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Implementing Generalized Empirical Method in Neuroscience by Functionally Ordering Tasks

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This article outlines a method of collaboration that will manifest a high probability of cumulative and progressive results in science. The method will accomplish this through a division of labour grounded in the order of occurrence of human cognitional operations. The following article explores the possibility of a method known as functional specialization, distinct tasks presently operative in neuroscience. Functional specialization will enhance collaboration within a science as well as initiate implementation of generalized empirical method. Implementation of generalized empirical method will be achieved through the focus of individual specialties on specific mental operations.

Keywords: Functional specialization, functional collaboration, neuroscience, method in neuroscience, divisions of labour, generalized empirical method, working memory.

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1. INTRODUCTION

The many tasks of neuroscientific studies are an evident feature of that broad field of inquiry and its application. In this essay, I shall enter into details of the divisions of such tasks in the present methodological suggestion of ways beyond present practice (Henman, 2013, 2015). However, it seems good to state, in the introduction, a fundamental root cause of present problems and disorientations (Henman, 2015, Shoppa, Zanardi, 2014, p.40). Disorientations relate to the intelligent ordering of tasks, which will become apparent in the later portions of this essay. I do so here in a very elementary descriptive fashion.

First, then, we can share the question, and indeed its common answers, "What is a science?" Common answers, we easily find, stem from the analysis of Aristotle of the nature of science. That analysis left the western tradition with a narrow and conventional view of good scientific work. My informed readers may think of other traditions, like those of China or North Africa, where serious sciences of health and building shook off that ill-fitting narrow perspective on the human effort to understand and control, even improve on, nature. There has been, in the West, a move towards what we might call clarity or ideal typology such that deviants from that clear type were considered, in some way, inferior. This is true whether one considers formulations of paradigms, such as constitute texts on philosophy of science, or discussions of paradigm-shifts, such as occur in the Kuhnian tradition.

Therefore, adverting, however briefly, to the position of Aristotle is extremely enlightening. Sir David Ross sums up my point: "Throughout the whole of his works we find him taking the view that all other sciences than the mathematical have the name of science only by courtesy, since they are occupied with matters in which contingency plays a part" (Ross, 1949, p.14). This simple identification gives us a context for understanding what has happened, especially in the modern period, in reflections on science. Take, for example, the reflections that are the telling of the story of science, a story of contingencies spread over time and space. One does not think of such reflections as science. Much less does one think of applied science such as medicine, as science (Douglas, 2013).[a] What, then, of such topics as the teaching of science, the aesthetics of science, the ethics of science, the technologies of science? An Aristotelian perspective would have us consider such topics to be, as it were, outside the world of genuine science.

But are not these pursuits intelligent, rich with understandings of data, of the flow of events? "The immobility of the Aristotelian ideal conflicts with developing natural science, developing human science [...]" (Lonergan, 1972, p.24) and with reflections on these developments, their application, their importance, their ethics and their aesthetics. There is, then, a whole world of *scientia* – in the normal sense of the translation from the Latin – that escapes from, or is denied dignity by, Aristotle's narrowness. It is time to raise the question, "What is science?" with a freshness that takes the full modern data seriously.

Discussions of Generalized Empirical Method (GEM) as a means of including both the data of sense and the data of consciousness in scientific research implicitly raise issues about just what that *new science* might consist in (McShane, 2013). This article will outline the structure of that new science which will be found eventually to function as a method of implementation of GEM (Henman, 2013, 2015).

The essay attempts to outline a method known as Functional Specialization. First, I quote Bernard Lonergan's definitions of a method: "Method is a framework for collaborative creativity" (Lonergan, 1973, p.xi). Later Lonergan expands on this definition to say that "method is a normative pattern of recurrent and related operations yielding cumulative and progressive results" (Lonergan, 1973, p.4) So, thinking of both definitions, would a normative pattern of related operations be a framework for collaborative creativity, and furthermore, would such activity provide cumulative and progressive results? To answer these questions I turn now to the data in the full reality of human interest in neuroscientific work.

2. DIVISIONS OF LABOUR IN NEUROSCIENCE

This section of the essay will distinguish stages from data to results both in past, present and future experimentation in an effort to outline the "new science". In order to outline and describe the order and function of the divisions that occur during the scientific process from data to results, we begin with a summation of a particular article describing an experiment in neuroscience.

