

Reducing Reductionism: A discourse analysis of neuroscientific literature from the perspective of Critical Neuroscience

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May 21, 2018

1 Introduction

Critical neuroscience, a recent movement started by a group of interdisciplinary scholars around Chudhury and Slaby (2012) is calling a more critical attitude in the neurosciences. One of the fundamental pillars of the critique is an increasingly unquestioned commitment to the reductionist program. Similar to the Gestaltists in the 1910s in Germany who proposed a holistic approach to psychology (Koffka, 2013), or as systems biology does for medicine (Ahn, Tewari, Poon, & Phillips, 2006), critical neuroscience tries to emphasise a holistic and interdisciplinary program for cognitive neuroscience. But what is reductionism? The term is used widely in everyday life, philosophy, and obviously across all of the sciences and humanities. Especially the academic use of reductionism is often vague in its meaning. Using a discourse analysis I propose to address this difficulty and uncover reductionist discourses within neuroscientific literature. The analysed texts consist of scholarly publications within the broader field of cognitive neuroscience that may cover foundational research within neuroscience, molecular neurobiology, as well as research in psychology that relies on neuroscientific methods and have been identified as problematic by authors committed to the critical neuroscientific programme. The results may reveal how reductionism expresses itself within the text as well as beyond the limits of the written word.

2 Background & Literature

Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience (Choudhury & Slaby, 2012) was born out of a tension in the neurosciences, which “represents the need to respond to the impressive and at times troublesome surge of the neurosciences, without either celebrating it uncritically or condemning it wholesale”. (Slaby & Choudhury, 2012, p.29) It is within that

narrative when the authors then further describe two understandings of “critical” in the name for their proposed program that settles between neuroscience and the human sciences. The first one is closer to the traditional everyday meaning of a crisis, is rooted in the Greek sense of the term — a turning point or decisive point of a progression (especially in diseases) — while the secondary meaning is associated with the Frankfurt School critical theory. While there is no direct, theoretical origin within the Frankfurt School (even though Martin Hartmann (2012) does elaborate the connections between the two), critical neuroscience definitely shares the emphasis of the historico-political nature of any scientific endeavour. The practical and theoretical points of critique are manifold and hardly restricted to one discipline or method. If anything, it is true interdisciplinarity and collaborative work of sociologists of science, philosophers, cognitive neuroscientists, cultural or medical anthropologists, and historians of science (Slaby & Choudhury, 2012, p.43ff) who might be able to relieve the field of the previously addressed tension.

In chapter 9, Dumit (2012) elaborates one of the central themes within critical neuroscience — the metaphor of the *looping journey* of a “brain fact” — by describing how a such “brain facts” are birthed within the research process (i.e., research design, PET scans of patients, analysis of results, interpretation of data, production of images for publication) then find their way back into society (i.e., mainstream media taking up these reports and reproducing the images) theoretically influencing the initial subjects of research again. This metaphor is suggested as a help to think critically about given brain-based phenomena. “But wait, there’s more!” Critical neuroscience also suggests that, in addition to these first-order loops (observations of brain and behaviour), researchers should be aware of the second-order loops (observations of neuroscientists observing behaviour) in place within the current academic system.

A particular notion that is repeatedly referred to in this book and can be found in other fields that “share a sense of uneasiness” (Slaby & Chudhury, 2012, p.31) such as Science and Technology Studies, is prudence of “crude reductionism” (Slaby & Chudhury, 2012, p.15), “ruthless reductionism” (Rose, 2012, p.56 in reference to Bickle, 2006), “neuroreductionism” (again Rose, 2012, p.64), the “denouncement of scientific reductionism” (Langlitz, 2012, p.260), or even the “limits of reductionism” (Kirmayer Laurence J. & Gold Ian, 2012, p.307). In total 112 references to ‘reduct’ + (ion|ions|ionism) were identified in this piece (see Appendix A for a breakdown into chapters). But what is that *reductionism* that everyone is writing about exactly?

