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Bridging languages for the constructed realities of different scholarly domains

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Abstract The search for a single interdisciplinary language for science, philosophy and religious studies is doomed to failure. Rather than the coarse granularity of these three fields, we focus on scholarly *domains* and demonstrate that even translation between a pair of domain languages may be impossible. Each domain language must support description of observations and theory, and provide satisfaction criteria for results asserted within the domain. Crucially, interaction between domains is based on human interaction, whether directly or through documents or artefacts. Thus we explore the relation between the mind of the individual scholar and the emerging consensuses that define a domain. The framework is based on Hesse and Arbib's *The Construction of Reality* (CoR), extending a theory of "schemas in the head" to address the "social schemas" of a community. Members of a specific community -- such as a group of scholars within the same domain – may in some cases reach near agreement on the usage of terminology, but much scholarship is centered on disagreements, and these are magnified across different domains. Conversations between scholars in two domains requires a bridging language in which scholars may reach shared understandings of the terms each uses and thus reach shared conclusions, or agree to disagree. Developing bridging languages across domains of scholarly study may make new research questions arise and hence new domains of scholarly study may emerge – as exemplified by a case study bringing together linguistics, psychology, and neuroscience in the cognitive neuroscience of linguistics.

Keywords: Bridging Language, Conversation, Domain Language, Metaphorical Language, Philosophy of Science, Pragmatic Criterion, Satisfaction Criterion, Schema Theory, Social Schema

Invited paper.

1. Introduction

1.1 Conversing across domains to answer shared questions

The stated topic of this Special Issue of *Rivista Italiana di Filosofia del Linguaggio* is "The interdisciplinary language of science, philosophy and religious studies." Some might argue that their native language serves as this interdisciplinary language, but this serves only for general discussion, and no single interdisciplinary language could set forth all

the technicalities of the disciplines.[1] More specifically, the request for papers sought studies to enable "disciplines as far [apart] as the natural sciences, philosophy and religious studies [to] mutually interact in a creative way, in order to achieve a deeper and more comprehensive understanding of nature in all its facets and dimensions." To proceed, I need the notion of a *scholarly domain* at a finer grain than the overall disciplines of science, philosophy, or religious studies – contrast mechanics and embryology, or Christian and Hindu theology, or cross-cutting domains such as philosophy of mind.[2] A domain is defined by a set of questions, ways of gathering data, and styles of theorizing. A *domain language* is then the vehicle for scholars to discuss these matters. However, expertise in the domain is not limited to the language – it includes the ability to link language to what the domain is about. Research in a domain involves a set of observation techniques, whether with specialized apparatus or "tools of discernment", a theory or underlying set of arguments, and criteria for what constitutes a satisfactory argument or result.

Research is conducted by human individuals. Different scholars may seize on different data (guided in part by intuitions gained through life outside the domain as well as experience within it) and develop different theories to address the chosen data. A new paradigm emerges when "enough" scholars in the domain come to agree on the importance of certain observations and the power of the new theory. However, humans being argumentative creatures, a given domain may have several paradigms at the same time, and the scholar seeking to enter the domain must master key paradigms before entering the debate on the merits of each and what further changes are needed.

Each domain is thus a dynamic, multi-directed entity, and may be defined as much by scholars' shared sense of important questions as by commitment to any one paradigm. The domain's semantic resources – concerns, techniques, and assertions – may well be in flux. There may be only a family resemblance[3] between activity in states of the domain as it changes across the decades. Thus, the domain's language must also be dynamic.

Interaction between domains is also based on human interaction, whether directly or through documents or artefacts. §1.2 briefly introduces the book *The Construction of Reality* (Arbib & Hesse 1986, henceforth CoR) based on the 1983 Gifford Lectures in Natural Theology in Edinburgh. §2 then shows how CoR lays the basis for the general framework for our study of domain languages, linking the minds of individual scholars with overall patterns in the domain by extending a theory of "schemas in the head" to address "the social schemas of a community." §3 uses this framework to explore the relation between contributions of individual scholars and the consensus(es) that arise and change in each domain.

Rather than seeking a single language for unifying all of science, philosophy, and religious studies, I focus on *conversations* between scholars in different domains who attempt to discuss issues of mutual interest. Discussing the phenomena of a scholarly domain may require the deployment of a technical vocabulary. Moreover, for many pairs of domains, translation will be impossible. One cannot translate elementary

[1] Knowlson (1975) surveyed *Universal language schemes in England and France 1600-1800*. Assessing these efforts clarifies why no universal language can be created whose vocabulary and structure directly captures the elements and combinations of nature. But that is not the notion of unifying language that is being considered here.

[2] While this article focuses on *scholarly* domains, there are many other domains in which diverse groups of people have shared concerns – for example, creative arts such as painting or ballet, blacksmiths sharing techniques of their craft, or mothers sharing ways of balancing their own well-being with that of their children.

[3] For discussion of Wittgenstein's use of the term *family resemblance*, see Sluga (2011: 74-88).

particle physics into the language of Thomist philosophy, or vice versa. At most a conversation will be possible, but only if a *bridging language* is developed to make aspects of one domain *somewhat* comprehensible to scholars in the other, and may rest in great part on finding effective ways to deploy the everyday resources of a shared natural language. The back and forth of conversation can build a bridge but the result is not a translation.

Finally, §4 examines the cognitive neuroscience of linguistics as a case study for the general account, focusing here on the bringing together of three domains: linguistics, psychology, and neuroscience.

1.2 *The Construction of Reality* by Arbib & Hesse

We are concerned with the type of conversation in which people in two scholarly domains push (whether successfully or not) to reach some measure of shared understanding on some topic of mutual interest, each knowing something that the other does not. Crucially, they must share enough of a natural language in which the conversation is initially conducted to detect when what they say is being misunderstood and seek to develop paraphrases and telling examples to get across what they mean. The idea of knowing what the other knows and does not know is crucial to the process even though such knowledge is fallible. A conversation may end in misunderstanding and even conflict.

My collaboration with Mary Hesse offers a general framework that we can apply (§2) for assessing inter-domain conversations. Mary and I were summoned from mutual ignorance of each other's work to jointly prepare the Gifford lectures.[4] I had not studied Mary's work on history and philosophy of science. She had not studied my work on modeling the brain. But our topic, *The Construction of Reality,* was inspired by *The construction of reality in the child* (Piaget 1954) – I had developed a variant of schema theory that related action, perception and learning to brain mechanisms. We did not doubt that there is an external Reality (though we disagreed about its nature, nonetheless), but agreed that we could only come to explicitly know certain aspects of that Reality, and that these "constructions of reality" emerge from both individual experience and from cultural evolution, and may be subject to change.[5] However, we also agreed that the exact sciences have evolved to make certain of those constructions more robust in that they can depend on well-defined methods of observation and prediction based on clearly articulated theories.