2.1 The neurochemical basis of working memory

Neurons projecting to the prefrontal cortex contain a specific neurotransmitter, acetylcholine, which is delivered by a specific type of neurotransmitter pathway, the cholinergic pathway. Recently, it has been hypothesized that an increase in acetylcholine to the frontal cortex might lead to an improvement in working memory (Furey et al., 2000). Furey et al. administered the drug physostigmine (which increases the amount of acetylcholine available) to a small group of men and women who completed a working memory task as a functional Magnetic Resonance Imaging (fMRI) scanner monitored their brain activity. Participants completed the same task the following day but received a placebo (saline). The task involved watching a human face for three seconds, and then after a nine-second delay when the face was removed, identifying which of the two or more subsequently presented faces was that originally seen.

Participants who received the physostigmine showed increased activation in the visual cortex during the encoding of the face, activation that was significantly lower in the saline condition. The physostigmine condition also produced better face recognition when participants had to decide which of the faces had previously been presented. The finding suggests that the improvement in working memory may be due to enhanced visual processing in the earliest stages of encoding. One practical example of this may be to administer such drugs to patients with stark memory deficits, such as patients with Alzheimer's disease (Robbins et al., 2000, pp.2275-6) (Martin, 2003, p.167).

2.2 Functional Research

Before a researcher begins to plan a research project, one has a question within a hypothesis or a hypothesis. Once the question or the hypothesis has been formulated, the researcher works out what form of data will be required to test the question or the hypothesis, and the type of data required dictates the type of experiment required and the various technologies to be employed to provide the required data. Various meetings are held with colleagues to discuss the hypothesis and the form that an experiment might take.

An experiment such as the one described above requires a significant amount of planning before the experiment can occur. There are proposals, consent forms to ethics committees when using human subjects, applications for funding and/or grants need to be made, planning out the materials required, preparing images of faces, determining adequate times for recognition, selecting proper timing devices, staff required, facilities, recording technology, access to fMRI scanning technology, finding subjects, consent forms for subjects to sign, determining what information is to be conveyed to subjects prior to the actual conducting of the experiment, setting the date and place, plans for no-show subjects, approving and acquiring medications, interviewing subjects regarding their physical, psychological and mental health and suitability for the experiment, and finally, meetings with colleagues to monitor stages of planning to ensure all necessary planning is being carried out properly. This listing provides one with some idea of the immensity of conducting any research project.

Seasoned researchers would be familiar with this entire process. This process of planning can take months or a year or more before the experiment is finally conducted. Even though, in the present case, the experiment took place over two days, the post-experiment work can also take weeks, months or years to understand the data and what to do next.

Taking into consideration both the data of sense and the data of consciousness, a brief outline of the cognitive operations involved in the above planning stages follows. A brief definition of Generalized Empirical Method describes the focus of this process.

> "Generalized empirical method operates on a combination of both the data of sense and the data of consciousness: it does not treat of objects without taking into account the corresponding operations of the subject; it does not treat of the subject's operations without taking into account the corresponding objects" (Lonergan, 1985, p. 141).

What operations correspond with the planning stages in the above description of the process prior to the experiment? The pre-experimental tasks that need to be accomplished are initiated by questions towards planning and practicality. So, a series of questions such as, What kind of experiment will test the hypothesis? Who will write the research proposal? Who will draft the ethics consent form? Who will seek out human subjects? Who will reserve time on the MRI scanner? What type of recording devices is required? What information is to be communicated to the subjects prior to the conducting of the experiment? Who will draft a request for the medications required? One can easily notice that these are common sense activities orientated towards practicality and not scientific in a theoretical context. But these questions do reveal a reach for an ordered structure of achieving outcomes. The questions are eventually resolved through insights into the different talents or capabilities of the various colleagues involved in the planning stage. Once these insights are achieved the group makes decisions on who will do what. In this manner, an ordered structure, from the data of the hypothesis, to questions, to insights, to judgments about the correctness of their insights and to final decisions, occurs all through the planning stage. The cognitive structure orders the process heuristically towards achieving the desired outcome. I would note here that a parallel complexity occurs in venturing into work in any of the specialties, but brevity requires that I not repeat the details in the other specialties.

When these activities and tasks are accomplished, the next step is running the experiment, and even this process is not pure scientific knowing. It is in the order of doing in terms of implementing a process organized by all that has gone before, but it too requires planning. Ensuring all devices are ready and working properly, all the subjects are present, medications are prepared, initiating the proper efficient order and detailed operation of the experiment so that the data desired is objectively achieved. So, the operations involved are a checklist of questions, and in summary; Do we have everything here required to run this experiment? The question initiates an ordering of procedures of checking for last minute details. If all is ready, a judgment is made that all is ready, and a final decision is made to begin.