2.1 Definitions, definitions, and more definitions

As an avid user of the internet, the first thing I did after asking myself what exactly reductionism is, was asking Google, Wikipedia, the Stanford Encyclopedia of Philosophy (SEP), and the Internet Encyclopedia of Philosophy (IEP) for definitions. I realised quite quickly that it was hard to find a definition that was not either too broad (or even failed to define without a circular usage of ‘reducing’) or relied on pre-established knowledge from a discipline.

Let us briefly go through some examples: The IEP (which is a highly regarded and peer-reviewed encyclopedia) says that “reductionists are those who take one theory or phenomenon to be reducible to some other theory or phenomenon.” (Ney, n.d., n.p) which starkly contrasts with the entry *Scientific Reductionism* in the SEP (another similarly prestigious, peer-reviewed philosophical resource):

“The term ‘reduction’ as used in philosophy expresses the idea that if an entity x reduces to an entity y then y is in a sense *prior to* x , is *more basic than* x , is such that x *fully depends upon* it or is *constituted by it*. Saying that x reduces to y typically implies that x is *nothing more than* y or *nothing over and above* y .” (van Riel & Van Gulick, 2016, n.p.; emphasis in the original)

Others often exert certain assumptions, in this case, epistemological and ontological ones, in their definition:

“Fundamental intuitions of reductionism include: (1) The whole is not greater than the sum of the parts. (2) The behaviour of the whole is *caused and explained* by the behaviour of the parts. (3) There is a *unity to the world and to science*.” (Ladyman, 2007, p.322)

Apparently, the term reductionism is used in various contexts and meanings in science, philosophy, and everyday life. Ian Hacking faced a similar challenge when he set out to write his influential piece on social constructionism *The Social Construction of What?* (Hacking, 2001). Rather than simply tackling the question “What is constructionism?” which would be equally hard to answer in a satisfactory manner as the question “What is reductionism?”, he investigated the actual primary literature and tried to analyse how scientists had interpreted and used the term. The next section is a brief outline of the results of a tentative analysis that I might have named *The Reduction of What?*. The presented results are an excerpt from the final report produced for the graduate course *Science, Technology & Culture* (IAT803) under the instruction of Dr Kate Hennessy.

2.2 Three types of reductionism

Hoyningen-Huene (1989) argues that the big common types of reductionism are ontological, epistemological, and methodological while specifically referring to literature in the life sciences (Ayala 1974; Hull 1981; Mayr 1982, pp.60-63). Another type of reductionism that requires some further elaboration is what analytical philosophers usually refer to as *scientific reductionism*; claims and theories about scientific reductionism in some sort relate to the way science works, to the way assumptions and evidence is used, and also about the success of science (van Riel & Van Gulick, 2016). For our purposes, it is sufficient to

replace treat the generic term reduction equivalently with scientific reductionism.

In what follows, I will introduce three types of reductionism based on secondary literature in the general philosophy of science and life sciences, which are fittingly named for the kinds of matters they reduce.

2.2.1 Ontological Reductionism

Ontological reductionism is a metaphysical position that in some way asserts that reality consists of a minimal number of substances. While one might, in most cases probably rightly, be reminded of some sort of monism (e.g., materialism — the belief that the world including cognition and consciousness reduces to material exchange of matter) it is important to notice that a commitment to ontological reductionism does not come with a specific number of substances (e.g., monism and dualism) nor preference for one (e.g., materialism and idealism). Most authors seem to agree on the terminology in this case (e.g., Ayala & Dobzhansky, 1974; Hoyningen-Huene, 1989; Ladyman, 2007; Ney, n.d.; van Riel & Van Gulick, 2016) with the exception of Mayr (1982) who talks of *constitutive reductionism* in biology. “It asserts that the material composition of organisms is exactly the same as that found in the inorganic world” (Mayr, 1982, p.60) which basically constitutes a kind of ontological reductionism with specific qualities, viz., physicalism.

