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# St. Anne's Academic Review

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# St. Anne's Academic Review

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## Letter from the Editor

Emily Schultz

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Appearing in this seventh volume of the St Anne's Academic Review (STAAR) are thirteen pieces from current or recent postgraduate students in the humanities, sciences, and social sciences at St Anne's College, University of Oxford. This edition of STAAR thoughtfully weaves together interests across academic disciplines to give readers a window into current postgraduate research at St. Anne's. Due to the interdisciplinary nature of this publication, and at the risk of forgoing consistency, I encouraged contributors to maintain writing and referencing conventions unique to their disciplines. I greatly admire each contribution's achieved balance between technical rigour and accessibility to an audience of nonspecialists, undoubtedly a feat worthy of praise. This seventh edition invites readers into thirteen different conversations unique to the corresponding areas of research. Despite thematic and methodological differences, each piece seeks to explore its respective discipline more fully, an attribute which unifies the work of all contributors.

I am both delighted and proud to have worked alongside a team of such diverse talents to publish this edition of STAAR, and offer my sincerest gratitude to the contributors and editorial staff for the production of the issue. Not only were they a joy to work with, but I found them each inspirational in their diligence, academic integrity, and commitment to the aims of the project. Additionally, I am thankful for the guidance of Valeria Taddei, the MCR Academic Affairs Officer, and for the help of Alex Jamieson, my Assistant Editor in Chief. Their support during the editing, formatting, and publication process was essential to its successful completion. Lastly, I would be remiss not to acknowledge Kal Leung for sharing his talents in designing the cover for this publication. It has been a pleasure to serve as the Editor in Chief, and an honour to have worked alongside such bright minds and kind souls. I wish you all the best, and sincerely hope the readers enjoy our seventh issue of STAAR.

Sincerely,

Emily Schultz  
Editor in Chief

# Letter from the Principal

Helen King QPM

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I would like to start by expressing my thanks to the Editorial Board for their diligent work in bringing this publication to fruition. I am sure that this has not been an straightforward task. They can rightly feel proud of what they have achieved, as should the authors whose work you find here.

Each of the Editorial Board and everyone who has contributed an article has also been carrying their own academic workload. Undertaking a postgraduate degree at Oxford is not an easy option and can feel both demanding and isolating. So it doesn't always feel comfortable taking on additional responsibilities alongside the hours of reading or lab work, deadlines, days of doubt, if not despair, and the sheer slog of writing up the assignments or submissions required by your programme. That everyone involved in STAAR voluntarily committed their time to this endeavour is greatly to their credit.

In managing the pressures of graduate study I believe Oxford Master and Doctoral students have an advantage, if they choose to take it, of having a College life as well as a Departmental one. This publication is a literary manifestation of what a College MCR is: a place where individuals, each deeply immersed in different but specific areas of study, can come together and enrich each others' thinking with their diverse expertise. Sciences, humanities, arts and varied disciplines within each are meticulously described and explained in each of the articles in this volume in a way that does not require expert prior knowledge. Thus each of us can read STAAR as intellectually curious equals.

St Anne's College has Eleanor Plumer and Robert Saunders Houses, but of course they are not the MCR. St Anne's graduate students are the MCR and represent a hugely diverse and talented group of people. I would predict that whatever path your future takes, you are unlikely ever again to be part of such an interesting and varied cohort. If you're not convinced then read STAAR and remember that this publication has involved only a small proportion of the total of the MCR. This also only captures a specific area of each of their individual interests and that beyond their academic interests our MCR members also represent many nationalities, languages, backgrounds, cultural and sporting talents, charitable and political causes, and personalities. Just as I encourage you to sample the full range of material included in STAAR I would also encourage graduate students to involve themselves in MCR life. Its relevance to particular academic studies may not be immediately apparent, but we all learn from others and from new experiences and perspectives.

This inclusive, open minded, outward looking approach is one that has long been a part of St Anne's history. It means that students from St Anne's leave with much more than a degree.

I started by thanking the Editorial Board and contributors. I will end by thanking you the reader, for even in the act of absorbing yourself in this publication, you are participating in the rich life of the MCR. Learn, enjoy, contribute!

Helen King  
Principal of St. Anne's College

# The Cypherpunk Vision of Techno-Politics

Maud Barret Bertelloni

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The cypherpunk movement emerged out of the convergence of online cryptology discussion groups and a mailing list founded in 1992 by technologists John Gilmore, Timothy May, and Eric Hugues. A year later, Hugues wrote “A Cypherpunk’s Manifesto”,<sup>1</sup> coining a name that combined the “cypher” prefix, both a reference to cryptography and to the secrecy which it preserves, with “punk”, a term with anarchist, anti-authoritarian and generally irreverent connotations.<sup>2</sup> The name echoed May’s “Crypto-anarchist Manifesto” presented at the group’s first meeting,<sup>3</sup> in which he highlighted the transformative potential of technologies related to cryptography. Throughout the years, the group assembled – online and offline – some of the most important technologists and cyber-activists in the world,<sup>4</sup> forming organizations ranging from the Electronic Frontier Foundation to WikiLeaks, tied to the development of technologies ranging from the onion router Tor to various crypto-currencies.<sup>5</sup> They shared the conviction that their anarchist beliefs were to be implemented through the technologies they developed, the majority of which relied on cryptography. In this sense, the cypherpunk movement can be termed a techno-political movement, because it realises its political aims through technological means.<sup>6</sup>

Although some view “techno-politics” as the political controversies over technological questions, particularly over their accessibility or over the openness of the Internet,<sup>7</sup> the cypherpunk movement seems to take a more expansive view of techno-politics, believing that technology itself, when implemented, is a political tool in its own right and serves to propagate particular values. This echoes Langdon Winner’s theory that artefacts have inherent politics, by design,<sup>8</sup> just as networks like the Internet, in Lawrence Lessig’s words, are regulated by architecture.<sup>9</sup> But in this case, would it still be possible to distinguish the “aims” from their technical “means”? Wouldn’t this techno-political stance

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1 Eric Hugues, “A Cypherpunk’s Manifesto”, Electronic Frontier Foundation, accessed December 20, 2016, [https://w2.eff.org/Privacy/Crypto/Crypto\\_misc/cypherpunk.manifesto](https://w2.eff.org/Privacy/Crypto/Crypto_misc/cypherpunk.manifesto).