The overall outcome of all the work prior to running the experiment was to obtain data that will, hopefully, help in testing the original hypothesis. This entire process, then has been one focused on gathering data. It is a focus of attention towards that one outcome. Attention is an act of consciousness. As much as other operations such as questioning, understanding, judging and deciding occur throughout the process (Henman, 2013, p.51. Lonergan, 1992, pp.343, 361), attending to the outcome of gathering the data was the overall focus at that stage of the process. The final process in obtaining that data was to run the experiment.

The experiment was run as described above and in the article sited. It is in the order of doing where attention to detail of procedure is paramount in terms of each stage of the experiment. Timing of the various phases of the experiment is crucial. Earlier stages of planning were designed to ensure that such is the case. One can envisage possible test runs prior to the actual experiment to ensure that everyone involved understands his or her role or function and that all equipment is in proper working order. There are operations of cognition involved in attention to detail and one's understanding of not only his or her role, but also some overview of the entire experiment and how their function or role fits into the overall plan. The experiment was conducted and the data had been recorded and reproduced.

The data consist of pictorials showing the results of the fMRI scans followed by two graphs all reproduced in the original article (Furey et al., 1997). Figure 1 of the fMRI scans reveals patterns of regional cerebral blood flow (rCBF) increasing during working memory (WM) tasks as compared with rest for the off and on drug conditions as well as the group comparison of activations. Figure 2 graphs the rCBF according to drug response in the right prefrontal cortex. Figure 3 consists of graphs showing the change in rCBF in relation to the changes in the reaction time of facial recognition. These three figures represent the data derived from the experiment.

2.3 Functional Interpretation

The second task is to understand just what this extended data means. This task is focused on interpretation or understanding. The division of tasks correlate to acts of cognition and not to different forms of data, which traditionally specified a science. First, the researchers attended to the many processes orientated to gathering data and now the second task is focused on understanding that data. The following is an excerpt from the article by the authors offering their interpretations of the data.

> "Given that acetylcholinesterase inhibitors prolong acetylcholine activity at the synapse, one might expect improvement in performance to be associated with increased rCBF in a task-specific brain region, yet we observed a reduction in right prefrontal rCBF. **One possible explanation is that reduced activation in right prefrontal cortex may reflect the shorter time required to perform the WM task**, although several papers, including a recent functional magnetic resonance imaging study, indicate that right prefrontal activity is associated more with maintenance of an active representation over the memory delay than with response selection.
>
> **The observed reduction of right prefrontal activity might have been a direct effect of physostigmine. Anatomically, the synaptic circuitry of cholinergic prefrontal fibers includes symmetric synapses on pyramidal cells; symmetric synaptic morphology is characteristic of inhibitory mechanisms**. It is unclear, however, why a direct inhibition of right prefrontal activity would be correlated with improved WM performance. Moreover, direct inhibition demands neuronal activity and therefore may result in increased rather than decreased cerebral blood flow.
>
> **An alternative explanation for the physostigmine-induced reduction of the right prefrontal rCBF response is that right prefrontal activity is associated with the effort needed to perform the WM task, and that this region is recruited as the effort required to perform the task increases**. Prefrontal cortex may become more active with tasks that require a greater allocation of attentional resources. *A PET study of word list recall showed that increased memory load resulted in greater rCBF increases in frontal cortex as well as in other brain structures. Another PET study showed that increases in the difficulty of a face-matching task increased rCBF in the right midfrontal gyrus with a local maximum 6 mm from one of the anterior local maxima identified in this study. Similarly, studies of event-related electrophysiological potentials show that the response amplitude in the prefrontal cortex increases with task difficulty during WM*. **The anticholinesterase effects of physostigmine may enhance efficiency of WM processes, thus reducing the effort required to perform the task and the need to recruit prefrontal cortex**. The mechanism by which physostigmine reduces effortful processing during WM remains unclear. **Physostigmine may enhance efficiency by amplifying processing of information in the focus of attention[b] or by minimizing the effects of distracting stimuli**." (Furey et al, 1997) (Bold and Italics formatting added)

The authors of this article have offered five possible explanations (Bold) for the results of the experiment and three alternative explanations (Italics) by other researchers conducting different experiments with a similar objective. The five explanations offered on Furey's experimental results were achieved by correlating the results of the three different recordings during the experiment. The researchers admit that much is still unclear about what exactly is enhancing the efficacy of working memory.

