the full span of trivial and intuitive to cognitively awkward and massively counterintuitive notions. The horizontal dimension represents *ecological niches* in the form of social formations, including institutions, distribution networks, and loosely connected milieus. The bottom "intuitive" end represents concepts that are spontaneously processed, while the top "reflective" represents hard-to-grasp, cognitively awkward concepts that require reflective reasoning. The cognitive optimum –especially as represented by high-salience, highly memorable MCI concepts, occupy the middle region of the cognitively optimal.

The mirrored funnel suggests that both the scientific and the religious ecological niches allow for a broad variety of concepts that span the entire processing range. Catholic doctrine on the Trinity and special relativity's account of time dilation are both more complicated than optimal, but considered in their totality, Christian theology and modern physics equally depend on a vast repository of much more intuitive representations. As the physicist Arthur Eddington once quipped, to suppose that religion is mainly about extraordinary and "mystical" phenomena "is like supposing that Einstein's theory is mainly concerned with the perihelion of Mercury and a few other exceptional observations" (Eddington, 1928: 340). In their day-to-day workings they encompass much more basic concerns that go unnoticed precisely because they are trivial. The simpler representations may in many cases even be more important to practitioners than the complex ones. A scientific paper might, for example, garner citations because of a lucid (but boring) description of an experimental design rather than for its surprising outcome, or the intuition-shattering theory that explains it.

The editorial constraints on successful popularization are different from those of peer-reviewed journals. Popularization caters to a broad audience, and must seek a balance of high salience and quick comprehension in order to win shares in a competitive market. As a result, popular science tends to center on a small segment of the total store of scientific concepts produced by the world's research communities. It attracts material that *already* involves attention-grabbing and memorable MCI concepts, while the more difficult concepts tend to undergo mutations that converge on the cognitive optimum. Popular science thus functions as a filter that both pre-selects and molds representations before they get distributed to new audiences. It *selects* minimally counterintuitive representations, it *minimizes* the massively counterintuitive, and it *re-represents* (or translates) hard-to-process concepts in inferentially rich, intuitive metaphors that are better to think with. The result is a cognitively narrow attractor space.

Representations that have gone through this optimization process will get more exposure and are thus more likely to get picked up and re-embedded in new contexts. However, the transmission from popular science to other cultural domains is not merely a *receptive* process. Once they come to the attention of people situated in a different cultural niche, the optimized science concept fuels active meaning-making processes through which it come to take on yet new shapes and meanings. Communication is not simply a process of coding and uncoding information capsules, but a process in which we activate each others' inferential capacities (Wilson and Sperber 1986; cf. Sperber 1996: 82-83). We don't transfer information as much as incite mimesis. Attractive inferences are largely determined by pragmatic criteria of *relevance*, provided by the context of the communicating parties rather than by strictly semantic relations (Wilson and

Sperber 1986: 118-170). Thus, when the context changes, people are able to draw different inferences from a representation, stopping the interpretive process as soon as local criteria of relevance have been met.

We can distinguish two stages of this process by drawing on the distinction between "situational" and "global" meaning-making in the social psychology of religion (Paloutzian and Park 2013b; Paloutzian and Park 2014; cf. Park 2010). Closest to the popular science domain are the "situational" inferences that people make by calling upon the science-based MCI to make up meanings on the fly. Examples might include casual references to "quantum entanglement" as explanation of a subjectively meaningful coincidence – or to brain lateralization when need arises to explain (away) a critical conversation partner's "narrow-mindedness". (The latter is an excellent example of a science-based MCI with rich inferential potential that has long outlived its scientific credentials). Beyond situational meaning-making, science-based MCI representations may mutate further as they get embedded in "global" webs of meaning. Mirroring McCauley's "reflective processing", these global "meanings made" tend to increase the complexity of representations by embedding them in written texts and doctrinal systems, creating increasingly abstruse theologies and esoteric cosmologies.