2 Craig O’Hara, *The Philosophy of Punk*, AK Press, Oakland, 1999.

3 Timothy May, “The Crypto Anarchist Manifesto”, Activism.net, accessed December 20, 2016, <http://www.activism.net/cypherpunk/crypto-anarchy.html>.

4 Cyberactivists like Julian Assange, founder of Wikileaks, TOR developer Jacob Applebaum and Runa Sandvik, Electronic Frontier Foundation activists.

5 For instance, Zooko Wilcox O’Hearn, developer of DigiCash and founder of Zcash, Wei-Dai, creator of b-money, Nick Szabo, creator of bit gold.

6 Terje Rasmussen, “Techno-politics, Internet Governance and some challenges facing the Internet”, Oxford Internet Institute, Research Report 15, October 2007.

7 Mark Rumold, *The Freedom of Information Act and the Fight Against Secret (Surveillance) Law*, 55 Santa Clara L. Rev. 161, 2015, cited in Can Kurban, Ismena Pena-Lopez and Maria Haberer, “What is technopolitics? A conceptual scheme for understanding politics in the digital age”, Building a European digital space. (paper presented at the 12th International Conference on Internet, Law & Politics at the Universitat Abierta de Catalunya, Barcelona, July 7-8, 2016). Human Enhancement and the emergent technopolitics of the 21st century”, in *Managing nano-bio-info-cogno innovations*, ed. W.B. Bainbridge, Springer, 2006. Cited in Kurban, Pena-Lopez and Haberer.

8 Langdon Winner, “Do Artifacts Have Politics?”, *Daedalus* 109, n°1, 1989, pp. 121-136.

9 Lawrence Lessig, “The Laws of Cyberspace”, paper presented at the Taiwan Net ‘98 Conference, Taipei, March 1998.

imply that the implementation of particular technologies in turn imposes particular political values and visions?

Thus, in order to analyse the political beliefs and methods of one of the groups that has accompanied the development of the Net in the past three decades, it is pertinent to ask: What is the relationship between technology and politics in the conception of the techno-politics of the cypherpunk movement? This essay will make use of written sources, notably Eric Hugues' "A Cypherpunk Manifesto"<sup>10</sup> and Timothy May's "The Crypto Anarchist Manifesto,"<sup>11</sup> the archives of the cypherpunk mailing list, and analyses of widely circulated software, protocols, methods, and distributed technology, to render the articulation between political and technical views in the cypherpunk conception of techno-politics.

The cypherpunk movement advocates crypto-anarchist political views. The term was coined by Timothy C. May, in the homonymous manifesto, a version of which he read at the cypherpunk founding meeting in September 1992. It consists in a form of anarchy rendered possible by the use of cryptography and its applications.<sup>12</sup> The "crypto" form of anarchism is one that, as May himself later specified, is very distant from Proudhon or Bakunin's anarcho-syndicalism or Kropotkin's communal anarchism: May intends anarchism "in the same sense of anarchy used in anarcho-capitalism, the libertarian free-market ideology that promotes voluntary, uncoerced economic transactions"<sup>13</sup>, referring to Hayek and Friedman.

Apart from obvious divergence on the role conferred on the market, another difference resides in different interpretations on the meaning of anarchism, determining its nature. May rashly traces back to the term's etymology, as "literally 'an arch,' without a chief or a head"<sup>14</sup>. It is quite different, however, from the absolute negation of power, as in Proudhon's powerless order. In fact, it is not power that is contested, but its form: anarchism requires "no central control, no ruler, no leader (except by the example or reputation), no 'laws'."<sup>15</sup> Given Lawrence Lessig's thesis that normativity in cyberspace occurs through four instances, these being legislation, social norms, markets and "architecture", it is only the first of these components that crypto-anarchism rejects, for it advocates a free market and ensures social regulation through 'reputation', all this through "code"<sup>16</sup>. In this sense, the type of anarchism that is advocated is close to punk anti-authoritarian, anti-statist currents,<sup>17</sup> with appeal to individual liberty.

These traits allow us to solve the apparent contradiction raised by the proximity of the cypherpunk movement to open source movements.<sup>18</sup> As Applebaum explained in an

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10 Hugues, op. cit.

11 May, op. Cit.

The Manifesto had previously been presented at the Crypto Conference in Santa Barbara in 1988.

12 *Ibid.*

13 Peter Ludlow, *Crypto Anarchy, Cyberstates, and Pirate Utopias*, The MIT Press, Cambridge, Massachusetts, 2001.

14 *Ibid.*

15 *Ibid.*

16 Lessig, op. cit.

17 O'Hara,, op. cit., p. 27-28.

18 For instance the fact that all source code produced from crypto.is project is open source, or Cypherpunks development of open source versions of technology, like OpenPGP, OpenSSL, etc.

interview, cypherpunk attachment to free software derives from its empowering role: each individual can employ it as a tool for his own freedom.<sup>19</sup> The deployment of cryptography can help oppose governmental influence in anarchist cyberspace and foster individual independence, opposing a “general trend to defer to authority”. Technology is for cypherpunks the way to situate the primary source of agency at the level of the individual and this is a vision of techno-politics intended as the potentiation of political aims through technical means.

“Cypherpunks write code”: both at personal and systems level, to individual liberty, anti-authoritarianism and free market correspond different applications of cryptography, from implementations of public key encryption, to P2P networks and distributed-ledger-technology-based crypto-currencies. Privacy, for instance, which Erich Hugues defines as “the power to selectively reveal oneself to the world” is permitted by public-key cryptography (PKC), which ensures individual protection against state surveillance and censorship. PKC can be used for communications encryption, guaranteeing their anonymity (through plain encryption like PGP or applications like MixMaster remailers).<sup>20</sup> It can also ensure authentication (digital signatures), allowing pseudonymity, setting “persistent” and non-forgable identities, and bypassing state-assigned ones: they are, in Chaum’s words, “credentials without identity”<sup>21</sup> that enable sustained individual action free from any control other than reputation.

Individuals are also at the core of decentralized peer-to-peer networks, participating with their personal devices in tasks that range from running nodes to maintaining networks to hosting files for file sharing. This type of network can be coupled with encryption to ensure, for instance browsing anonymity, like in the case of TOR, the Onion Router. Here, the importance of “architecture” is quite evident: by setting the Internet up as a decentralised system, cypherpunks attempt to secure its lawlessness.