2.2.2 Epistemological Reductionism

This is the one kind of reductionism that most of the literature in philosophy (of science) has been about. Without going into the technicalities and details of analytical philosophy and logic, epistemological reductionism deals with scientific theories which are proven to be special cases of other more general theories or laws. The most famous (or at least most discussed by the philosophers of science) examples are the laws of motion formulated by Kepler and Galileo which were then reduced to Newtonian mechanics, which in turn was then reduced to Einstein’s general relativity. While most authors (Ayala & Dobzhansky, 1974; Honderich, 2005; Ney, n.d.; van Riel & Van Gulick, 2016) use these definitions — sometimes also simply called *theory* or *intertheoretic reductionism* — a slightly more generalized account is given by Hoyningen-Huene (1989, p.30) who describes the epistemological reductionist position as the one which assumes that “a knowledge of all the (relevant) properties of the elements of one level of the organizational hierarchy, together with a knowledge of how these elements are arranged at a particular higher level, would in principle be sufficient to redefine all the properties of, and derive the laws governing, the entities of this higher level.” This broader definition now introduces some vocabulary which has been highly discussed in the recent decades as anti-reductionism has been on the rise (Nagel, 1998). Specifically concepts such as organizational hierarchy, also known as levels of analysis, closely connected to the ideas of causality, emergence, and supervenience. For instance, an epistemological reductionist represents a po-

sition that strongly rejects emergence, which is the introduction of new causal power while between levels of analysis, i.e., in Mayr’s words “knowing all properties at a lower level in the organizational hierarchy” would not suffice to explain all properties and laws at a higher one. The topic of emergence and the relation of theories and causality has been quite visible in popular science magazines such as *The Scientific American* or the *Quanta Magazine* (Koch, 2014; Wolchover, 2017).

2.2.3 Methodological Reductionism

The third and final type of reductionism relates to the actual practices of science. While ontological reductionists have a certain position about metaphysics and epistemological reductionists have certain assumptions about how scientific knowledge is structured, methodological reductionists believe in a certain way of acquiring new knowledge, which is also known as *explanatory reductionism* (Mayr, 1982, p.60). The traditional mode of scientific enquiry, established throughout the last centuries, has been one that orients itself to a reductionist position, emphasising the importance of the parts rather than the whole. Mayr (1982) provides some examples in the life science: the way genes work was not fully understood until Watson and Crick discovered the structure of DNA. Likewise, our understanding of organs heavily relies on cellular and molecular processes.

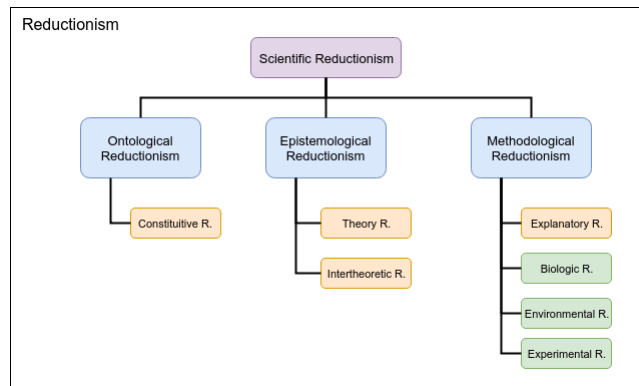


Figure 1: Scientific reductionism and three subcategories. Orange terms are often used synonymously with the blue terms. The three green terms are special subterms used in psychology to describe different modes of methodological reductionism.

2.3 Critical Neuroscience & Reductionism

Out of the 16 chapters that mentioned reductionism (or reduction) only Kir-mayer and Gold (2012) also provided a closer discussion of the concept. It is

great to see that their basic topology coincides with my classification extracted from the secondary literature, while, it is important to note that Kirmayer & Gold also, in this justifiably, enter their discussion from a point that is already assuming knowledge and familiarity with cognitive neuroscience and its controversies. Furthermore, the theory shows all three kinds of reductionism can be expressed in varying degrees of explicitness (e.g., the application of a certain method might imply a methodological and epistemological reductionist position, while not committing to an ontological one).