B. Six Morphological Stages

The mirror funnel allows us to distinguish six stages in the epidemiology of science-based representations from scientific to religious contexts. The key process of each stage is listed below, together with the social environmental niche in which it takes place:

(1) Formation of hard-to-process, reflective scientific content (science-internal articulation);

(2) MCI-concept formation in constitutive forum (science-internal communication);

(3) Theoretical disembedding of MCI-concept in contingent forum (science-external communication);

(4) Dissemination of MCI-concept (communication in popular culture, social media, private networks);

(5) Casual re-embedding of MCI-concept in situational meaning-making (e.g., in the "cultic milieu");

(6) Theoretical re-embedding of MCI-concept in global meaning-making (New Age science literature, institutionalized NRMs, natural theologies).

These are *not* to be viewed as *developmental* stages that every science-based representation must go through, but rather as *morphological* stages that link formal properties with both the social and the cognitive contexts that tend to produce them. In a developmental sense, the shortest route from (1) to (6) is a straight line that does not stop at any of the points (2) to (5). Such cases are not hard to come by: the history of science knows numerous examples of scientists who have immediately seen their work (or the work of their colleagues) as profoundly meaningful in terms of emerging situational or global meanings or theological meanings already made (for discussion of examples, see e.g. Asprem 2014b, 2015; Bowler 2001, 2009).

The vast majority of people will, however, encounter the science in morphological stage (3) or (4). From there, different interests may take people in various directions – they may search out the more complex science behind the catchy metaphor, or seek the "hidden meanings" revealed in esoteric interpretations on the bookshelf marked "Science & Spirituality". Individuals may explore the continuum in either direction; however, the processes that shape and disseminate the representations to begin with are largely unidirectional. Their formation begins in science-internal activities and intra-scientific communication networks. Once they have spread to the general public and taken on novel meanings, these new meanings and inferences are unlikely to get reintegrated with the original scientific concept in constitutive forums pertinent to the originating discipline.

This is not to say that conceptual transfer from popular science back to professional science is impossible, but when it happens, it is typically to *other disciplines* than the one in which the concept originated. A representation from professional physics may be routed through the popular science domain before getting absorbed in a professional social science forum, allowing new inferences in that context. Some humanists have, regrettably, earned themselves a bad reputation for citing scientifically incorrect versions of quantum theory, and absorbed grossly simplified (but cognitively optimized) neuroscience to aid their own speculative theorizing. The epidemiological process involved in such cases is identical to what we see in transfers to non-academic domains, including religious ones.

C. Advantages of the Model

The mirror funnel has three advantages over existing attempts to account for science-based representations in religious contexts. First, it is a *dynamic* model that seeks to explain and map continuously ongoing processes of cultural transmission and innovation. It does not identify "science" or "religion" with a specific type of processing, but looks at dynamic transfers between cultural domains. The basic processes that produce these transfers are generic, and not limited to these specific domains. Secondly, the model is *symmetrical.* It postulates a continuum between scientific and religious meaning making, and characterizes the flow between them in terms of a shared set of cognitive mechanisms. This allows us to make important observations. For example, we see that the use of science in religious contexts is not simply the product of shameless "appropriation" of expert knowledge by non-scientists, but rather the result of a gradual transmission process that *includes* scientific actors in important steps along the way. The optimization process starts with the communication and translation strategies of scientists, whether to their colleagues, to journalists, or directly to the general public. Thirdly, the model affords ways of integrating cognitive perspectives with social and cultural ones. We can for instance map specific *genres* (peer-reviewed article, popular essay, New Age literature), *institutions* (universities, research institutes, publishers, NRMs), and dissemination strategies (to specialists, general audience, targeted interest groups). This makes it possible to uncover representational attractor positions and correlate them with genres, institutions and cognitive constraints. We can best demonstrate how these three advantages work together by way of a historical case study of scientific concept-formation and transmission into religious contexts.