Finally, anonymity and decentralization are coupled in crypto-currencies that run upon DLT. Those rely on cryptographic software protocols to generate the currency and to validate transaction through the verification of the digital signature of payers’ public keys, stored on a public distributed ledger operating without central authority on a decentralized network.<sup>22</sup> Cypherpunks were involved in the development of early crypto-currencies,<sup>23</sup> and their mailing lists enabled Satoshi Nakamoto (an example of famous pseudonym) to share his manifesto, “Bitcoin: A Peer-to-Peer Electronic Cash System”. Although studies have indicated that Bitcoin might be de-anonymized,<sup>24</sup> its deployment has facilitated the

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19 Julian Assange, *Cypherpunk*, OR Books, New York, 2012, p. 42.

Another analogy with punk attachment to “DIY”, fostering individual independence.

See O’Hara, *op. cit.*

20 Mixmaster remailer was developed by Lance Cottrel, another member of the cypherpunk mailing list, using the chaumian concept of mix networks.

21 David L. Chaum, “Security without Identification: Transaction Systems to Make Big Brother Obsolete”, *Communications of the ACM*, vol 28, n 10, 1985.

22 This ledger another analogy with Chaum’s “roster” described in David L. Chaum, “Untraceable Electronic Cash”, paper presented at the Crypto ‘88 Conference. Blockchain in the case of Bitcoin but term has become a general term to refer to distributed ledger technology.

23 See above.

24 Androulaki et al. “Evaluating User Privacy in Bitcoin”, presented at the International Conference on Financial Cryptography and Data Security, 2013.

emergence of unregulated parallel markets, including money-laundering circuits and illegal markets.<sup>25</sup> Cypherpunk advocates are aware of these dangers, but perceive them as outweighed by the benefits of the elimination of state monopoly over the currency and of its control over markets. May, for instance, wrote that “crypto-anarchy (...) will allow illicit and stolen materials to be traded”; it “will even make possible abhorrent markets for assassinations and extortions<sup>26</sup>”. But “just as the technology of printing altered and reduced the power of medieval guilds and the social power structure, so too will cryptologic methods fundamentally alter the nature of corporations and of government interference in economic transactions”<sup>27</sup>, overriding concerns with an element of teleology.

Cypherpunks therefore do not only rely on technological artefacts, namely on cryptography and its applications, to potentiate their political beliefs; they also confide in their inalterable properties. Technology is not only a tool, or rather a weapon to fight the “crypto-war” that cypherpunks fight against any government attempting to extend its sovereignty over the cyberspace.<sup>28</sup> The analogy between cryptography and weapons finds echoes in David Friedman’s analogy between individual capacity to use encryption and the constitutional right to bear arms granted by the 2nd Amendment in the American Constitution; in this sense “the continuation of politics through other means” could well mean technological ones.<sup>29</sup> This technology, however, is more than a neutral tool – it is held to possess intrinsic properties, which materialise when deployed. This conception, inferred from systems theory is, according to Turner, recurrent in the “cyberculture” in which the cryptography originated.<sup>30</sup> Just as Marshall McLuhan famously stated that “the medium is the message”, Phil Zimmerman hoped that PGP would spread “like dandelion seeds”<sup>31</sup> to defeat attempts of state control on cryptography, because its diffusion, regardless of the intentions of its users, would suffice to ensure its success.

Here, however, the belief that technical artefacts have inherent political qualities could entail two types of consequences: either that “certain kinds of technology are unavoidably linked to particular institutionalized patterns of power and authority”, or that “features in design and arrangement of a device or system [provide] convenient means of establishing patterns of power and authority in a given setting”.<sup>32</sup> Cypherpunks seem to support the latter: May talks about the “technological inevitability” of the inalterable mathematical properties of prime numbers cryptography is based upon. This highlights the clear preponderance of technique over politics, whose scope, in this vision of techno-politics, is very restricted. It isn’t quite clear, however, how this natural property actually translates at the level of application, let alone for a whole society: despite the unitary principle of blockchain, for instance, there have been forks deriving from disagreements

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25 Nicolas Christin, “Traveling the Silk Road: A measurement analysis of large anonymous online marketplace”, INI/CyLab working paper, November 2012.

26 Timothy May in Ludlow, *op. cit.*, p. 26.

27 *Ibid.*

28 “The Crypto Wars: Governments Working to Undermine Encryption”, Electronic Frontier Foundation, accessed January 1, 2017: <https://www.eff.org/document/crypto-wars-governments-working-undermine-encryption>.

29 David D. Friedman, *Future Imperfect*, Cambridge University Press, Cambridge, 2008, p. 41.

30 Fred Turner, *From Counterculture to Cyberculture*, The University of Chicago Press, Chicago, 2006.

31 Andy Greenberg, *This machine kills secrets*, Penguin, London, 2011.

32 Winner, *op. cit.*

over “block size debate”.<sup>33</sup> Some crypto-currencies have set up internal governing bodies (RSC coin) and there is no evidence of the ineluctability of the development of an anarchist decentralised society through the deployment of cryptography. The first interpretation, which appears more insightful, would claim that, in line with Lawrence Lessig’s words, it is true that different architectures of software and hardware determine how people interact, or exist, in cyberspace, and reflect different philosophies about access, carrying political values. They are in this sense inherently political, but they can also be altered: it is an error of naturalism to believe that some architecture “will guarantee us freedom; that it will of necessity disable governments that want to control.”<sup>34</sup> Features in design do entail the establishment of patterns of power and authority in a given setting, but this is by no means an automatic task.

What isn’t sure either is whether technology will be a tool for individual empowerment, or at least, for the empowerment of all individuals. May again explains that with the deployment of cryptography, “something that is inevitable is the increased role of individuals, leading to a new kind of elitism. Those who are comfortable with the tools described here can avoid the restrictions and taxes others cannot.” Technology, clearly, is tailored for those who master and design it, and so is the cypherpunk cyberspace. This trait of the cypherpunk vision can be explained historically by the fact that in the context of development of cryptography, forms of deliberation other than “rough consensus and running code”<sup>35</sup> were not necessary, so long as the political self-identity of users and creators “belonged to the same equal and limited circle”.<sup>36</sup> However, the change in context tied to the privatization of the Internet and its subsequent mass deployment has brought about a great variety of new problems and views concerning the way the Net should be run. The fact that problems of political participation are not contemplated in the cypherpunk vision can help explain why debates over the Internet and cryptography have been so confrontational: from the “crypto-wars” to the “Declaration of Independence of Cyberspace”,<sup>37</sup> regardless of the intentions of the parties, teleological accounts of the impact of technology on politics leave little room for alternative stances, other than the goodwill of the technologists.