Our first challenge was to develop an epistemology that linked Mary's analysis of how scientists come to agree on a new paradigm in some domain of science (§2.1) and my concern with what goes on in the brains of individuals as they learn about their world (§2.2) –bridging between the "construction of reality" in the head of individuals and in a community. Mary brought to this the notion of a scientific community coming to agree on which facts were to be seen as salient and what theory to accept to explain them – and also how new data could convince the community to change their theoretical framework. We extended my schema theory with the notion of a *social schema* (§2.3), a

[4] I refer to Mary Hesse as Mary rather than Hesse in what follows because I am reporting on a collaboration and the friendship that emerged during it, and this is reflected in the choice of the more personal appellation. For more on the collaboration, see my tribute for the celebration of Mary's life hosted at Peterhouse College of Cambridge University in 2017 (Arbib 2022).

[5] I make no attempt to distinguish *knowledge* from *belief*. Indeed, each domain of science, at least, offers an account of what experts in that domain believe to be true but with the understanding that new observations may force radical change in their theory. Similarly, we may *know* a friend can be trusted until they break that trust.

pattern of behavior in a community (scientific or not) that can shape the individual schemas of people as they become members of the community. For example, how is it that in learning a language through interaction, we come to extract certain commonalities in the use of language around us to become a member of the language community? Our approach to language gave a central role to metaphor (§2.4).

Our further challenge was to make our lectures relevant to theology. We concluded with an agreement to disagree, but with an expanded understanding of each other's viewpoint. The reader is referred to CoR for the second conversation.[6] Mary argued (Chapter 11) for a Christian faith grounded in God as a Reality outside space and time. Although conceding that we cannot know God in detail, she argued for the Bible as the Great Schema conveying truths (in metaphorical language) concerning the triune God as the non-spatiotemporal Reality that grounds the meaning of human lives. I argued (Chapter 12) for a secular world view. We expressed this early in the book by posing the question "Is God more like gravitation or like embarrassment?" Gravitation is a reality that constrains our schemas of the physical world by the well-understood processes of testing and experimental feedback. Theories of gravitation cumulatively (as, for example, we move from Newton's theory to Einstein's general relativity) give us at least part of the "truth" about it. But no matter how theories and empirical observations change, you're still going to fall to the ground if you jump out of a building. Embarrassment, on the other hand, is based on human physiology, but the occasions for it form a social artifact, arising when the person finds she has broken social rules and is to some extent isolated from her group. Similarly to the latter, I argued that most people feel a need to believe in something beyond their individual existence, but the way that belief takes form in a God or gods in some societies or a more Confucian mode in others is in fact a social construct.

Once we met, we had a great rapport. We started with a shared mastery of English and a background in mathematics and physics and enjoyed not only educating each other, but debating the issues as they emerged. This makes the general point that scholars in two domains must be able to communicate from the start as they develop a bridging language and must be motivated to learn more of each other's domains. Note the differences, then, between a *common language* (a natural language for sharing everyday experience and simplified aspects of each domain), *domain languages*, and *bridging languages*. Only rarely can two domains be unified to form a new domain with a new domain language that can express whatever remains salient from the two constituent domains (§3.2).

2. Bridging the construction of social and individual realities

2.1. Hesse on philosophy of science

Mary brought to our collaboration a distinguished series of contributions to the history and philosophy of science (Hesse 1962, 1963, 1974) and also brought in an assessment of sociological and hermeneutic theory (Hesse 1980). Directly related to our work, she had given the Stanton Lectures on the Philosophy of Religion in 1978-1980. This section focuses on three key notions of her philosophy of science: the *observation language*, the *theory language,* and *the pragmatic criterion* testing the theory in terms of what "works."

Any two people who have shared many experiences together will reach a point where one recalls the details of a particular event and the other disagrees. In some cases, no

[6] A related conversation between George Ellis and myself appears in the book *Neuroscience and the Person: Scientific Perspectives on Divine Action* (Arbib 1999a, 1999b; Ellis 1999).

resolution can be found. The exact sciences compensate for this by requiring that observations be made using agreed-upon apparatus with observations recorded in a precise agreed-upon *observation language*. The exact sciences are (ideally) such that any scientists who uses the same apparatus to observe the same situation may come up with similar results, as exemplified by observation of the motion of the planets or the result of chemical reactions. However, there is no such thing as an independent observation language (Hesse 1974, Chapter 1, "Theory and Observation"). Observations will be theory-laden.

The Methods section of an experimentalist's scientific paper will describe (in more or less intelligible and thus reproducible fashion) what operations were carried out on what apparatus and under what conditions, and the Results section will present (a selection of) the observations made under these conditions. By contrast, a theoretical paper will offer explanations for a range of phenomena reported using the observation language, and such explanations will be couched in the *theory language* of that domain. This language may combine mathematical formalism with portions of a natural language, but employ a specialized lexicon and methods of inference that are not part of the everyday use of that language. Such explanations may vary in their rigor, and may be distorted when they depend on incomplete or erroneous reports of observations. Moreover, such explanations will tend to accept various prior arguments – but theory may advance significantly when accepted aspects of theory are called into question by observations that appear to conflict with current views within the domain.

The observation language is expressive enough to present not only the data but also predictions for possible future experiments, as well as "observations" that do not arise. In the "exact" sciences, a theory is successful if it can not only support explanations of current observations but also predict the results of new experiments before they are performed – satisfying the *pragmatic criterion* of successful prediction and control. When we turn to sciences like cosmology or biological evolution the criterion may involve retrodiction in the sense of drawing puzzling phenomena into the web of the theory to offer explanations of what had at first seemed inexplicable.

Moreover, new findings in the domain may support development of new theoretical entities and new apparatus to provide observations that test claims about those entities – requiring extending the observation language accordingly. Subsequently, the theory that has informed design of the apparatus and the observations they provide may make predictions that do not agree with the observations made from new experiments. When predictions fail, a decision must be made as to whether the new data are "crucial" – we see here the idea that "objective" observations are assessed by subjective evaluation of what data are "important" for the domain, but with strong restrictions that limit the role of subjectivity. Following Duhem and Quine, Hesse (1969) emphasized that scholars in any science will make choices to reach consensus as to which observations must be taken into account. If these results contradict current theory, an attempt must be made to revise or replace it. The latter case may lead to the search for a new "paradigm" (Kuhn 1962) that may require a new theory language that can accommodate the hitherto anomalous data.

At times, the "elegance" of a new theory may convince researchers to take it seriously and only then acquire the data that accords better with the new theory than the old – Copernicus advanced his heliocentric theory before (after his death) others made the astronomical observations that, in the hands of Kepler, Galileo, and others, showed its superiority in explaining and predicting numerical data on planetary, solar and lunar orbits over Ptolemy's geocentric theory of epicycles (whose elaboration had served well for more than 14 centuries!).