IV. Thought Experiments and the Making of Science-Based MCI Concepts: The Case of Schrödinger's Cat

We start on the input side with something as complicated and confusing as the problems in quantum mechanics in the interwar period. As physicist James Jeans expressed it in 1933, "the history of physical science in the twentieth century is one of a progressive emancipation from the purely human angle of vision" (Jeans 1933: 5). The exceedingly "counterintuitive" nature of fundamental physics in the early twentieth century sparked a worry that physics was losing what the Germans called its *Anschaulichkeit*: the "visualizability" or "intuitiveness" of science was rapidly corroding (Forman 1971; cf. Asprem 2014b: 100-149).

While the new physical concepts of the era were frequently described as ”counterintuitive”, the casual use of this term is not to be confused with the technical use in CSR. Following Boyer (2001: 65), the technical term could more properly be named ”counterontological” as it deals specifically with breaches and transfers between intuitive ontological domains. Modern science is "counterintuitive" in a more colloquial sense; however, I suggest that this sense also *includes* the counterontological dimension through an emphasis on representations of the world that are alien from everyday embodied experience. Space can be curved, time is a geometrical property, particles may also be waves and in several places at once. These are not only contradictions of Newtonian mechanics, but breaches with the inferential expectations of *intuitive* physics as well. The colloquial use of "counterintuitive" in the context of modern science also stands for the increasing cognitive awkwardness of scientific inferences, brought on by more advanced experimental designs, increased reliance on instrumentation, and (especially) the centrality of statistical and mathematical methods that humans find particularly hard to grasp. This is precisely the sort of awkwardness that McCauley calls the cognitive unnaturalness of science.

The scientific representations that enter as input to the mirror funnel are massively counterintuitive in both of these senses. The emergence of the Copenhagen interpretation of quantum mechanics in the 1920s and 1930s was ripe with paradoxes and confusing problems that apparently could not be grasped through intuitive categories, but instead had to be spelled out in advanced mathematical and statistical models. However, the swift and effective communication of ideas with colleagues required that the scientific conceptual content be translated from mathematics into natural language. Some degree of cognitive optimization of concepts is necessary in order for a scientist to raise points about specific aspects of a theory, whether the aim is to criticize an opponent or enlist a colleague. Optimization starts with the professional communication between scientists.

A particularly rich insight into this process is gained by looking at the use of *thought experiments*. Thought experiments are commonly accepted as an important part of research in both philosophy and the natural sciences, and there is a rich literature on their historical development and epistemological status (see overview in Brown and Fehige 2011). Karl Popper proposed an influential typology of thought experiments based on their different argumentative functions, distinguishing between "critical", "heuristic" and "apologetic" types. Critical experiments are designed to reveal logical inconsistencies or contradictions in a theory; heuristic ones aim merely to illustrate a theory, while the apologetic attempts to vindicate it (Popper 2002).

In Popper's view, the critical type is an indispensable part of scientific reasoning, while the heuristic type is useful for communication purposes or for clarifying conceptual relationships. The apologetic type, however, adds nothing of scientific value.

Thought experiments work by singling out specific problems and translating them into metaphors that activate intuitive inference systems. They reduce cognitive awkwardness to manageable levels, enabling more efficient communication. But they may also create minimally counterintuitive scenarios in order to point out specific features of a theory. The creation of MCI representations is especially common in the type of thought experiments aimed *against* a theory: deriving a breach with ontological categories from the implications of a theory can function as a powerful *reductio ad absurdum* argument.

Erwin Schrödinger's famous cat experiment is an illustrative example of this. The experiment was first published in a science-internal constitutive forum in 1935 (*Die Naturwissenschaften*), and was thus part of professional communication rather than popularization. The experiment involves a diabolical contraption where a cat is locked into a steel box together with a Geiger counter, some unstable radioactive material, and a hammer that will break a glass tube containing prussic acid whenever the radioactive material decays and releases an alpha particle. The life of the cat is thus dependent on the state of an unstable atom. Since the decay of radioactive materials is an inherently indeterminate process that can only be described probabilistically, the state of the cat itself remains unknown to those outside the box. The Copenhagen interpretation held a particularly radical view on the metaphysics of this experimental situation:

both outcomes (alpha decay having happened [=dead cat] or not happened [=living cat]) are equally (un)real until the time of measurement. As Schrödinger put it, the Copenhagen physicists have "the living and dead cat (pardon the expression) mixed or smeared out in equal parts" until researchers break the suspense by opening the box (Schrödinger 1935: 812).