As Slaby & Choudhury (2012) pointed out, critical neuroscience is interested in investigating and questioning both first-order and second-order loops within cognitive neuroscience. Among the four specific suggestions they make for examples for a fruitful crossover between the socio-cultural human studies and experimental neurosciences is:

“examining the subtle relationships and feedback loops between popular opinion or ideologies about the brain and findings in neuroscience.” (Slaby & Chudhury, 2012, p.43)

A discursive analysis of reductionism in neuroscientific literature and an operationalisation of the concept would open the door for further empirical investigations of these “subtle relationships and feedback loops” in neuroscience, specifically the ones impacted by one of the varieties of reductionism that the authors are warning against.

3 Research Interest & Research Questions

A problematization of unquestioned reductionism is fundamental to the critique of contemporary neuroscience voiced by critical neuroscience as proposed by Chudhury and Slaby (2012). However, the concept of reductionism itself is manifold in its usages and meanings intra- and interdisciplinary. This research project attempts to explore the implicit and explicit reductionist discourses in the neuroscientific literature.

1. How can reductionism be observed on a textual level in the literature that has been referenced in the context of a critique of reductionism?
 - i. How does epistemological reductionism reveal itself?
 - ii. How does ontological reductionism reveal itself?
 - iii. How does methodological reductionism reveal itself?
 - iv. How does non-reductionist reveal itself?
2. How does reductionism express itself in the literature that has been referenced in the context of a critique of reductionism beyond the confines of the text?
 - i. What are the sociocultural indicators for reductionism?

- ii. What are the grammatical and stylistic indicators of reductionism?
- iii. How do images and figures relate to reductionism?

4 Ethical Dimension

No ethical considerations apply to the project.
 No conflict of interest to be declared.

5 Methodology

The intended analysis will be carried following the directed approach to content analysis (Hsieh & Shannon, 2005) the initial categories are derived from the theory, while the goal is to validate or extend this scheme. Up to this point a content analysis, it here where I want to introduce elements from critical discourse analysis according to Fairclough (1989, 1995) while also incorporating the concept of *evolutionary coding* from Mayring (2002, p.120).

The three basic categories derived from the theory are:

- Ontological reductionism
- Epistemological reductionism
- Methodological reductionism

Guided by the theory I will then continue to extend and, hopefully, validate these categories while reading texts from my sample. As the basic categories are very broad I am expecting that further subcategories will emerge. Ideally, these subcategories will be grounded in the texts, thus, empirical data. Following, a brief example of possible subcategories and examples:

Table 1: Example for a subcategory and example for each basic category

Basic category	Subcategory	Example
Ontological reductionism	Commitment to functionalism	<i>Authors endorse Emile Durkheim</i>
Epistemological reductionism	Neurolaw	<i>Authors investigate the neural correlates of crime</i>
	Commitment to functionalism	<i>Authors suggest hormone treatment for depression</i>
Methodological reductionism	Reductionist methodology	<i>Authors use fMRI</i>

Some more levels of analysis in this investigation that go beyond a qualitative content analysis have been taken from Schneider (2013) which proved to be a succinct and practical guide to the critical analysis of a corpus.

Context and production process of the texts

When, where, by whom were the articles written? Where were they published? Are the publications openly accessible or behind a paywall? Are the authors known for a particular philosophical position in regard to reductionism?

Identify cultural and intellectual references

Which other sources and authors does the text reference? Which ones do they omit?

Identify linguistic and rhetorical mechanisms

Are there certain groups of words that are used frequently? Do they belong to certain supercategories? Is the text written in a certain style? What about grammatical features such as passive and active voices, use of first-person and third person? Do the authors use metaphors and analogies? Especially in the context of ontological and epistemological reductionism: Are the authors using modalities (i.e., should, could) or evidentialities (i.e., obviously, of course, as everyone knows, and other)?

Visuals

Are the authors using figures and images in their articles? Highly relevant as the negative effect of brain images on judgement tasks has been shown (McCabe & Castel, 2008).