2.4 Functional History: Context of Interpretations

The fact that much is unclear and various possible interpretations have been offered brings us to a third task in the scientific process. This task focuses on the context of the experiment, the experimenter and the various explanations with an effort to make a judgment on the context of interpretations. The specialist in this zone brings forth the various interpretations and judges which ones are viable for further study. In order to do this a review is carried out of the various stages leading up to the interpretations, as well as on the conducting of the experiment. Once such a reconstruction of the interpretative process is completed, the historian of contexts attempts to judge which interpretations should be brought forward for further study, further experimentation and reflection (Lonergan, 1972, p.203). As much as the specialist, in this zone, is focused on judgment, all cognitive operations are active. Attention to the various stages of the process are required; understanding what the hypothesis is, what questions were asked, how the experiment was comprised, how it was run, how the data was collected and how it was interpreted. These stages of cognitional operations are all part of the process of arriving at a judgment on which interpretations are worthy of passing on to the next stage of the scientific process.

One needs a more than an adequate understanding of the science in question to function properly in this specialty. Lonergan makes the point in the following.

> "Clearly, therefore, the historian of any discipline has to have a thorough knowledge and understanding of the whole subject. And it is not enough that he understand it any way at all, but he must have a systematic understanding of it. For the precept, when applied to history, means that successive systems which have developed over a period of time have to be understood. The systematic understanding of a development ought to make use of an analogy with the development that takes place in the mind of the investigator who learns about the subject, and this interior development within the mind of the investigator ought to parallel the historical process by which the science itself developed." (Lonergan, 1960, pp.130-132)

2.5 Functional Dialectics

The historical fact of having more than one possible interpretation of the data obtained from the experiment raises the issue of deciding which interpretation passed forward from functional history is the most viable or best explains the results of the experiment. The focus here at this stage is on the cognitive act of decision. How is such a decision to be accomplished? The differing interpretations offered reveal that much is still unknown about the workings and functioning of the brain in terms of working memory, the specific interaction of various chemicals involved, how brain chemistry affects attention: if so, how does it achieve this, and so much more. Obviously more experimentation will be required in the area of working memory. Are there particular points made in the interpretations that can be brought forward that would appear to have some basis for further development in understanding the functioning of working memory? This is addressed in the discussion section of the essay. This process involves comparison, but not in some common sense descriptive mode. Such comparison requires that the dialectician operate out of a foundational context regarding an understanding of his or her own mental operations as well as familiarity with the rules of interpretation[c] that contribute to an eventual genetic sequence of development (Lonergan, 1992, pp. 600-603). The task of dialectic is to establish

> "a final objectification of horizon when the results of the foregoing process are themselves regarded as materials, when they are assembled, completed, compared, reduced, classified, selected, when positions and counter-positions are distinguished, when positions are developed and counter-positions are reversed (Lonergan, 1972, p.250)."

2.6 Interlude

Before moving forward to further stages, it will be helpful to outline briefly, what has been going forward up to this point in the process. Four tasks have been described 1) research with a focus on attention to gathering data, 2) interpretation with a focus on understanding the data, 3) history with a focus on judging the contexts of the various interpretations offered and 4) dialectic, deciding which interpretation(s) is worthy of further study. Each stage reflects on the results of the former stage. The results of each stage are the “datum” for the next stage, but the focus of each stage is on a different mental operation. So, researchers focus on attention, interpreters on understanding, historians on judging the story and dialecticians deciding about the progress of the story. The order of the focus parallels the unfolding structure of human knowing (Henman, 2013, p.51, Lonergan, 1992, p.299). Specialization is grounded in the cognitive operations. Because it follows the cognitive order, from experience (attending to data), understanding, judging and deciding, it provides a greater possibility of more cumulative and progressive results. Such interdependence of the emerging specializations brings to the process a form of collaboration that is functional in as much as each specialist is intentionally focusing on providing data for the next task.

The results of the first phase provide data for the second phase. A further feature of these four specialities is that they bring forward work from the past into the present with an orientation to the future. The second phase begins with the speciality foundations but springs from the dialectician’s efforts to point towards progress.

2.7 Functional Foundations

This second phase of functional collaboration, as an orientation to the future, pushes forward the decisions of the previous specialty on what specifically is a position from phase one. Foundations, the fifth speciality, is focused on decision as is dialectic. Dialectic determined which explanation was the best available from those offered by the historian. Foundations focus on whether or not the interpretation offered is an adequate explanatory account of the data. Are there results from the previous work that will lead to further developments in the field of neuroscience research relating to medications to improve working memory and treat Alzheimer’s disease? This stage of deliberation is one of appropriation of the researcher’s own procedural cognitional operations that underlie the position. The following quotation from the discussion section of their article states what the researchers considered as the main result of their experiment.