The experiment is of Popper's "critical" type. Schrödinger was *not* demonstrating how to turn cats into zombies (or "smearing them out through space"), but rather showing that the Copenhagen interpretation entails intolerable absurdities and must be rejected. To make its point, the thought experiment takes the basic physics as understood at the time, and invents a scenario where the key properties of the theory are illustrated in terms of intuitive, everyday-life categories. As the experiment unfolds, it becomes clear that the intuitive categories break down in a contradictory manner, a contradiction that is effectively encoded in the emblematic counterintuitive image of a cat simultaneously dead and alive. It is precisely the introduction of a living being to the experiment, triggering intuitive inferences about biology, that makes the contradictions in this thought experiment (a cat dead and alive) more salient than the breach of intuitive physics already implicit in the theory itself (a particle being in multiple states at once). In short, cats are better to think with than particles.

While thought experiments make science simpler and easier to process, they remain connected to complicated philosophical problems that involve densely reflective forms of reasoning. Things change, however, when the thought experiment enters the domain of popular science proper. In the popularization of thought experiments, complicated logical features tend to be simplified as they conform to optimal cognitive heuristics. The basic *description* of the thought experiment as an *event* may be faithfully reproduced, but the original philosophical context and argumentative structure through which it was understood gets replaced or distorted. At this stage, we are left with a *theoretically disembedded* MCI concept (a dead-and-alive cat in a box), which captures the attention of readers, but also tends to introduce scientific incorrectness. Here is an example from physicist John Gribbin, who wrote a best-selling popular science book on quantum physics in the 1980s:

> quantum mechanics says … that nothing is real and that we cannot say anything about what things are doing when we are not looking at them. Schrödinger's mythical cat was invoked to make the differences between the quantum world and the everyday world clear. (Gribbin 1984: 2).

Gribbin's rendering is illustrative of the optimization process. While it is true that the experiment emphasized the conflict between "the quantum world" and the everyday (intuitive) world, this contrast was certainly *not* made to illustrate that "nothing is real" or that existence is produced by perception – both of which are metaphysical claims quite distant even from the positivistic instrumentalism of the Copenhagen physicists (cf. Brush 1980; Beller 1999). These are, however, easy inferences to make from the disembedded image of the cat, especially if a philosophical bias in the direction of subjective idealism or anti-realism is already present. The MCI properties of the representation are thus successfully transferred, while the *use* of the thought experiment shifts from Popper's "critical" to the simpler "heuristic" or illustrative type. Schrödinger's poor cat has gone from servicing a pedantic point about problems in the Copenhagen interpretation, to becoming a catchy emblem for "weird new science".

At every step of the way, it is *scientists* who have been responsible for forging this emblem by compressing difficult concepts for ease of communication. First, a piece of hard-to-process science was optimized for communication in a *constitutive forum* (i.e. from scientist to scientists) by way of a thought experiment that created an MCI concept. Second, the MCI concept was communicated in a *contingent forum* (from scientist to general public), with new, cognitively simpler meanings. Already at this second stage, before non-scientists have done anything with the representation, the science-based MCI starts becoming *theoretically disembedded* from the conceptual structures of the context in which it was first produced, and deployed in the service of different aims.[4]

What, then, happens at the output end of the mirror funnel? New meaning-making processes begin the moment that consumers of popular science start engaging with the representations, processing science-based MCIs in light of the criteria of relevance determined by their situational needs. On the most basic end, entertainment may constitute such a need. Indeed, a particularly common form of transmission of Schrödinger's cat is precisely through "shares" and "likes" in social media, as the representation generates humorous memes on

[4] The processes of "theoretical disembedding" of a scientific representation is offered in analogy to *cultural* disembedding as described in sociological terms by Anthony Giddens (1990: 21-27). The framework of dis- and re-embedding is a useful alternative to the misleadingly simple language of "appropriation".

the Internet. At this point the cat has fully entered the cultural repository as an MCI agent. It inhabits the same cognitive-cultural space as other popular creatures of the living dead – zombies, vampires, and nazghul included.