Cypherpunk techno-politics rely on technology to realize anarcho-capitalism in cyberspace, and technology is intended as more than a mere tool for political aims. Through PKC and its applications, the deployment of decentralised networks and the establishment on crypto-markets online, cypherpunks strive to emancipate the cyber realm from the interference of centralised power structures, and to confer to individuals the sole base of agency. Technology, in this sense, as embedded in artefacts design and network architecture, is considered as the inalterable carrier of particular patterns of power and authority, subordinating other political activities to a teleological and technicist vision of techno-politics, the consequences of which ought to be taken under account in the examination of the past and future development of the Internet.

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33 Grace Caffyn, “What is the Bitcoin Block Size Debate and Why Does it Matter?”, Coindesk, accessed January 5, 2017: <http://www.coindesk.com/what-is-the-bitcoin-block-size-debate-and-why-does-it-matter/>.

34 Lessig, *op. cit.*

35 These words, attributed to David Clark, are held to be the motto of the IETF.

36 Rasmussen, *op. cit.*

37 John Perry Barlow, “A Declaration of Independence of Cyberspace”, Electronic Frontier Foundation, accessed on January 5, 2017: <https://www.eff.org/cyberspace-independence>.

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# Necessary Existents and State Space Theory

Alexander (AJ) Gilbert

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Necessitism is a controversial view concerning the layout of the modal landscape. It seeks to settle the question of which things exist in the different possibilities for how our universe could have unfolded. There are good reasons to take necessitism to be correct. In §1 I will outline the view being defended before, in §2, presenting an argument for why it should be accepted. In brief, our best scientific theories commit us to the truth of necessitism. But the consequences of the view remain controversial and I will explore two ways to push back against the argument. These are the topic of §§ 3-4 respectively. Both responses will be seen to be unsatisfactory so that the argument for necessitism from state space theory remains a compelling reason to adopt the view.

## 1 Necessitism

Trump could have failed to win the electoral college vote. As a result,

Donald Trump is currently president of the USA.

is only *contingently* true. The history of the world could have played out differently and resulted in a Clinton presidency in 2017. More dramatically, it seems that Trump's very existence is a contingent matter.

(2) Donald Trump might not have existed.

His parents, Fred and Mary Anne, might never have met. Or they might have angrily fallen out on being introduced to each other and never spoken again. Or the earth might have formed in an uninhabitable region of the solar system. Indeed, there appears to be countless ways in which the history of the universe could have played out so that Trump did not exist. It is instructive to contrast this case with that of mathematical objects, which are generally taken to exist *necessarily*. Unlike Trump, there is no possible way that the world could be according to which the number 7 did not exist. More mundane entities such as tables, chairs and presidents – unlike mathematical objects – seem to exist only contingently.

According to *necessitism*, this appearance of contingency is misleading. In a slogan, this view holds that

(N) It is necessarily the case that everything exists necessarily.<sup>1</sup>

For example, Trump, like the number 7, exists necessarily. There is no possible history of the world in which Trump fails to exist. Perhaps more counterintuitively,

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<sup>1</sup> The relevant claim of modal logic is  $\Box\forall x\Box\exists y x = y$ . Necessitism has been defended by Linsky and Zalta (1994) and more recently by Williamson (2013).

necessitism is committed to the existence of *merely possible* objects. For instance, it is certainly possible that Clinton and Trump had a daughter, whom we may call 'Clump.' That is to say, there is a possible history of the world in which Clump exists. But if N is true, then Clump too exists necessarily. She exists in all the possible histories of the world, and in particular, she exists in the actual world. Or so say the necessitists.

Necessitists have argued that the most controversial consequences of their view, such as that Trump and Clump necessarily exist, withstand scrutiny. The central move is to distinguish between existence simpliciter and *concrete* existence. A concrete existent is an object that exists in space and time. Crucially, necessitists hold that an object can exist without being a concrete existent. An object might be a concrete existent in one possibility and a non-concrete existent in another. For instance, in the actual world Trump is a concrete existent, while in the possible world where his parents never met he is a non-concrete existent. Analogously, in the possible world where she is conceived by Clinton and Trump, Clump is a concrete existent but in the actual world she is a non-concrete existent. Trump and Clump both exist necessarily, since they exist in all possible worlds. But it is a contingent matter whether they are concrete or not.

## 2 Argument from state space theory

Distinguishing between concrete and non-concrete existence fails to amount to a compelling case for necessitism. Why should we complicate our understanding of what exists by allowing that Clump exists as a contingently non-concrete object? Why should we not just reject the need for the contingently non-concrete and insist that Clump *does not exist* in the actual world, although there are other possibilities in which she does exist? Necessitists have tried to motivate their view beyond these suggestive remarks in a range of ways.<sup>2</sup> Most recently, Williamson has tried to draw support from contemporary scientific practice by arguing that only necessitists can account for the successful use of state space theory. Necessitism, he claims, is presupposed by our best scientific theories.

State spaces appear throughout science and are used to formulate our best theories of the world. They appear in physics, to model the interactions of fundamental particles, as well as biology, where they can represent population changes, and economics, to describe the behaviour of stock prices. A state space consists of the set of all possible states of a physical system at a time.<sup>3</sup> Each state represents a possible way for the system to be. Typically, no path goes through every state in the space and hence some states represent *merely possible* ways for the system to be.

The central claim of the necessitist argument is that the theory of state spaces presupposes a necessitist account of what exists. Williamson claims that applications of state

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<sup>2</sup> For instance, Williamson has argued that necessitism is superior to its denial, contingentism, on the grounds that necessitist modal logic is stronger than its rivals. The former, he claims, is simpler, less *ad hoc* and supports more true generalisations about metaphysical modality. Williamson (2013).

<sup>3</sup> A state space is made up of a set  $S$  with a topological or geometrical structure, an indexing set  $T$  with an additive structure, and a set of functions  $\{f_t : t \in T\}$  such that for all  $s \in S$

(i)  $f_0(s) = s$

(ii)  $f_t f_{t'}(s) = f_{t+t'}(s)$ .