> “The results of this study show that enhancement of cholinergic neurotransmission results in an improvement in WM efficiency that is correlated with an alteration of brain activity in a cortical region known to play a central role in WM.” (Furey et al, 1997)

The specialty foundations, takes a position on the decision offered in dialectics, but what is a position? Lonergan offers the following as the cognitional and the epistemological foundations of a position. The decision offered in dialectic will be a position if:

1) the knowledge reached is the result of the process of intelligent and rational operations and not some sub-division of the ‘already out there now’;

2) the researcher becomes known when he or she affirms him/herself intelligently and reasonably and is not known yet in any prior ‘existential’ state; and

3) objectivity is conceived as a consequence of intelligent inquiry and critical reflection, and not as a property of vital anticipation, extroversion, and satisfaction (Lonergan, 1992, p.413).[d]

Foundations, then, decides if the account offered is an explanatory account of the data correlates with the three characteristics of a metascientific position. The above quotation from Furey is a descriptive account. A partial explanation for this result is that physostigmine which is an acetylcholinesterase inhibitor increases the duration of action of acetylcholine at the synapse. Regional blood flows in the prefrontal cortex reacted differently than expected, and the authors were unable to explain this and offered various possible explanations. No definitive explanation was offered in the article. Underlying this failure is methodological unclarity. Foundations, then focuses on what methodological improvement in a given research experiment is a position that is worth passing on. Resolving the lack of a methodological clear explanation serves as a position to be passed on to our next specialty, policies.

2.8 Functional Policy

The task of metapolicy is to work out what plans can be constructed or developed grounded in the position taken in foundations. The focus is on judgment, to develop policies and to judge which policies are viable. The function of developing policies is to establish a sequence of plans of operation that are orientated towards further development within the science. What improved plans of operation can be developed based on the results of Furey's experiment? The results of Furey's experiment reveal that further experimentation is required especially as some results were unexpected regarding the reduction of rCBF in the right prefrontal region. What is the methodological explanation for this and how is it relevant to working memory? A policy to be established is that further precise experimentation, regarding the correlation between changes in brain activity and the enhancement of cholinergic neurotransmission be carried out in an effort to understand the unexpected results. We now move to our next specialty, systematics, which focuses on understanding what this policy means in the full context of a genetic systematics of the science.

2.9 Functional Systematics

Systematics focuses on the cognitive act of understanding. The specialist is attempting to understand contextually the results of the prior specialities that have culminated into policies. The overall outcome is to provide a genetic systematic understanding of the policy that can be developed into an adequate form of communication for both all other seven specialists and for the various possible audiences. What does the policy of further experimentation mean? On what forms of experimentation should researchers focus? What methodological steps, if any, have been missed or operationally misplaced? These questions are a small sampling of the types of questions that systematics attempts to answer in relationship to the particular experiment discussed in this article. But to conceive of it in its intrinsic structure is a huge task of the future. There is at present little reach towards even an imagining of the layered structuring of its developmental neurodynamics. Think of the problem of accounting for the evolving patterns of the pre-natal brain; think of the growth of a sunflower. Then think of an inquiry into such different thinkings that would become a genetic sequencing of the open advancing of theories of all such things.

2.10 Functional Communications

The understanding that has come forward from systematics must now be expressed selectively in various ways that are appropriate to the various possible audiences. Those audiences certainly include researchers, clinicians and non-technical. Furey's article was written for other researchers. The language is technical, and one requires a background in neuroscience in order to understand the meaning correctly. Clinicians would have some grasp of the article's meaning but an adequate form of communication for the clinician would focus more on possible treatment regimens. The patient or the non-technically trained person would require another form of expression that would provide that group with some common sense description of what is going forward. At this stage, Fuery's work would not warrant any treatment regimens.

For our purposes the first form of communication is relevant, that of the technical form of expression to other experimental neuroscientists. This form of communication is now data to be recycled through the eight functional specialities. Note that the communication also is to reach the various specialists. In other words, the process of functional specialization begins again, but with a fresh lift of method and context.

The results of Furey's work became data for further experimentation. In fact, many experiments were carried out in the years following Furey's work. F. Coelho and J. Birks carried out a study of experiments and reviews by searching the Cochrane Controlled Trials Register. One could detect elements of our precise collaborative process in this work, but it would be a separate article. The overall conclusion was that the evidence of effectiveness of physostigmine for the symptomatic treatment of Alzheimer's disease is limited (Coelho and Birks, 2001). This result differs from the conclusion of Furey's 1997 article.

> "The results of this study show that enhancement of cholinergic neurotransmission results in an improvement in WM efficiency that is correlated with an alteration of brain activity in a cortical region known to play a central role in WM" (Furey et al., 1997).