The counterintuitive cat tells the non-specialist audience that quantum mechanics is really, really weird – but what does that *mean*? Taking one step up from the level of entertainment and situational meaning-making towards the level of *global* meaning-making, the MCI concept tends to get classified and connected with other "weird things" – from telepathy and reincarnation to channeling, parallel universes, and mind-over-matter. An excellent illustration of this stage is the *What the bleep do we know* series of "documentaries", which revels in the weirdness of quantum mysticism, mediumship, parapsychology, New Thought and New Age ideas (cf. Stenger 2009). These weird things, I suggest, are a subclass of what Sperber calls "relevant mysteries": half-understood, paradoxical representations that are stored in meta-representations as "mysteries" in order to keep them consistent with other representations with which they would otherwise conflict (Sperber 1996: 73-74). Mysteries are *relevant* when they are closely enough related to other representations that are frequently evoked, while at the same time remaining baffling so that no final interpretation can ever be given. When science based MCI representations become the object of global meaning-making, they are also brought in contact with other "relevant mysteries", in an *affinity of the weird*: Thus, for example, two representations that both defy intuitive notions of space and time (e.g., paranormal communication and quantum mechanics) will be connected on the level of meta-representations for breaching in similar ways with basic intuitions. This linking of mysteries also appears related to the question of how science is used to *legitimate* unconventional beliefs. The science-based representation (unlike the paranormal one) is linked to the meta-representations that "scientists say this is true" and "scientists' opinions are valuable".[5] By linking a science-based relevant mystery to a paranormal relevant mystery, the air of authority that holds for the science-based representations may be partially transferred to the non-scientific representation.

An affinity of the weird is characteristic of the fluid and playful engagement with subversive knowledge-claims that is fundamental to what sociologists of religion call the "cultic milieu" (Campbell, 1972; cf. Kaplan and Lööw eds., 2002; Barkun, 2003; Partridge, 2004, 2005). A staple element of engagement with representations spreading in these subcultural reservoirs is that individuals pick and mix to serve specific, situational needs – one person may invoke quantum mechanics to explain an event attributed to telepathy, while another seeks to justify a belief in immortality. In either case, Schrödinger's counterintuitive cat can be a useful resource for weaving meanings across free-floating representations in the reservoir of "stigmatized knowledge" (cf. Barkun, 2003: 26-29). I suggest that an affinity between disembedded MCI concepts may provide the basis for a *positive* explanation of this important feature of the cultic milieu: It may be shared weirdness rather than shared stigmatization that is driving the process, fuelled by a linking of

[5] Admittedly, things are more complicated on the ground where entrepreneurs in the cultic milieu are known for sharing anti-establishment attitudes that *distrust* authorized expertise, while at the same time attempting to trade with the authority of science whenever it suits current interests. See Campbell, 1972; Barkun, 2003.

relevant mysteries. This can explain why we do not, after all, *only* see a trafficking with presumably "stigmatized" representations, such as alien abductions, telekinesis, conspiracy theories or spirit possession, but also representations (in mutated form, to be sure) that originate in authorized scientific discourses.

Eventually the science-based concept may be integrated with existing theologies, or entirely new theological formations may emerge around it. In the case of Schrödinger's cat, there exists an abundant literature on "quantum mysticism" in which this sort of meaning-making has been verbosely developed for decades (see Hanegraaff 1996: 62-76, 113-181; Hammer 2001: 271-302; Asprem 2014b: 259-278). The science-based MCI representation now leaves the cognitively optimal behind, as it is re-embedded in new and fixed conceptual structures – from Theosophy and parapsychology to Advaita Vedanta (e.g. Talbot 1991; Radin 2006; Goswami 1993).