To summarize: any domain must have a language that incorporates, at least, an observation language as complemented by a theory language that supports arguments as to whether an observation is to be trusted, what can be explained, and what must be rejected. The exact sciences such as physics and chemistry and some domains within biology, engineering and medicine adopt the *pragmatic* criterion of successful prediction and control. As we move through psychology and sociology to the study of religion, the pragmatic criterion loses its hold**,** suggesting the need for *satisfaction* criteria (§3.2). These may be domain-specific, to assess what observations are relevant and what conclusions expressed in the theory language they support.

2.2. Arbib on Schema Theory

The term "schema" has been used in diverse senses in philosophy, psychology and elsewhere, and so it is important to distinguish the version of schema theory that I brought to the conversation in the early 1980s (this section), and the extended version developed with Mary (§2.3).

I took *action-oriented perception* as central to an integrated perspective on artificial intelligence and brain theory (Arbib 1972), linking processes for perception and action at two levels of dynamics, one abstracted from observations of behavior and the other linked to data from neurophysiology that could be explained in a computational model of neural networks. Richard Reiss (a pioneer in neural modeling, see Reiss 1964) suggested that there were enough similarities with Piaget's notion of sensorimotor schemas to refer to these processes as *schemas*, and the terminology was adopted (Arbib 1975). Before addressing the implications of linking neural networks and my schema theory for our philosophical understanding of person and society, let me briefly recall several other notions.[7]

While Kant's notion of schema has long proved influential, the 20th century history of schemas starts with the neurological study of Head and Holmes (1911) of the *body schema*, based on ways in which lesions to the parietal lobe can disrupt an individual's perception of their body.

Bartlett (1932) adopted a different notion of schemas as familiar visual images or narrative tropes, showing that people tended to remember more by relating what they experienced to familiar schemas than by memorization of details. Craik (1943) observed that the brain creates an adaptive model of the world, allowing a person to form expectations on which actions could be based adaptively, and we may see such models as precursors of the linkage of perceptual and motor schemas, or of the control systems that offered a foundation for cybernetics (Wiener 1948). As Craik comments

> …even [the] 'coherence test of truth' may indicate, as perhaps it does in the case of Kant's 'architectonic', not so much the objectivity of [a] theory as the groove in which the author's mind runs. Instead of his theory being as wide as reality, his perception of reality may be as narrow as his theory (Craik 1943: 1)

the general point being that, even within a domain, the notion of "truth" may depend strongly on the criteria for observation and argument within that domain.

Piaget's use of schemas (Piaget 1971) explored cognitive development in terms of *assimilation* (making sense of the situation in terms of the available stock of schemas), *accommodation* (developing new schemas to the extent that mismatches arise), and their interaction. *Reflective abstraction* provided processes whereby sensorimotor schemas laid

[7] This all-too-brief sketch is adapted from the still brief sketch of (Arbib 1991).

the foundation for increasingly abstract schemas (Beth & Piaget 1966). My theory teases apart the perceptual and motor components of sensorimotor schemas, with the motor schemas having antecedents in the motor schemas of Schmidt (1975) and the reduction of degrees of freedom in the synergies of Bernstein (Arbib 1984; Bernstein 1967).

What makes my approach distinctive is its linkage to the analysis of brain mechanisms, seeing action-oriented perception, thought, and language as subserved by large assemblages of schemas, complementing this with a fine-grain analysis of how a particular network can adapt.[8] A crucial challenge has been to assess whether behavior-based hypotheses need updating when the data from neurophysiology are taken into account, the payoff being that the revised schema account could then yield more insight into observable behavior and make novel predictions.

Models from my group include brain mechanisms of visuomotor coordination, intermediate-level programs for mediating vision and touch and control of the movements of robots, and formal models of language acquisition and production. Some key points:[9]

- Perceptual schemas are not pattern recognition devices that simply categorize objects. For example, a schema recognizing a mug can pass parameters about handle position, orientation and size to motor schemas controlling coordinated movement of arm and hand to pick up the mug. Recognition of the mug may be a conscious act, but matching of sensory details to muscle activation need not involve conscious control.
- Schemas have activity levels expressing a degree of confidence (e.g., that the perceptual schema corresponds to activity in one region of the perceived scene, or that a motor schema is appropriate to attempts to achieve a current goal).
- Schemas are activated by a process of *cooperative computation*. For example, in a visual scene, *schema instances* may be activated "bottom-up" by sensory data, by context as represented by activation of other schema instances, or "top-down" by schema instances related to goals, expectations, and interest. To support this, schemas in long-term memory form a parametrized network. Thus, for example, activation of a schema instance for /roof/ in one region of a scene may cooperate (raising activity levels) with a schema instance for /wall/ below it but compete (lowering activity levels) with a schema instance for /sky/ associated with the same region. Thus, what we consciously perceive of a situation corresponds to the network of schema instances that are in some sense above threshold, but our ongoing behavior and experience may be influenced by the subthreshold schema activation of which we are not conscious. In the present case, then, there are two kinds of networks: A relatively stable network of schemas and their relationships that sits in long-term memory, and a highly dynamic network of schema instances that provide the representation of current relevance.

[8] Much of the current excitement about neural networks as an AI technology centres on their use of learning rules to enable a network of simplified "neurons" to adapt itself automatically to conform to some specification of its input (and, possibly, output) data and employ their regularities in novel situations.

[9] An exposition of early results appears in (Arbib 1989, Chapter 5; 2012: 10-20, 65-71). A later effort from my group developed a schema-based theory for how visual perception and language might interact, with language represented as a network of schemas representing word meanings and constructions, and with the processes of both scene description and sentence understanding involving cooperative computation linking language schemas and perceptual schemas with each other as well as sensory data (Arbib & Lee 2008; Barrès 2017; Barrès & Lee 2014; Lee 2012).

- As emphasized by Craik and by control theory (e.g., Haruno *et al.* 2003), the interplay of motor and perceptual schemas with current goals must also provide expectations about what will happen next so that we may choose our actions appropriately. These expectations may be wrong, and so it is that we sometimes learn from our mistakes. Schemas are fallible. Schemas, and their connections within the schema network, change through the processes of assimilation, accommodation, and reflective abstraction. These processes adjust the network of schemas so that over time one may handle an expanding range of situations in a more adaptive way.
- In this framework, a schema is a unit for the construction of our representations of reality through cooperative computation in networks of parameterized schema instances engaged with the neural networks of the sensory and motor peripheries of the body, but may only serve its role through the results gained through interaction with other schemas. Each mind comprises a richly interconnected network of schemas, a network that brings together our notions of reality (and fiction) at many different levels. Our schema theory thus sees behavior *not* as based on inferences from a few simple axioms, but rather as the result of analogical processes (not only explicit reasoning) based on a vast array of examples encoded in our schemas that, by dint of our limited experience, do not constitute a completely consistent logical system based on axioms or, like the hard sciences, rooted in rigorous and (in principle) shareable observations.