Williamson (2016a, p. 472), Nolte (2010, p. 33).

space theory in science ‘implicitly take for granted a necessitist modal logic.’<sup>4</sup> In the systems studied in science, individuals are sometimes created or destroyed. For instance, biologists use state spaces to model ecosystems where the population varies and physicists use spaces to represent particles that are created and then annihilated. It may appear to be a contingent matter what individuals there are, since a given individual may be created on one trajectory through the system but not on another. However, state space theory involves generalising over all the states and sets of states, which is in effect to quantify over merely possible individuals. Scientists regularly quantify over objects such as merely possible predators and merely possible particles, which assumes a necessitist conception of what there is to quantify over. In order to formulate the best current theories of, say, particle interactions, it is necessary to refer to particles that are concrete in some possible states of the system, but non-concrete in the actual state. In brief, state space theory involves modal commitments that can only be accounted for within a necessitist framework.

From these considerations an argument for one of necessitism’s most controversial claims, namely that there exist contingently non-concrete objects such as Clump, may be extracted.<sup>5</sup>

Contingently non-concrete objects are indispensable to our best scientific theories. If contingently non-concrete objects are indispensable to our best scientific theories, then contingently non-concrete objects exist.  
Therefore, contingently non-concrete objects exist

In order to test the strength of Williamson’s argument from state space theory, I will consider two natural responses. These contingentist manoeuvres are unconvincing.<sup>6</sup>

### 3 Response I: eliminative contingentism

One response to this line of argument would be to accept Premise II but deny Premise I. This would involve accepting the existence of contingently non-concrete objects if they could be soon shown to be indispensable to the best current theories. But, this response continues, such objects are not in fact indispensable. Rather, necessitist commitments in scientific practice can be *eliminated*. This would allow contingently non-concrete objects of state space theory to be treated as useful fictions. Although these objects do not actually exist, they allow scientists to elegantly state and then fruitfully study our best scientific theories.<sup>7</sup> If contingently non-concrete objects are eliminable from the best current scientific theories, then scientists may use them as theoretical posits without being committed to their existence.

In order to show how contingently non-concrete objects are eliminable from state space theory revisions to the logic used there may be proposed. Contingentists can try to simulate in their own terms the necessitist effect of quantification using their own logical

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<sup>4</sup> Williamson (2016b, p. 576).

<sup>5</sup> This form of argument is influential in the philosophy of mathematics, where a similar argument is taken to support mathematical platonism. Cf. Quine (1960, Chapter 7), (1969, p. 97) and Putnam (1971, p. 37).

<sup>6</sup> Contingentism is the denial of necessitism, namely the claim that some objects only possibly exist.

<sup>7</sup> Field (1980) defends this response to the Quine-Putnam argument in the philosophy of mathematics.

apparatus. Contingentist quantifiers range only over *actual* objects. Nevertheless, they allow contingentists to simulate the effect of necessitist quantification over contingently non-concrete objects.<sup>8</sup> Crucially, however, the reconstruction breaks down in the case of second-order quantification, where merely possible *properties* as well as merely possible objects are quantified over.<sup>9</sup> The necessitist account of second-order quantification cannot always be simulated in contingentist terms. Yet such quantification over properties of possible states is ubiquitous in the study of state spaces. Hence, revising the logical principles alone does not show how contingently non-concrete entities can be eliminated from the best current scientific theories.

It may be hoped that the contingentists response can be sustained if mathematical principles in state space theories are revised. One such principle central to the use of state spaces in analytic mechanics is Hamilton's Principle.<sup>10</sup> In the case of simple systems, there is a statement equivalent to Hamilton's Principle that does not mention possible histories of the relevant system.<sup>11</sup> This is precisely the kind of result needed to show that the *eliminative* response is viable. But for mechanical systems that are not simple, this suggestive equivalence breaks down. Moreover, there is no reason to suppose that the modal commitments can be eliminated in the more complex cases. While simple principles in analytic mechanics can arguably be expressed without necessitist commitments, attempts to remove these commitments from *all* the mathematical principles of the best current theories appear hopeless.

Even supposing that contingentists can extend their logic to circumvent these concerns, or put forward mathematical principles that are fully equivalent to those used in the best current theories, a methodological problem remains. Even granting for the sake of argument that it is possible to paraphrase state space theory so that it is in fact acceptable to the contingentist, this alone does not answer the indispensability argument of the previous section. For the most straightforwardly interpreted theory may be superior, on general theoretical grounds, to the paraphrased replacement. The proposed replacements are likely to be *ad hoc* and cumbersome, lacking the theoretical virtues of comparative simplicity and strength displayed by the current state space theory. Even if theories of state spaces are developed where reference to contingently non-concrete objects is eliminated, such theories are unlikely to constitute part of the best current scientific theories. Yet it is the best scientific theories, rather than more cumbersome alternatives, that are looked at in order to determine what really exists.

#### 4 Response II: Non-eliminative contingentism

Given the difficulties faced by an attempt to eliminate contingently non-concrete objects from our best scientific theories, the contingentist might try to undermine the argument from a different direction. This would involve attempting to show that we need

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<sup>8</sup> The idea is to understand 'there is a possible object *x*' as 'possibly there is an object *x*'. Fine (1977, p. 118)

<sup>9</sup> Williamson (2013, p. 305).

<sup>10</sup> Hamilton's Principle states that, in the case of simple state space systems, the action integral of the Lagrangian for the system is stationary for the actual path. The principle allows theorists to state the actual law as a condition that compares the actual history of the system with counterfactual histories that do not obey the law. Butterfield (2004, p. 14).

<sup>11</sup> Butterfield (2004, p. 29).

not be committed to the existence of contingently non-concrete objects, even granting that reference to them cannot be eliminated from the best current scientific theories. That is, this reply concedes Premise I, but denies Premise II.

When scientists investigate the state space of a physical system they often do so for the purpose of model-building. In so doing, simplified mathematical models of the target system are developed to help us understand its actual features. It may be that the assumption of merely possible particles or predators in applications of state space theory is an idealisation employed in order to make theoretical models tractable. As such, the assumption that merely possible objects exist should not be taken to be true just because it is employed in theoretical models. This would fit with aspects of scientific practice more generally. Scientists often make idealizations in their theories that are explicitly contradicted by other theoretical assumptions. For instance, in order to have a tractable theory of the dynamic behaviour of fluids, it is assumed that fluids are continuous substances, even though this is known to be false.<sup>12</sup> Likewise, it might be argued that even if it is *indispensable* to a tractable theory of analytic mechanics to quantify over contingently non-concrete objects, this does not commit us to their existence.

In order for this contingentist position to be viable, it must be shown how it is possible to coherently quantify over merely possible objects in the best scientific theory and then go on to deny that these objects exist. Suppose that the state space theory used by physicists implies

(P) There is a merely possible particle  $x$ .