In closing we should note that embedding a science-based MCI in a natural theology tends to increase cognitive awkwardness. The cognitive optimization process instigated by popular science only helps account for the limited *range of motifs* that occur in religious engagements with science; after selection, representations may beget a wealth of different interpretations and be employed for a great variety of purposes in their new contexts. These new complexities stem from the metaphysical, theological, and esoteric reflection elicited by the science-based MCI concepts, resulting in new global "meanings made".

V. Concluding Comments

To tackle cultural transfers between science and religion we need dynamic models that integrate parallel lines of research from different disciplines. Focusing on the role of popular science, I have presented two tools that may help us in this endeavor. The first tool (Figure 2), developed from McCauley's typology (Figure 1), served to show how we can conceptualize the move from "reflective science" to "popular science" as a translation system that connects up with existing literature on conceptual blending, intuitive ontologies and inferential potential. This process remains entirely on the cognitive level, and focuses on the process of popularization only. The second tool (Figure 3) allows for a broader vision. It places popular science in the context of the epidemiology of cultural representations, and views popularization in terms of cognitive optimization. This allows us to construct a culture-sensitive map of attractor positions along different cultural sites between the scientific and religious domains, taking into account the social and institutional factors that are related to shifting criteria of relevance (Wilson and Sperber 1986).

Finally, I wish to suggest that the rough model that emerges can be used to develop and test specific predictions. In closing I would like to propose four lines of research that might help us do so:

1) Future work should develop methods of coding popular science for counterintuitiveness in order to generate quantifiable data for testing predictions about the distribution of science-based MCI concepts. Models already exist in the CSR literature for proceeding with this task (e.g. Barrett 2008), the most promising being the procedure used for studying MCI concepts in narratives gathered from folktales (Barrett, Burdett, &

Porter 2009). Unique problems in identifying and coding for counterintuitiveness in popular science must be carefully scrutinized, along with considerations of appropriate data selection for this type of material. This work would best be carried out in consultation with sociologists of science.

2) An empirical pilot project should code and quantify science-based MCIs across different literatures. For example, we may establish datasets representing both constitutive and contingent forums. These can be used to develop correlations: are peer-reviewed papers that already feature MCI aspects in their titles, abstracts or press releases more likely to get turned into successful MCIs in the popular science domain? Is it scientists or journalists who are responsible for producing most successful science-based MCI concepts? This research would also contribute to the ongoing interest in editorial selection mechanisms *within* constitutive forums, linking MCI to measures of journal impact factor and other citation metrics.

3) Develop ways to code "New Age science" (NAS) literature for how scientific themes are introduced and developed, and compare with the other data sets. How broad is the range of scientific themes across the literature sample, compared to the range in a popular science sample, and a constitutive forum sample? Following to the mirror funnel we should expect to find popular science representations as a limited subset of constitutive forum representations, and NAS representations as a further limited subset of representations found in popular science. Furthermore, we should expect to see the range and complexity of meanings increase

and diverge in the NAS sample when compared with the popular science sample. This line of research could contribute significantly to the development of comparative methods in the study of contemporary religion and spirituality (Asprem, 2014a).

4) Extend the epidemiological approach to theorize better about the amorphous category of the cultic milieu and, empirically, use this to track the development of movements and ideas in and out of the milieu. In particular, scholars working on the sociology of contemporary religion could explore the usefulness of the mirror funnel in order to develop a more robust epidemiological framework for explaining the distribution of representations in the milieu beyond notions of "stigmatized" and "rejected knowledge".

Each of these steps constitutes a research project that would require a significant amount of work. I hope, however, that the framework outlined in this article illustrates how such efforts could contribute to a larger interdisciplinary research program with the promise of contributing not only to religious studies, but to other pressing concerns as well, such as the complex dynamics of cultural innovation and the public understanding of science.

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