Schema theory can be used to frame testable theories focused on particular domains linking brain and behavior rather than being itself testable directly. In the same way, we do not offer English or Italian or Chinese or Swahili as theories of science, philosophy, or religion, but instead consider them as vehicles that, suitably extended and corseted, can express (aspects of) such theories. As in the use of mathematics in science and engineering or the diagrams of molecular structure in chemistry, the framework offered by any natural language may, in many domains, need expansion or adaptation to meet the needs of the domain.[10]

2.3. Social Schemas

Each of us has very different life experiences on the basis of which our personal schemas change over time and so each of us has our knowledge captured within a more-or-less different schema network. But we are, crucially, social beings. Brothers (1997) stressed that "The network of meanings we call culture arises from the joint activities of human brains. This network forms the living content of the mind, so that the mind is communal in its very nature: It cannot be derived from any single brain alone."

Much of the individual's construction of reality is guided by social convention. An individual's development is shaped by previous structuring obtained by society – as in the "rules" of language and social interaction. The key notion to address this in CoR is the *social schema* – be it a scientific paradigm, a legal system, an ideology, a language, or a religious symbol system— held by a community en masse that in some sense defines an external social reality for the individual. Our notion of social schema thus addresses the fact that entities like "The Law" or "Presbyterianism" or "The English Language" are not exhausted by any one individual's stock of schemas but are constituted by a

[10] Even mathematics requires extension to meet new challenges: Differential and integral calculus serve well for developing the implications of Newtonian mechanics, but quantum mechanics requires extensions from probability theory, and general relativity employs tensor analysis and Riemannian geometry.

"collective representation" (to adapt a term from Durkheim 1915) that is experienced by each individual as an external reality constituted by patterns of behavior exhibited by many individuals as well as related writings and artifacts. For each of these social schemas, we may note that different communities may have different variations, that people may belong to different communities with respect to ideology versus religion versus language; that the boundaries between these may be ill-defined; and that accomodating to a social schema may involve accepting a certain role in the community and behaving accordingly.

Consider, for example, a young child acquiring a language. The child is not exposed to the language as a unified external totality but comes to interiorize that language as a dynamic set of schemas for words and *constructions* (in the linguistics sense of "rules" for combining words into phrases and so on hierarchically: the tools for creating diverse verbal constructs) that allow her to use her emerging skill to interact successfully with other members – as well as developing new ways of thinking that language supports. The early words of the child are normally coupled with manual gestures, of which pointing is especially important (Volterra *et al.* 2018).

The framework of *two-way reductionism* (CoR, §4.1) holds, for example, that one can entertain both a reality of hard tables and a reality of molecules and atoms and then seek to relate them rather than reduce one to the other. In the present section, we are looking at the levels of social reality and individual reality and exploring their relationship. Another two-way reduction seeks to explore the relation between the realities of schemas and neural activity.

An individual's schemas will seldom if ever exhaust a social schema. In the case of "The English Language," as each child comes to internalize aspects of the language, she develops internal schemas that constitute an idiolect, creating the general need for each natural language to provide tools (whether used or not) that can be employed to reduce misunderstandings. People who live in close proximity may have idiolects that vary little; whereas English-speaking communities across the world may differ not only in accents but also in the use of certain words and idioms that make communication across those communities difficult. In the same way that linguists may argue over whether a community speaks a dialect or has its own language, so may we discuss whether two communities have different social schemas, or whether one social schema is a "dialect" of another – we are back to the challenge of iterated family resemblance.

Schemas "in the head" may vary greatly between individuals – both because of their individual experience and the social roles they have grown into – and yet support their behavior as members of a community. But these individuals' schemas in turn shape the social schemas and may change them incrementally or drastically. This is because related schemas in the heads of individuals create patterns of behavior across a community that can provide the dynamic environment in which a new member may acquire the schemas that support behaviors that define them as members of the community (perhaps with designated roles). The variety *and dynamics* of religions, political ideologies or scholarly domains show that a social schema may create "realities" of belief and behavior where there is no "objective accuracy" available. Moreover, individuals may respond to social schemas as conformists or as rebels who reject and possibly change the social schemas that define society. Such change may involve a process of critique, whereby individual experience and social schemas are engaged in a process of accommodation in which either or both classes of schema may change.

We thus see the individual's reality constituted by her understanding of the external world, which is both a physical world structured in part by human artefacts and a social world constituted by how people interact with each other and with those artefacts. Mary's classic studies in history and philosophy of science addressed how, given a

plethora of observations, a group of scientists could come to agree on which data were most important, and on the structure of a theory that could make sense of these data and lead on to novel predictions and new observations about aspects of the world studied in their domain. In CoR (but see also Hesse 1980), Mary sought to extend her epistemology to deal with issues in the philosophy of religion. For example, CoR §8.3 treats "The language of symbols," while CoR §10.3 examines "Religions as symbol systems." However, a major shortcoming of CoR is that symbol systems are viewed there primarily as linguistic systems, without paying attention to the potency of, e.g., certain objects as religious symbols. Social schemas frame patterns of interaction with objects as well as people in ways that extend beyond the use of language. As we learn to handle physical reality as well as social reality, schemas in the head may be differentially shaped by a pragmatic criterion of successful control of objects as well as satisfaction criteria for "acceptable" social behavior.

A *social schema* defined by patterns of behavior (including use of objects) that help define a community must be distinguished from *schemas-in-the-head that guide social interaction*. What then is the difference in this process of construction of schemas-in-the-head between interacting with other people and interacting with a stone, a tree-branch, or an animal? Perhaps the answer is that the child's development of schemas-in-the-head for social interaction is linked with development of what is called *Theory of Mind* (Leslie 1987; Meltzoff 2005; Zukow-Goldring & Arbib 2007): learning how to behave by realizing that "other people are like me" and then building atop that to develop an understanding that "yes, but in fact some are not like me, whether in general or at this moment." Thus, one might seek a continuum between the embodied neural apparatus required to master the use of a hammer to drive a nail and particular actions like hugging one's siblings. However, what distinguishes the latter (as Brothers 1997, emphasized) is the recognition of *personhood* – not only recognizing whether or not the other is "in a huggable mood" but also recognizing who can be hugged and who cannot. Meanwhile the child is beginning to master a few words and phrases of the "mother tongue," and only later may come to the realization that some people can respond to those words and phrases while others do not – and so dawns the realization that there are different languages.