Some philosophers have argued that in some cases one can legitimately assert a collection of sentences whilst denying some of their logical consequences.<sup>13</sup> Melia describes this as ‘retracting an implication.’ In general, sentences are asserted in order to present a picture of how the world is and normally think of each successive sentence as adding a further layer of detail. Melia argues that we can understand some of the later sentences as taking back things that we earlier claimed by erasing or changing some of the implications in the previous part of the theory. If this practice is coherent, then the contingentist may make full use of state space theory and then finally clarify ‘but there are no such things as contingently non-concrete objects.’<sup>14</sup> The contingentist explains that the implications that the state space theory has for the existence of such things as contingently non-concrete particles are in fact false, but that the rest of the implications remain true.

This attempt to shirk the need to reconstruct scientific theories in order to eliminate the reference to contingently non-concrete objects cannot succeed. For, this proposal relies on there being a non-contradictory reading of

(P\*) There is a contingently non-concrete particle  $x$  [...] but there are no contingently non-concrete objects.

<sup>12</sup> Maddy (1997, p. 144) and Leng (2010, p. 112) make analogous moves in the philosophy of mathematics.

<sup>13</sup> Melia (2000, p. 456).

<sup>14</sup> Cf. Melia (2000, p. 467).

It is incumbent on the contingentist pursuing this position to explain why  $P^*$  should not be understood as an obvious contradiction.<sup>15</sup> One way of doing so would be to provide an appropriate paraphrase of  $P$  in order to show that, properly understood, it does not have the implication that merely possible objects exist. Statements of the best theories can quite often be paraphrased, as when it is claimed 'I didn't mean what I claimed, what I really meant was ...,' followed by the appropriate paraphrase. It is this way that the statements that are being retracted from the rest of the theory that is considered to be true are separated out.

However, if a paraphrase for something that has been claimed cannot be provided, then we are not in a position to retract the claim without contradicting ourselves.<sup>16</sup> In the absence of paraphrase therefore, contingentists cannot coherently deny that they are contradicting themselves in making assertions such as  $P^*$ . Of course, this criticism would be disarmed if an appropriate paraphrase of  $P$  that would give a non-contradictory reading of  $P^*$  could be provided. But this takes us back to the eliminative project, which there was no reason to take to be viable. A non-eliminative approach therefore fails to advance the contingentist position beyond its unpromising eliminative counterpart.

## Conclusion

In the models of state space theory, different trajectories through a system correspond to different possible states for the system to be in. Some trajectories model merely possible states of the system, in which there are merely possible objects. In order to formulate the best current scientific theories, such merely possible objects must be quantified over and hence, if science is to be taken at face-value, we are ontologically committed to such objects. This shows that the necessitist picture of what exists is correct. Of course, the view remains counterintuitive since it shows that Donald Trump, for instance, is a necessary existent. He exists (non-concretely) even in possibilities where his parents never met. However, just as pre-theoretic intuitions should carry no weight against the implications of the best theories in physics, so pre-theoretic intuitions should not be relied on in the realm of metaphysics.

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<sup>15</sup> Colyvan (2010, p. 295).

<sup>16</sup> Azzouni (2009).

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# When Excellence Kills Education: A Foucauldian Enquiry into Academia and Ambition

Friedrich Püttmann

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The French philosopher Michel Foucault is renowned for investigating history in order to understand contemporary society. A pinnacle example is his book *Discipline and Punish* published in 1975, in which he describes the evolution of what he calls 'disciplinary society'. He does so by analysing the historical shift from traditional punishment in the shape of public torture to the surveillance system in the prison of the 19<sup>th</sup> century. He argues that the modern prison is focused on disciplining the inmates to make them better people rather than simply punishing them for what they did. Foucault's central claim is that this disciplining power of the surveillance system of the prison with its observation, normalisation and examination can be found in many institutions of the modern age like hospitals, factories or schools. In consequence, this produces a disciplinary power that trains people to be "docile and knowable" making surveillance more efficient.<sup>1</sup> And it implies the constant subjection of individuals to an overarching power leading to a disciplinary society that gives full control over people. In a similar vein, Terry Eagleton defines ideology as the "activities of a dominant social power"<sup>2</sup>. For him, the purpose of an ideology is to "help unify a social formation that is convenient for the rulers" and to secure "complicity of the subordinated". In this sense, the use of disciplinary power within society as defined by Foucault amounts to the induced submission of society to an ideology.

Foucault's description of the role of discipline in society has subsequently been the object of debate for many scholars who discussed to what extent the society of their time was or is a disciplinary society. As a student at university, I am, in the words of Foucault, subjected to one of the educational institutions of society and represent a suitable object of analysis for this debate about societal disciplining today. With this essay, I therefore seek to carry forward this debate by posing myself the question to what extent I, myself, am subjected to a disciplinary society nowadays and thus instilled with an ideology. Does the university discipline me as its student? Does it not? Or is there possibly something else that disciplines me? To answer this question, I will first outline Foucault's concept of the disciplinary society and then relate it to my personal context. Furthermore, I will consider texts by neo-Foucauldians such as Gilles Deleuze and Bart Simon to develop my argument. Essentially, I argue that it is not the university that disciplines its students. Instead, I suggest that students and universities alike are subjected altogether to a disciplining that is imposed by the dominant power of the market, competition and meritocracy, and those who define merit.

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According to Foucault, the formation of the disciplinary society builds upon state apparatuses and establishments that use discipline as an instrument to exert power over a

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<sup>1</sup> Foucault 1991: 172

<sup>2</sup> Eagleton 1991: 29-30

multiplicity of individuals. The ideal form of this exertion of disciplinary power Foucault sees in the Panopticon of Jeremy Bentham: a model of a prison in which the inmates are isolated in cells, assembled in a circular construction around a watchtower and thereby constantly visible to a guardian who might, however, not even be present. What the inmates do not know is when exactly they are being watched. The consequence is that the mere possibility of being watched at any moment makes them internalise the feeling of being controlled. The consequence is a kind of self-policing – the individual observes herself to make sure she does not deviate from what she believes to be expected of her. The three main features through which this disciplinary power is established are hierarchical observation, normalizing judgement and examination.<sup>3</sup>