5.1 Sample

Unfortunately, I do not have the privilege (and very probably no one ever had) the possibility of repeatedly resampling from the very population of neuroscientific literature as Krippendorff (2012) suggests as one possible approach. Thus, in order to increase the probability of sampling texts that are able to answer my research questions, I will rely on the literature identified by the three articles that specifically address reductionism as a problem in *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience* (Choudhury & Slaby, 2012). These three articles are The Need for a Critical Neuroscience (Rose, 2012), Radical Reductions - Neurophysiology, Politics and Personhood in Russian Addiction Medicine (Raikhel, 2012), Re-Socializing Psychiatry - Critical Neuroscience and the Limits of Reductionism (Kirmayer & Gold, 2012). A close reading of this three source texts will identify my sample. In order to be considered, articles in the sample need be cognitive neuroscience publications, been mentioned by one of the source texts in connection to reductionism.

I have not finished this process yet and cannot assess the final sample size yet. However, considering the outlined detail going into the development of the coding scheme and further readings of the text I will limit the number of articles to a maximum of 20.

6 Strengths and limitations

The benefit of relying on the theory to create basic categories which are then iteratively extended with empirical data is that the results do not rely on the extensiveness and exhaustiveness of the theory. Furthermore, it is possible to identify a total misfit in the initial basic categories.

On the other hand, the results are highly dependent on the sample, which does not immediately imply that the validity is problematic. Rather, the results need to be interpreted and seen as what they are. A representation of how the specific authors in our sample constructed a reductionist discourse within the particular publications.

Finally, the overall approach of combining evolutionary coding and elements from critical discourse analysis is flexible enough to accommodate the structured analysis of a concept like reductionism which is highly undetermined and vague in its interpretation and usage. However, even more care has to be taken that the individual steps of the analysis and interpretations do not overstep their causal limits.

7 Funding and Timeline

No funding required.

Table 2: Work packages and timeline

From	To	Work package
19.04	01.05.2018	Specify sample
19.04.2018	unknown	Review and integrate feedback provided on proposal
01.05.2018	15.05.2018	Expand theory into the life sciences
16.05.2018	31.05.2018	Write up: Theory
01.06.2018	30.06.2018	Empirical work
01.07.2018	31.07.2018	Write up: Results
01.08.2018	30.08.2018	Finalize first draft

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9 Appendix A

Table 3: Table 1. Word count of ‘reduct’ in *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience* (Choudhury & Slaby, 2012)

	Chapter*	Author	R
1	Proposal for a Critical Neuroscience	Jan Slaby, Suparna Chudhoury	9
2	The Need for a Critical Neuroscience	Steven Rose	21
3	Against first nature	Martin Hartmann	2
4	Scanning the lifeworld	Shaun Gallagher	6
5	Toys are Us: Models and Metaphors in Brain Research	Cornelius Brock	4
6	The Neuromance of Cerebral History	Max Stadler	1
7	Empathic Cruelty and the Origins of the Social Brain	Allan Young	3
8	Disrupting Images	Simon Cohn	4
10	Radical Reductions	Eugene Raikhel	11**
11	Delirious Brain Chemistry and Controlled Culture	Nicolas Langlitz	3

Table 3: Table 1. Word count of ‘reduct’ in *Critical Neuroscience: A Handbook of the Social and Cultural Contexts of Neuroscience* (Choudhury & Slaby, 2012)

	Chapter*	Author	R
14	Cultural Neuroscience as Critical Neuroscience in Practice	Joan Y. Chiao, Bobby K. Cheon	1
15	Re-Socializing Psychiatry	Laurence J. Kirmayer, Ian Gold	39**
16	Are Mental Illnesses Diseases of the Brain	Thomas Fuchs	2
17	Are there Neural Correlates of Depression	Fernando Vidal, Francisco Ortega	2
18	The Future of Critical Neuroscience	Laurence J. Kirmayer	4

*Counts of ‘reduct’ in the introduction and index were ignored as they reflect the contents of the chapters. **Repeated counts of ‘reduct’ because of the chapter title and typesetting of the book were removed.