Thus the child's developing "schemas in the head" can depend on observing and interacting with the physical properties of objects and interaction with other people. There is no hard and fast division here. Social taboos may restrict our contact with certain types of object, and fragments of Theory of Mind may inform the way we interact with some animals, especially with pets, but may also underlie various degrees of animism. We are back to Piaget's accommodation and assimilation, but with a strong social component. Thus, for example, the way one talks to an intimate companion may differ from the way one talks to a casual acquaintance and differ in turn from the way one talks to an authority figure. In this way, social schemas shape the life of single persons not only to the extent to which they are "internalized, in their heads" but also through the behavior of others who have been shaped by manifestations of the social schemas of that community.

And here we come to another meaning for "the construction of reality." A concept with a relatively new name, *niche construction* (Laland *et al.* 1996; Odling-Smee *et al.* 2003), is crucial to the domain studying the interplay of biological and cultural evolution. This is the notion that the activities of species or a community change the environmental niche – consider how beaver ponds change the local ecology, or humans create buildings and other artefacts – to construct a new reality for further adaptation and evolution. The diverse changes in a niche (whether or not their accumulation merits declaring a new niche) bring about new schemas in individuals for dealing with them. These in turn may

yield adaptive advantage for genetic changes that yield creatures more capable of developing these new schemas. In modern human populations undergoing little or no selection on the genome, the changes in individual schemas may be recognized, imitated, and modified by others to the extent that we can declare new social schemas emerging as the fruit of cultural, rather than biological, evolution. In particular, for modern humans such changes will be accompanied by changes in language and the ways in which language is employed to educate, to describe new artefacts, or to exhort or proscribe new patterns of behavior. In particular, we can look to the emergence of professions and scholarly domains, each with their domain languages that extend but also constrain both language use and behavior in those domains.

We have stressed the role of skilled use of apparatus in developing the results captured in the domain language of a scientific domain. Similarly, modern religions (as social domains, rather than the scholarly domains that study them) have traditions both as to the form of the buildings where people come together in worship (mosque, synagogue, church, temple, …) and as to how the act of worship may be structured around varied objects of great symbolic value as defining and defined within the particular religion. Thus the social schema that is that religion will instill in its adherents the schemas-in-the head that include the ability to recognize aspects of that symbolic value and to participate (in a way defined by various roles) in certain practices.

In recent years, I have sought to bridge between the domains of neuroscience and architecture (Arbib 2021) by, in part, deploying insights from my schema theory and elsewhere to analyze the mental construction involved in the architect's design process – and I now understand that this interest in architecture is another chapter in the theme of "the construction of reality." Architecture is a form of conscious niche construction that can provide an environment that goes beyond the physical necessities to "embody" aspects of social schemas. A recent talk on sacred architecture (Arbib 2023) brings us back to the concern with theology that led Lord Gifford to found the Gifford Lectures. In discussing an image from the Abbey of Saint Peter in Assisi, I commented that what to the outsider might seem a horrific statue of a man being tortured to death has no such connotation for a Christian who sees in it the symbol of hope and the Resurrection. Sacred architecture in part has its impact because the faithful can relate it to various narratives that shape their perceptual schemas within that context; conversely, the building can help people appreciate the narratives of their faith. We see here ways in which architecture and language conspire to create or convey or modify social schemas that can transform people's lives as each comes to master their role within the social structure of their religion – or even, for those outside this faith, provide social schemas shaped in part by the impact of religion(s) on the history of their communities.

Returning now to the themes of this Special Issue: There is a certain level at which one can distinguish science from philosophy from religious studies, and I have suggested that a finer division into domains is required if we are to critique the notion of a unifying language. When we consider domain languages, although a language may provide a tool for argument and agreement in the domain, such talk is meaningless without connection through observation and action to an external reality that may (but not in all cases) include people and artefacts. We must distinguish the domain language from what it is about, the "slice of reality" that the language seeks to characterize. In many domains, the apparatuses employed for observing the relevant facts are among the relevant artefacts of the domain. In becoming expert in a given domain, a scholar is encountering the social schema (or schemas) of that domain and building up the individual schemas that support understanding and production of utterances in its domain language as well as the schemas that enable them to make observations and conduct tests of the theory – from highly structured experiments in the exact sciences to

personal experience, all linked by a series of questions of current relevance to the members of the community. For example, a scientist may develop skill in constructing apparatus and conducting experiments – but this must be distinguished from mastery of the domain language to describe the resultant observations and relate them to theory within the domain.

The domain and its language may be in a state of flux, and the understanding of individual scholars (rooted in their own internal schemas shaped in part by their limited samples of the social schema) may disagree, thus posing similar challenges to those we consider in bridging between different domains. In this way, scholars in a domain engage in a quest to construct an understanding of a particular slice or shadow of reality but the quest may lead to diverse assessments of what that reality may be – a scientist may (but not all do) dismiss God from their reality; for some (but not all) Christian theologians God may be at the core of reality, a very different reality from that envisaged by a Hindu theologian. The shared challenge here and elsewhere in this Special Issue is to respond to this diversity. The concern is not only to understand the nature of a domain language that can serve to express the dynamic flux of observation, argument and (dis)agreement within a domain, but also to face the challenge of supporting conversations between different domains.

2.4. All Language is Metaphorical

We have seen that schema theory describes a very complex phenomenon (of which we have offered a very small sample) in which the action, perception, emotion, social interaction, and the use of language by individuals are intertwined. Just as one person may be a keen observer of phenomena who can offer rather precise descriptions of what they have observed, another may make slapdash observations and describe them poorly – consider the challenge of describing someone's face accurately so they can be picked out of a crowd when you know nothing about the clothes they will wear or who they will be with. We have also seen that people shaped by the social schema of a community may interiorize it in different ways. Thus, in offering words or logical principles for a scholar within a domain, a domain language does not begin to exhaust the practical and theoretical (and conscious and nonconscious) knowledge that contributes to the skill of the scholar whose skill within that domain is affected by their everyday experiences, general knowledge, and the natural language that describes them. Nonetheless, the domain language must develop in ways that serve to help scholars in the domain move toward consensus on a range of issues.

This discussion frames the final topic in this tour of CoR, the notion that "all language is metaphorical." To oversimplify the discussion of "Language, metaphor and a new epistemology" (CoR, Chapter 8), let us start from the meaning of metaphor (not restricted to *scholarly* domains) as adopting a word in one domain and using it in another domain so that some features of the first domain carry over to the usage in the second domain, while others that are somewhat inapplicable in the second domain may be "dropped." We see here another example of competition and cooperation of schema instances. Nonetheless, features that are below threshold create a penumbra of potential meaning that may create possibilities for different shadings of meaning for the word as used within the new domain and these may, but may not, feed back into its range of possible meaning in the first domain.