It is to be noted that Furey's experiment focused on WM in healthy subjects whereas Coehlo and Birk's search through experiments and reviews focused on experiments with AD subjects. The interpretation of these results led to other experimentation with the cholinergic drugs donepezil, rivastigmine and galantamine in order to assess their possible aid in the treatment of AD. These reviews can be viewed at the Pub Med, US National Library of Medicine at:http://community.cochrane.org/sites/default/files/uploads/EPPR/CDSR_Impact-factor_and-usage-report_2013.pdf or the Cochrane Library Database Systems at: http://www.ncbi.nlm.nih.gov/pubmed/16437532 .

The above search by Coelho and Birk is classified as research, the first specialty, a gathering of statistical data to be cycled through the eight functional specialities. In that manner of organizing tasks, a higher control of understanding is initiated.

Dr. Furey has continued with the National Institute of Mental Health (NIMH) to experiment with working memory and various studies have been published of her results. See: https://intramural.nimh.nih.gov/research/clinicians/sc_furey_m.html

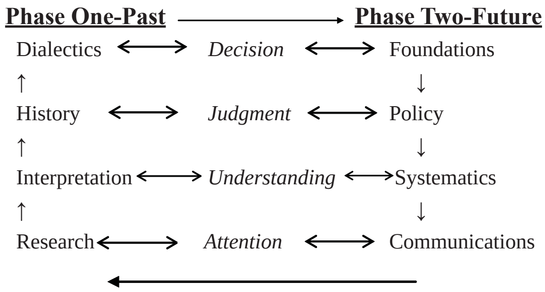
for some of her publications and more recently publications with Science Direct (Furey, 2009, pp.322-332). Furey's work influenced the focus and expansion of her later research as well as others. In that manner, there was ongoing collaboration and extension of the original work into other possible zones. What that process lacked was a division of labour structured by the order of the operations of human cognition, as outlined in this article above, but the components of that possibility were there.

2.11 Functional Specialization (Lonergan, 1972, ch.5; Shoppa and Zanardi, 2014, p. 28; McShane, 2013)

A brief outline of the different specialities and their functions has been provided above. The following provides a brief overview of the structure and meaning of this outline. The full work of research from data to results has been divided up into eight tasks grounded in the cognitive operations of the human intellect. Why are there eight divisions? There are four distinct operations of the intellectual process: attention, understanding, judgment and decision. These four operations give a heuristic pattern to knowing. Each operation presupposes the former operation as well as reaching for the succeeding operation. Data evoke curiosity expressed in the form of a question. A question seeks insight or understanding, understanding requires formulation into a judgment and judgment occurs as an answer to an IS question; Is it so? A decision is in the form of a to-do Yes or No regarding the method of verification. This heuristic is developmental as former verified insights into data form the ground for further questions and insights to be added to the composite of knowledge in a particular zone.

Each functional specialty is grounded in and focused on one of the cognitive operations so that development is made possible in an organized manner. There is a methodological ordering of content of the science in question (McShane, 1970, p.259). The first four specialties, the first phase, bring forward work from the past, and the second phase is orientated towards the future as to what this former work can contribute to the development of a particular zone or science. The following diagram provides an image of the flow of functional specialization.

A brief summary of the eight specialities describes the specific focus of each specialty (Anderson, 1996, p.167).



Research: Collecting and selecting the relevant data

Interpretation: Establishing the meaning of the data.

History: Working out what is going forward.

Dialectics: Sorting through the various interpretations and histories with the aim of deciding which one is the best explanation.

Foundations: Expressing the best directions forward in a way that is not tied to particular places, ages and times.

Policy: Reaching for relevant pragmatic truths within a foundational context.

Systematics: Drawing on past strategies and discoveries while envisaging future concrete possibilities and their probabilities.

Communications: Collaborative reflection on the local level that selects creatively from the range of possibilities developed in the prior seven specialities with a view to developing forms of communication to the various possible audiences.

3. DISCUSSION

In the **Introduction**, I quoted two definitions by Bernard Lonergan and raised two questions, which I repeat here and attempt to answer. Method is a framework for collaborative creativity (Method in Theology, 1973, p.xi) and method is a normative pattern of recurrent and related operations yielding cumulative and progressive results (Method in Theology, 1973, p.4).

In as much as each of the specialties is grounded in the heuristic structure of cognition there is also a functional capacity of performance imbedded in the structure. Each specialty has a function to be passed on to the next specialty and those functions form an interlocking of interdependence that works toward a completed whole. The division of labour that functional specialization orchestrates also provides a form of collaboration that increases the probabilities of cumulative and progressive results in a science. No scientist today can be a specialist in all zones of a science (Zanardi, 2011, pp.19-54).[e]

Neuroscience draws on physics for its understanding of electrical voltage regarding synaptic events, chemistry and biochemistry, cellular biology, anatomy, physiology, and psychology in its attempts to understand the human brain and its relationship to the body, to development and to consciousness.