In Foucault's argument, *hierarchical observation* means the permanent and total visibility of the subject who is observed by an institution that stands above her. It further involves one's isolation in a cell and continuous recording of one's actions. *Normalizing judgement* refers to how the individual is being shaped according to a prescribed social norm through an external judgement of her. Qualities of people are assigned ordered values, an ideal is established and by means of 'carrot and stick', training and correction the individual is moulded to strive to conform to this norm as much as possible. But the particular qualities aside, the main virtue the subject acquires is to conform in itself. Lastly, *examination* is the constant latent threat of being checked. It combines observation and judgement and manifests the power relation between the institution and the individual. That means, the institution will assess the individual; it will use its established truths of right and wrong, good and bad and will measure the individual accordingly. In total, the individual is disciplined for she is subjected to a higher force that possesses the accepted knowledge and authority. Conforming to the rules set out by the authority is what is necessary to live in peace. To fully understand the applicability of these concepts, it is important to interpret them at a more abstract level to see in what other contexts but the prison, the military or the school they may play out. The essence is that in the disciplinary society, interventions do not focus on guilt but on abnormality. Norms are established, people are classified and deviations are corrected. By the end of the day, individuals are normalized, even homogenized, which makes them more useful to the economy and easier to control, as Foucault contends.<sup>3</sup> Starting from these descriptions, scholars have posed the question of whether we thus live in a 'panoptical society' – do we?

Disciplinary power is said to be exerted through tangible institutions that bring together a number of individuals and submit them to three aforementioned mechanisms. One of society's finest institutions at which many young people gather is the university. Indeed, the university exhibits certain features that are reminiscent of panopticism. Every course defines certain objectives that the students are meant to fulfil whereby they deploy the aforementioned knowledge relations: the institution *University* fills the minds of the students with the knowledge it judges valuable. These minds are supposedly not blank but they are eager to function in the space of this institution. My appropriation of this knowledge and of these skills is moreover constantly examined and my progress or failure is judged accordingly through grades that are precisely recorded on a transcript. The quantification of evaluations through grades creates the appearance that performances are

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<sup>3</sup> Foucault 1991

made comparable – just like the workers in a factory. Evaluating a performance with a number is placing it in a seemingly objective category. The numerical judgement  $x$  seems to equal any other  $x$  in the nationwide or even worldwide landscape of higher education. Just as a workload of 5 ECTS-points is supposed to be equal across Europe to any other work being worth 5 ECTS-points. What matters for the disciplinary power is not so much the specific content of a university course, which, of course, may always differ, but the fact that the student is trained to follow a seemingly universal system of evaluation and accreditation. Content may differ but the ‘universal truth’ is that a B is better than a C and less good than an A. The imposition of the quantified evaluation system thus reflects the normalizing judgement of the disciplinary society: we identify our position on the quantitative scale and strive towards the highest end. This strife is the norm.

An immediate objection may be that the person who judges the performance is an individual, too, wherefore judgement can hardly be fully standardized, but this objection misses the point. Surely, what one needs to do in order to climb to the top of the evaluative scale, that is, to excel, may differ per course, per discipline, per university or country but the system of conformity remains the same: ‘Say what you want me to do and I will do it!’ is the slogan of the student who has internalised the will to strive for ‘the best’. It is statements like these that the German academic Christiane Florin quotes in her book *Warum unsere Studenten so angepasst sind* (Why our university students are such conformists)<sup>4</sup>. The problem with that is that students begin to think about education first and foremost in an instrumentally rational way (‘How can I best produce what is liked in order to get the best grade?’) instead of appreciating it in intrinsic terms (‘How can I best produce what I think is worthwhile?’). But what does this do to a critical education if it is increasingly reduced to being a means rather than an end? What kind of citizens will such a predominantly instrumentalist mentality produce? In fact, it is here that the disciplinary training deploys its full power over the student who primarily longs for gratification and merit. She is submitted to normalizing judgement and is induced to do the best she can to meet the norm. But is it really the case that she is therefore *subjected*? Does not the sentence above that the student pronounces to her tutor rather indicate that it is herself who willingly submits to the power of the teacher? After all, the university student is not enclosed in the university. Enclosure, which constitutes a central element in the panopticism Foucault describes, is missing here since the student is free to leave the university if she dislikes it and to go attend another one. But is the student therefore free from subjection as such? Not really.

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Gilles Deleuze, a companion and friend of Foucault, argued that the disciplinary society ended after World War II due to a “crisis of environments of enclosure”.<sup>5</sup> What he means by this is that, before, subjection depended on people to be gathered and distributed in an enclosed space. This space, however, was finite and once one had left the factory or the school, the enclosure and thereby the disciplinary power would stop. Today’s society, Deleuze claims, is no more a disciplinary society but a “society of control”.<sup>6</sup> Disciplining

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<sup>4</sup> Florin 2013

<sup>5</sup> Deleuze 1992: 3

<sup>6</sup> Deleuze 1992: 4

people in enclosed spaces has become redundant because control has become ubiquitous: it is the omnipresence of meritocracy, defined as the advancement and reward of people or institutions according to merit, that has disciplined students to regard competition as natural and to internalise the values that are necessary to be 'the best'. "The modulating principle of 'salary according to merit' has not failed to tempt national education itself".<sup>7</sup> The *encastrement*, that Foucault describes, the embedding in surveillance in which the individual finds himself, is no longer limited to the physical space of the university but has become all-encompassing through a dissemination across our entire culture.

Bart Simon describes that the *encastrement* of today is an "enculturation".<sup>8</sup> The new space of enclosure is not physical anymore but cultural; culture is the new panopticon. Hence, if the student leaves a specific university to go attend another one she is merely circulating within the culture of enclosure for it is not the university as particular institution that imposes the disciplinary power on her but society as such. The quantified evaluation has nowadays gone beyond the inside of the university. Not only the students' performance is judged in numbers but also the university itself is subjected to a normalizing judgement through its position in a worldwide ranking that appropriates the power to define 'a good university'. This may seem like a good thing from a free market perspective of international competition but – just like with international credit-rating agencies – the key question is how much power we are ready to give to the judgement of these ranking institutions in defining what is 'good'. From the perspective of liberalism, free choice is crucial. But how free does your own judgement of what is 'good' remain if the judgement of powerful institutions defines the life-courses that follow these choices? For the student to be 'the best' it thus no longer suffices to conform to the standards of the individual teacher or institution but he must conform to the standards of the highest instance to define 'good'; she internalises to strive for the 'best grades' at the 'best university'. Better A than B; better Harvard than the New School. Where formal achievement and prestige matter, true passion about the content easily becomes secondary. With increasing numbers of young British people going to university and enhanced competition, compromising your subject choices if needed to get into Oxford is the instrumentally rational thing to do. Likewise, it is rational to choose the courses with a reputation for 'easy good grades' instead of those that may otherwise really interest you and to keep on doing what you are already good at rather than to try out something new – after all, is expanding your horizon really worth the risk of losing out on success?