Use of a word is not exhausted by a literal definition delimited by a few lines in a dictionary but may rather initiate a web of associations in the mind of the individual. Scholars in a domain do not (cannot) operate entirely within the limits of their domain

language. Many terms used within the domain will also be terms they use in daily life, and so the way they think about these terms when working within the domain will nonetheless be affected by those quotidian meanings. Scholars are (or should be) motivated humans whose interest may be caught by certain questions, and the initial ideas for what may be the answers will be affected by that diversity of meanings that renders each usage to some extent metaphorical.

In Chapter 11, Mary explores the way in which a metaphorical reading of the Bible is essential if one is to engage as a scientist with a Reality that extends beyond space and time to find its meaning in the triune God. However, here we turn to a key question for work both within and between domains:

In some variations of linguistics, a language is specified (to simplify somewhat) by a lexicon and a grammar. The challenge of linguistics is then to characterize how the grammar provides constructions that hierarchically combine words into phrases and so on to build "grammatically correct" sentences. The further notion (formalized in various ways) is that given the meaning of the words and the way constructions were deployed, the meaning of the sentence can be inferred. If this were all there was to language, one might ask "If a language is defined in part by its semantics, how can people using the same language disagree?" The answer is that semantics are defined in part by our personal idiolect and set of schemas.

An example from mathematics may be helpful in carrying this notion forward from everyday discourse to the greater rigor of a scholarly domain. We all have a fairly good notion of what we mean by a point and a straight line and might think these set the meanings for geometry. Euclid captured some of these notions in his axioms for plane geometry. One axiom (somewhat restated) asserts that for each line and for each point not on the line, there is one and only one line parallel to the first that passes through the point. Many mathematicians thought this so obvious that they tried to derive it from the other axioms. It was only two millennia later that Riemann and Lobachevsky proved that this was impossible. For example, Riemann showed that a sphere satisfies all Euclid's axioms except the parallel axiom if by *point* we mean "diametrically opposed points on a sphere" and by *line* we mean "great circle on the sphere" – for then there are no parallel lines and each pair of distinct lines intersects in one "point." Changing just one among a number of axioms changed the whole "reality" to which the geometrical language applied. My point (metaphor strikes again) for our discussion of domain languages is that we may think of new observations as offering what may very loosely be described as new "axioms" that may require us to modify our theory to regain a measure of consistency in the domain, and that in doing so we may change our understanding of even the most fundamental concepts of the domain.

This relates to Mary's *Network Model* of science (Hesse 1974): reiterating that theory does not build atop an independent structure of observations, but rather observations and theoretical claims constitute an interdependent network where changes at any point may modify a range of observational and theoretical understandings.

Indeed, as we move away from the hard sciences, two scholars within the same domain may be using key terms in different ways. It is thus unsurprising that, as people come together from two different domains, we have an intensification of possible misunderstandings of the use of terms familiar in both domains, especially when a term from domain A is only known to the scholar in domain B in watered-down forms of popular discourse that confuse rather than aid mutual understanding. For example, most speakers of English use the word *quantum* only in the expression "quantum leap" to mean a significantly large change, whereas quantum theory in general deals with the submicroscopic.

3. Bridging Languages and Conversation Between Domains

3.1. Domain Languages and Satisfaction Criteria

We have seen that a domain language relates to the art and skill that make a scholar expert in the domain by providing tools for documentation and discussion within the domain. It includes observation language, theory language and success criteria for establishing "facts" (privileging certain statements in the observation language) and accepting the results of theory or argumentation – while nonetheless supporting disagreements as to what observations are relevant and what arguments are convincing. The exact sciences add the pragmatic criterion of successful prediction and control in linking observations (both established and predicted) with theory, and we have added retrodiction for some sciences. Even though physics, chemistry, and electrical engineering all employ the pragmatic criterion, the choice of what variables to consider and the success criteria for prediction will vary between domains.

We introduced the notion of *satisfaction criterion* to replace, or complement, the pragmatic criterion *in a domain-dependent way* as we consider domains in which detailed predictions of (as yet) unobserved phenomena are difficult to obtain. Since the notion is domain-dependent, no rigorous definition can be given, but the following speculations may offer guidance to scholars seeking clear criteria for what might count as a success in their domains:

- In the domain of history, one type of success would be to find and analyze documents to provide new observations that ground novel explanations for the forces that led to the observed changes accompanying, e.g., the Cultural Revolution or the emergence of Protestantism. Here the satisfaction criterion is one of "providing new understanding." However, what constitutes an explanation that enhances understanding is subject to changes in scholarly thinking and fashion. For example, historical study has veered between Great Man theories (schemas in one notable head) and social histories (focusing on how events shape and are shaped by the dynamics of social schemas).
- Literary or art scholars adopt no pragmatic criterion of offering people the means to produce successful novels or paintings. Rather their efforts include developing a methodology for assessing how a particular work did or did not achieve success, examining the influence of the work of others, the individual imagination of the writer or artist, and so on. Note that these scholarly domains are distinct from performative/poetic arts such as music, poetry, sculpture, painting, theater, where the emotional impact on an audience is far removed from scholarly discussion – though the work of the artists and the reaction of their audiences may provide observations that the scholar seeks to explain.
- Turning to theology: at one time I might have thought that the issue was one of accepting a particular religion and trying to justify its tenets. However, having visited the University of Chicago School of Divinity c.1982 when I was preparing for the Gifford Lectures, I have learned that the motivations of theologians can be diverse, and that a theologian may be an atheist or a devout believer or anywhere in between and yet find nourishment for their work in what has already been written about one or many religions, whether they seek to understand them in purely theological terms or in light of the work of psychologists, sociologists, or others.

Recall the insistence that a domain language includes an observation language in which to report what are currently established as "facts". Historical explanation must respect the known historical facts, subject though they are to revision and to new discoveries.

Similarly, different domains in religious studies may hold wildly divergent theories, and yet cannot do violence to observations of religious behavior or ignore the relevant sacred texts.

One task for a bridging language would be to support conversations in which scholars can make clear to each other what their satisfaction criteria might be. This might in turn inhibit further conversation, or allow it to be shaped to the benefit of one or the other or both.

Consider two very different domains within medicine and religion. Duffin (2007) assessed medical data to diagnose that a patient had an incurable disease, and later learned that, surprisingly, the patient had fully recovered. The recovery was interpreted by specialists in the Vatican as a miracle and became part of the evidence for the sainthood of a woman who had died 200 years earlier. This led Duffin to examine 600 miracle records in the canonization files of the Vatican Secret Archives from the seventeenth to the twentieth century, finding that more than 95% recorded inexplicable healings from illness. Duffin concludes that "medicine and religion emerge as parallel semiotic endeavors, using their canons of wisdom and careful observation to derive meaning in suffering." The canonization team must have sufficient knowledge to assess a medical diagnosis, though medicine need take no account of how canonization proceeds nor its theological foundation. However, the meaning of the "meaning of the suffering" in the two domains is widely different (an example related to §2.4 on the divergent uses a word or phrase may be put to in different domains). We see here overlapping, yet distinct, criteria in the two domains. In medicine, the remission is the starting point for following through on the details of the patient to seek clues as to how to cure others with the same disease (Goodfield 1984; Tsung & Norton 2006). For the Church, the remission is the endpoint, evidence of a divine intervention that supports a claim for sainthood (see also Severance 1912; and Vidal 2007). Of course, some physicians are devout Catholics – and for them the miracle may be that the saint has revealed the path to a new cure.