> "For good or ill a division of labour has to be accepted, and this is brought about by dividing and then subdividing the field of relevant data. [...] to make the specialist one who knows more and more about less and less" (Lonergan, 1973, p.125, Agoritsas, 2013, p.448).[f]

A division of labour focuses not just on the data of the content results of each specialty but also on the data of the cognitive operations making possible a methodical ordering of content which makes possible a higher probability of cumulative and progressive results in an age of ever increasing data. Such a division distributes the various tasks in an orderly and manageable manner. The focus on both the data passed on from one specialty to another and on a particular cognitional operation challenges the scientist not only to be a specialist in one zone of a science, such as the influence of drugs on working memory, but also as a specialist in one of the functional specialities. So, the specialist focused on history need not only an adequate background on working memory as it pertains to neuroscience but a good knowledge of the history of work accomplished on working memory and an understanding of the role of judgment in scientific knowing. Would a normative pattern of related operations be a framework for collaborative creativity and furthermore, would such activity provide cumulative and progressive results? Creativity is the exercise of the human capacity to raise the questions that have not been asked and then to follow through to achieve the insights that call for verification. There is the challenge of openness in the scientist's psychological and intellectual poise towards their work (McShane, 2013, chs 3 & 4). Openness is expressed in the form of one's curiosity, one's ability to ask questions, uninhibited by ulterior motives.

> "Arts and our aesthetic experience in the form of interpretation are thus connected to how we learn" (Gillis, 2015, p. 138).[g]

Curiosity is the genesis of one's questions leading to understanding, the normal and natural resolution to a question (Henman, 1984, ch.1 & 2. Lonergan, 1992, pp.34-35). Any other motive for asking a question becomes an inhibition to scientific achievement (Lonergan, 1992, Ch.6, sec. 2.7 & ch.7 sec 6, 7, 8).

There are three distinct forms of questions that are exercised during the functioning of the eight functional specialities. There is the "what" question in functional research: what data are relevant to this study? There is the what question for interpreters: what is the meaning of this datum? The historian: what is the context of this interpretation? The dialectician: what interpretation is the best? The Foundational person shifts to a new form of question: an Is it so? type question or Is this interpretation a position? Policy asks the question: What is to be done with this interpretation? Systematics asks what this policy means. Communications asks what form of communication is to be developed and for whom. Therefore, we have What questions, Is questions and What to do questions.

Questions can have many motivations or distractions. A question normatively seeks understanding. Functional specialization will begin to offset ulterior motivations by its focus on cognitive operations. Such extended focus over time would achieve this outcome. That achievement would increase the creative aspect of curiosity with a more focused attention on the desire to understand as opposed to other motivations (Henman, 2010, 2012). Because the pattern of functional specialization divides the question types and cognitive operations among specialists, it encourages and shares the creative capacity among the specialists increasing the probability of development. This sharing of intellectual capacities further reveals the collaborative character of functional specialization.

Cumulative and progressive results occur when labour is divided along the lines of the cognitive operations because the heuristic structure of attention, understanding, judgment and decision are the ground of human progress (Lonergan, 1992, p.8). Insights correct, revise or build on former insights. Insight is an integral operation. The centrality of insight in cognitive activity provides the possibility for development in a science or zone of enquiry. The act of insight integrates former insights into a higher viewpoint modestly exemplified in the transition from understanding addition to understanding subtraction or the transition from Newtonian mechanics to Relativity theory. The emergence of new questions and new insights is not an automatic process, but the order is intelligible. They are the result of a dedication to understand, or the unrestricted desire to understand (Lonergan, 1992, pp.667-669), a curiosity that in principle, knows no bounds.

4. CONCLUSION

The operation of functional specialization in the sciences would eventually implement Generalized Empirical Method (GEM) constituting the New Science. Its implementation would ensure that scientists take into account not only the data of sense but also the data of consciousness when performing scientific work thereby increasing the odds of a systematic understanding of data generating a genetic sequencing of instances of development. As the eight different specialists become more at home with GEM (McShane, 1976) any tendencies towards reductionism will be gradually countered (Henman, 2015). Only through the ordered functioning of the specialities, will a more adequate understanding of their function as the new science come to be appreciated in terms of the functional ordering of results that occur. Without knowledge of the order of the operations expressed in functional specialization, a degree of haphazardness is present in the work of a science.[i] Functional specialization can reduce such randomness due to the very structure of the human intellectual operations increasing the probabilities of cumulative and progressive results. The transition from present operations to GEM, taking into account both the data of sense and the data of consciousness, will be one of historical relevance and far-reaching in terms of time. It will be one of centuries before we are at home in such a process.