3.2. When Translation Does Not Suffice: The Case for Conversation

To further our discussion of the relation between two domain languages, we consider an example within physics, relating *the language of Newtonian mechanics* based on a *deterministic* worldview to *the language of quantum mechanics* based on a *probabilistic* view. We have one external universe but have constructed two different languages to support two different accounts of (aspects of) what constitutes that reality. This is instructive because *we cannot translate* probabilistic statements from quantum mechanics back into the deterministic language of Newtonian mechanics – but we can to some extent reconcile them, employing an additional assumption of statistical mechanics to incorporate Newtonian findings as *limiting cases* of quantum mechanics for most systems familiar to humans in our terrestrial world prior to the discovery of the transistor and VLSI for computers.

As a result, we have here one of the cases where two domain languages *can* be placed within a unifying language that combines the two languages together with the bridging language – in this case for deriving Newtonian mechanics of *some* systems from quantum mechanics. This new language of "unified mechanics" is mastered by most physicists and many electrical engineers. But note how specialized it is. While the previous paragraph is recognizably in English, its full understanding would require not only extending the English lexicon with various terms from physics but also providing some understanding of what the two different descriptions of mechanics entail and why statistical mechanics might provide a bridge. Thus it could be made "somewhat more

intelligible" to someone unversed in physics or applied mathematics – if one could only hold their attention long enough – by a multi-page extension that gives at least some intuitive grasp of key terms involved and their relationship to each other *and to everyday experience*. Such a description would introduce new terms or new meanings of those terms to the natural language employed, and these might establish the core for a bridging language between this domain of "unified mechanics" and a scholarly domain whose language lacks the necessary mathematical grounding. But even with such a bridge, the understanding of the "outsider" who has not followed the mathematics would be based on acceptance of the authority of the physicist and the trust that various assertions can indeed be justified – while finding that persuasive metaphors (§2.4) may give a glimpse (but only a glimpse) of the physicist's construction of reality. As "the "meaning of the suffering" shows, when scholars in two domains seek to communicate with each other with a shared natural language as foundation for their effort, there are still going to be words that have distinct "core" meanings within the two domain languages, and each meaning may be inexplicable without understanding substantial "lore" from its domain.

In the above case, then, there is a bridging language that allows the two languages to be subsumed in a unified language open to those with training in mathematical physics. However, in the general case we can only hope for a *bridging language* that allows scholars in each domain to share *expositions* or *narratives* that allow each to gain a partial understanding of the observations, arguments, and satisfaction criteria of the other's domain – hopefully as a means to engage in addressing questions of mutual interest.[11]

Different communities may agree on certain truths and disagree on others, or may find some of the central truths of another group totally irrelevant to their group. Nonetheless, this does not license an unrestricted relativism. An outsider who has not mastered the key experimental results linked to quantum mechanics and the mathematical arguments to justify them has no grounds to reject them as a valid perspective on reality. However, it is no simple matter to adjudicate debates between those whose beliefs conflict. Consider a scientist whose language has no room for the supernatural and a Christian believer who firmly believes in the reality of a triune God. Similarly, consider a Christian who believes in the resurrection of the body in the Kingdom of Heaven and a Buddhist who believes in reincarnation. While there could be illuminating conversations between scholars in such pairs of domains, there could be no translation between the domain languages if this means that truths expressed in one language can be translated into truths in the other, and vice versa.

The problem here seems different from translating between natural languages. My impression is that translations between Italian and English, say, of papers on quantum mechanics would be "easy," and similarly for translation of papers within subareas of Christian theology – but in each case, the English or Italian involved would be a similar specialized extension of parts of each language, richly mathematical in the first case but not in the latter. Translations of Dante into another language offer manifold challenges, including making ideas from a long-vanished society accessible to a modern reader (often addressed by the "cheat" of copious footnotes) and the problem of translating poetry where the language offers pleasures through rhythm, rhyme, and the sounds of words alone and in combination. For a reflection on the differences between thinking in Italian and English, see Lahiri (2016, 2022). The reader in either language is accepting that Dante transports them into a different reality (the "storyworld") rather than – in

[11] When I say "no unifying language can be used," I am excluding the trivial solution in which any statement X by A is translated into "A says 'X'" and similarly for "B says 'Y'" and no attempt is made to enable A to understand Y or B to understand X.

the case of the scholars considered here – seeking to view the two constructed realities of their domains as perspectives on the same (at best partially knowable) Reality.
Rather than *translation* of "truths" of one domain into "truths" of the other, then, I argue for a notion of *conversation* of the sort exemplified in CoR. Such a conversation has the prerequisite that the scholars involved in two domains must share an interest in certain questions. CoR discusses *hermeneutics* at various points, noting that

> a model of dialogue emerges; in this model, the investigators … engage in mutual attempts at understanding, breaking with the traditional separation of observer and object assumed in natural science. There is, in Gadamer's phrase, a *fusion of horizons* (Gadamer 1975: 273) in which the presuppositions and modes of understanding of both partners in dialogue are shifted ….

> [E]ven natural science, in its attempt to objectify nature by using the pragmatic criterion, is involved in "hermeneutics" – scientific theory is a "reading" of the "book of nature," requiring circular reinterpretations between theory and observation and also theory and theory, and also requiring "dialogue" about the meaning of theoretical language within the scientific community. (CoR: 180-181)

CoR Chapter 6 advanced the claim that Freud's psychoanalysis came from a fusion of the horizons of late 19th century neurology (Freud 1895) and Greek myths. More generally, though, many scholars will have no interest in fusing horizons with those in different domains, though in some cases later work by other scholars will show them to have been mistaken in their disdain.
Where conversation is desired, the ideal bridging language provides the resources in which each party can outline their methods of observation and satisfaction criteria as the basis for defending their own results relevant to a conversation (or, at least, present the outlines of such a defense) in a fashion comprehensible to the other. In this ideal case, a state of understanding will be reached where certain initial disagreements can be resolved or, even when they persist, each party can gain a new understanding of why the other holds the beliefs that they do. More importantly, the seepage of the bridging language back into the domain languages may lead to changes in both the observation and theory languages of each domain and thus change core understandings with which scholars entered the conversation and lead to new findings in their domains.

4. From Bridging Languages to New Domains

It must be reiterated that each domain, and each domain language, is dynamic. As new data are gathered, and new theories arise, so the concerns of scholars within the domain change. Not only may satisfaction criteria change, but new theories may demand and support new methods of observation and thus an update of both theory and observation languages.
Setting the boundary between domains is problematic. Even within what appears to the outsider to be a single domain, scholars may support quite different paradigms. For example, there are diverse schools within linguistics, but here I single out two:

- *Generative linguistics*, most associated with the changing theories of Noam Chomsky, sees constructions as concerned only with pure syntax: general rules for combining word forms and phrases according to their general syntactic category, without regard

to their meaning. Only after a "grammatically correct" string of words is formed do secondary processes determine the meaning and sound of the result.

- In *construction grammar* (Croft 2001; Goldberg 1995), syntax is integrated with semantics right from the start – as words are assembled into utterances using constructions, each construction assigns a meaning to the new construct based on the meaning of its components.[12]

One could debate whether generative linguistics and cognitive grammar actually constitute two different domains. However, given a shared concern for how words are put together and convey novel meanings it might seem better to consider them as competing theories within the domain of linguistics – and to the extent that scholars address such differences (they may refuse to do so), explanation in the domain may converge on more powerful paradigms.

With this, we can turn to a brief case study of the way in which interaction between domains may not only pass ideas back and forth between the domains but may also crystallize out a new domain – here we consider the three-way interaction between linguistics, psychology, and neuroscience.

van der Burght *et al.* (2022) assess how theory and methodology affect experimental outcomes in cognitive neuroscience of language (*neurolinguistics*, for short). The situation here is rather different from that in which scholars in different domains raise shared questions that motivate bridging between their domains. Between them, three scholars (Broca 1861; Lichtheim 1885; Wernicke 1874) established *aphasiology* as the search to correlate deficits in language production or comprehension with localization of damage to the brain. Thus, the issue for neurolinguistics is not people seeking to bridge between the three separate domains so much as aphasiology becoming transformed into a new specialization as bridges developed between linguistics, neuroscience and psycholinguistics, the latter being a domain crystallized out from bridging between the domains of linguistics and psychology. Rather than scholars in two or more domains developing a bridging language to discuss questions of independent interest to those within each domain, here a new domain builds upon extracts from each domain (theory language, observation language, satisfaction criteria) to raise and answer questions that may be of only peripheral interest to scholars within the resource domains.

van der Burght *et al.* (2022) stress that researchers define "language" – here, language as what is being studied, not the domain language of the study of language – in radically different ways, focusing on a wide range of phenomena, properties, and levels of investigation. They survey various theoretical assumptions imported from linguistics, psychology, and neuroscience, and then turn to methodological issues. The latter include choosing a language modality (e.g., spoken, signed or written) in which to provide stimuli relevant to a linguistic phenomenon, deciding how to avoid confounds, and choosing the neuroscientific research technique to be used (e.g., EEG, MEG, TMS, or fMRI[13] – they don't discuss clinical studies) as well as the analytic approach to be used in employing the data gathered in testing hypotheses of interest. However I want to concentrate here on their discussion of theoretical assumptions imported from

[12] Note that neither framework does justice to the notion that the meaning of words cannot be defined in isolation as building blocks for the meanings of sentences. Not only is context relevant, but we have seen that the meaning-network of a word shifts as we encounter new sentences that employ the word in new contexts. Thus we need a theory of grammar that makes explicit this dynamics – but pursuing this notion falls outside the remit of this article.

[13] The definitions of EEG, MEG, TMS, or fMRI and the differences between them are irrelevant to our *general* concern with inter-domain conversations, as are the differences between the Merge and Unification operations mentioned later.

linguistics to make one point relevant to our general investigation of conversations between domains.

The authors warn that "the choice to begin conceptualizing an experiment from the algorithmic level of psychological theories of language processing or from the abstract analysis of language *competence* may lead not only to a focus on different phenomena, but also to radically different interpretations of the data—unless a more comprehensive comparison of models accounting for different *performance* factors is taken into account." However, they focus on generative linguistics as their theoretical framework, thus failing to address what for me is a crucial question: "Does the brain process syntax prior to assessing semantics (suggesting generative linguistics as a good first approximation to 'grammar in the brain') or are syntactic and semantic processes integrated throughout comprehension and production (suggesting that construction grammar may provide a better first approximation)?" They suggest that neural data could be informative in distinguishing between the neural correlates of two purely syntactic operations, Merge and Unification. They do note that Merge is limited to syntax whereas the Unification from a processing perspective can also be extended to apply to semantics, phonology, and combining of elements retrieved from memory. However, they still ignore the integration of form and meaning offered by any variant of construction grammar.

Of even greater concern, they suggest that neural data currently "remain uninformative with regard to which theoretical definition should be preferred over another." My concern is not with the conclusion that neural data are currently inadequate (indeed, they are) but rather that the authors pose the question "Which theory in current linguistics will neurolinguistics favor?" rather than "How might future neurolinguistics shape a new vision of language processing that leads to restructuring (non-neural) linguistic theory?" thus using the conversation to affect work in the parent domain of linguistics.[14] None of this is to deny that much work in linguistics can be pursued in blissful ignorance of concepts and findings from neuroscience – but even here the neurolinguistics-inspired changes in general grammatical theory may have widespread implications.

5. Conclusion

Rather than seeking a unifying language for science, philosophy, and religious studies, we have seen that:

1) We need a finer grain of scholarly domains, each of which may have a domain language in which to describe observations of phenomena of interest in that domain, and to accommodate the theories that support development of explanations that may meet satisfaction criteria more or less specific to the domain.

2) We built on CoR (Arbib & Hesse 1986) to offer an understanding of the social schemas, as well as the artefacts, that characterize a domain and the way in which individuals must develop "schemas-in-the-head" that complement the schemas and language of everyday life to become qualified scholars in the domain. In particular, interaction between scholars can change their own internal schemas, and these individual changes may accumulate in ways that modify the scope, apparatus, and social schemas of the domain. Domains are dynamic systems.

3) Translation of *detailed* arguments and results of one domain into the domain language of another will often be impossible. Nonetheless, scholars in two domains may develop

[14] Elsewhere (Arbib 2017), I offer preliminary steps toward such an effort, comparing the implications of Template Construction Grammar with the schema-based interpretation of their neurolinguistics data (using a notion of schema different from my own) by Bornkessel-Schlesewsky and Schlesewsky (2013).

a bridging language in which to conduct a meaningful conversation in which each gains some understanding of the other, while possibly misunderstanding the subtleties of the other – we see here both the advantages and pitfalls of metaphor.
5) As a bonus, §4 demonstrated that conversation between two domains of scholarly study may not only make new research questions arise within one or both domains but may also give rise to new domains of scholarly study. Such emergence of new domains has important consequences for the future of human knowledge.

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