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Endnotes

a: Douglas' article goes to great length debating the dialectical history between pure and applied science. Reflection on scientific performance would end this debate, but such work is part of the process of a history of a developing science.

b: The issue of attention or lack thereof may be the more adequate explanation of some forms of dementia and AD. Patterns of chemistry formed as correlates to experience are related to one's conscious attention to experience. Trauma, tragic loss, relational breakdown, and the inability to finalize situations on the level of decision can create a distraction so that one's ability to attend to experience is weakened resulting in insufficient patterns of chemistry correlating to the experience. As well as searching for pharmacological solutions to forms of dementia and AD, it would be helpful to work on both this solution as well as the therapeutic side and those innate systems of dysfunctionalism that exist in current social cultures. See Martin (2003) pages 156-157 for a discussion of how repeating synapsis form more permanent memories.

c: The rules of interpretation would require a further lengthy article. See Lonergan, 1993, pp. 600-603.

d: I have edited the quotation of Lonergan to fit the particular context of neuroscience research.

e: Professor Zanardi explores methodologically the binding problem and the difficulty of working out the various correlations and processes involved in the formation of sensation. The case for functional specialization is supported by his analysis of what is increasingly found to be a series of very complex processes.

f: Agoritsas and Guyatt report that Medline publishes more than 2000 articles a day. A portion of those articles would be in the area of neuroscience and others related to the ongoing work of neuroscience. This does not include textbooks. This immensity of output only serves to further support the need for a method of organizing the content of all the sciences if development and progress are to be achieved and the probabilities of such are to be raised.

g: Gillis explores the aesthetic experience in terms of its ability to develop the openness of one's wonder as the ground of human aspiration and well-being in a world in which artistic training and scientific training can and often does stifle one's curiosity. Gillis was kind enough to allow me to read her completed thesis and she does have plans for eventual publishing.

h: Bernard Lonergan outlined functional specialization as a method of establishing theology as a science. It has been pointed out by Professor Karl Rahner that the method would also apply to any of the sciences. Rahner, K. (1970) Kritische bemerkungen zu B.J.F.Lonergan's Aufsatz: Functional specialties in theology, Gregorianum, vol.51, page 537. " Lonergan's theological methodology seems to so general that it applies equally to all sciences, and so is not a method of theology as such but a general method of science illustrated by examples from theology." Quinn (2015) explores how generalized empirical method within the context of functional collaboration will respond to the problems of imagined molecules in systems theory in biology. Pages 18-19. Shute (2015) listed the following applications of functional specialization in footnote 8, page 69.

Philip McShane has explored the implications of functional specialization in physics in "Elevating *Insight*: Spacetime as Paradigm Problem", Method: Journal of Lonergan Studies 19/2 (2001); in economics in, *Economics for Everyone* (Halifax: Axial Press, 2002), chapter 3; in linguistics in *A Brief History of Time* (Halifax: Axial Press, 1998); in musicology in *The Shaping of Foundations* Washington, DC: University Press of America, 1976), chapter 2, available online at www.philipmcshane.ca; and in literature in *Lonergan's Challenge to the University and the Economy* (Washington, DC: University Press of America, 1980), chapter 5 available online at www.philipmcshane.ca. Bruce Anderson in *Discovery in Legal Decision-Making* (London: Kluwer Academic Publishers, 1996), discusses functional specialization as applied in philosophy of law. Terrance Quinn discusses functional specialization in mathematics in "Reflection on Progress in Mathematics" *Journal of Macrodynamic Analysis* 3 (2003) 97-116. Ian Brodie has applied functional specialization to religious studies in *"Bernard Lonergan's Method and Religious Studies: Functional Specialties and the Academic Study of Religion"*, M.A. thesis, Memorial University, 2001. More recently there is Scott Halse, *Functional Specialization and Religious Diversity: Bernard Lonergan's Methodology and the Philosophy of Religion*, PhD. Thesis, McGill University, 2008. Most recently, a functional specialist approach has been applied to the practical issue of housing. See Sean McNelis, *Making Progress in Housing: A Framework for Collaborative Research* (Oxon: Routledge, 2014).

i: Theil, Stefan, (2015) Scientific American, Volume 313, Issue 4. Theil highlights the difficulty of collaboration between the European Human Brain Project (HBP) and the American Brain Initiative. Politics and funding are part of the challenge in this particular case but a more overarching and profound challenge is the establishment of a method that correlates the two projects and their desired outcomes intelligently. For the entire article see
http://www.scientificamerican.com/article/why-the-human-brain-project-went-wrong-and-how-to-fix-it/?WT.mc_id=SA_MB_20150923

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