Self-interest is not the same as an interested self and today's *homo academicus rationalis* has been taught to prioritise taking an instrumentally rational approach to what higher education offers rather than to explore intrinsic value in it. But how will the self-interest ever know what it really desires if the actor is trained to primarily think about her choices instrumentally? The idea behind Rational Choice Theory is that actors strategically choose their courses of actions to maximise the fulfilment of their preferences. But how can the actor discover or develop her preferences beyond the basic desires for esteem and existential security if the actor never 'goes for what sounds interesting'? The idea behind liberal education is to unfold one's personality by taking steps in the diverse directions that our

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<sup>7</sup> Deleuze 1992: 5

<sup>8</sup> Simon 2005: 10

passions point us to. The logic of rational action is to play it safe and pursue the prime desires one already holds in the most strategic way. So does the 'rational' course of action really just arise from individual free preference formation? Or is it the economic constraints and the worries about the future that actually make glittering grades a stronger incentive than enlightening endeavours?

The same goes for researchers who have to weigh between rationally pursuing what is asked for and investigating what they ascribe value to. In a higher education system that is increasingly dependent on endowments from the outside, the incentives are clearly set. But likewise, how will we ever discover what we as a society may have an interest in that we did not know of if the foci of research are increasingly on what is instrumentally useful at the current time? And how much do we want to give to those who may have the financial means to decide 'what is asked for'? Similarly to the education of students, where will this leave the freedom of research and the potential for change? To be sure, this does not preclude that objectively useful research on, for example, illnesses for that matter is misleading us. Yet, much of our societal progress did not start from self-interested instrumental behaviour but from actors pursuing intrinsic value. In contrast, today, the strife for performance begins to prevail over the drive by curiosity; merit matters more than *Erkenntnis*, and ambition and willingness are the new currency. It is the omnipresence of meritocracy determining jobs for graduates and funding for institutions that subjects students and universities alike to the control forces of those who define merit and it makes them – knowingly or unknowingly – obey.

This is the two-sided face of meritocracy: it creates the room for many to aspire to benefits by virtue of merit. But what actually constitutes merit, first of all, needs to be defined, and those who are in the position to do so, exert power over those who are subjected to it. This is why the sociologist Michael Young, who coined the term *meritocracy*, said in 2001: "It is good sense to appoint individual people to jobs on their merit. It is the opposite when those who are judged to have merit of a particular kind harden into a new social class without room in it for others".<sup>10</sup> 'Achievement' is only recognised as deserving if it corresponds to the definition of merit that is predominant in society. In a Foucauldian sense, striving to deserve in meritocracy is like striving to say the truth in discourse: before the potential truth of one's proposition can ever be recognised as truth, it must be 'in the true', that is, it must meet the requirements that define whether it is part of the discourse at all. "One is 'in the true' only by obeying the rules of a discursive 'policing'".<sup>11</sup> Transferring Foucault's statement on discourse to meritocracy as another disciplining mechanism, one could say: 'One is 'in the merit' only by obeying the rules of how merit is defined.' In Foucault's terminology, meritocracy therefore represents a "procedure of control".

While disciplinary power was already invisible, the society of control is moreover ubiquitous. The meritocratic and competitive labour market is the new panoptist tower isolating its inmates, that is, basically every working person, in cells of 'self-marketing' and 'employability' by establishing meritocracy and competition as universal ideology. 'Can I

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<sup>9</sup> From the German, loosely translatable as 'discovery', 'knowledge', 'insight' or 'epiphany'

<sup>10</sup> Young 2001

<sup>11</sup> Foucault 1970: 61

afford to travel over summer if my fellow student does an internship at the same time?’ or ‘How can I play it safe to get the highest grades?’ are the new questions the student begins to ask and it is at that moment that the student becomes a docile body. In the moment that a ‘good student’ is seen as a ‘student with success after graduation’ and ‘success’ is seen as ‘being highly employable’, then being ‘the best’ simply begins to mean being ‘the most useful to the economy’. As argued by Foucault, waste of time has become “forbidden”, efficiency is the *maxime* that pervades all areas of life and speed is “a virtue” – values that imbue today’s university.<sup>12</sup> Under a process of gradual marketization of higher education, universities are increasingly being pushed to orient their programmes towards the major value of employability. From ‘islands of reflection’ they are turning into intellectual factories, producing the new workforce for the knowledge economy. Of course, use and applicability of knowledge and skills are virtues of an education, too, and many may salute the end of the idleness of academic ‘ivory towers’. But to what extent can thorough intellectual innovation really emerge, fundamentals be rethought and new horizons be reached if education is predominantly judged by the economic imperative of immediate utility? What if efficiency and speed start impeding the gradual maturation of new ideas and the depth of thoughts? How, then, will students claim back the space and the time to develop ways of thinking that may not be instrumentally rational or efficient but that bear intrinsic value for them? This is what Foucault’s theory leads us to question. However, I argue that it needs to be adapted to 21<sup>st</sup> century society: Foucault’s belief that “discipline sometimes requires enclosure” is no longer valid. Enclosure has become cultural. The dissolution of the group, the new “solitude” and the imposition of a “general duel” that mark today’s generation of university students, who are soon to enter the labour market, have created a societal *prisoners’ dilemma*.

“The corporation constantly presents the brashest rivalry as a healthy form of emulation, an excellent motivational force that opposes individuals against one another...”<sup>13</sup> This is precisely the mechanism of the “prisoners’ dilemma” in economic theory. The docile bodies have internalised to behave instrumental-rationally. They are rational agents that always seek the greatest benefit for themselves wherefore in the prisoners’ dilemma the participants are likely to play on each other’s costs by betraying one another, which in the end makes both players end up worse. Being isolated and seeking to win, they play against each other instead of co-operating – and consequently both lose. Today’s generation of students is made “docile and knowable” by being conditioned to meritocracy and competition through the structures of the modern labour market and the interests of employers. Put in different terms, this phenomenon is what the Harvard sociologist Aage Sørensen has called a ‘neo-classical soup’: the future of work contracts and employment relations is their complete individualisation and marketization.<sup>14</sup> It is the return to the world of spot-market exchanges to the greatest possible extent that we are driving towards. In this world, employees are pitted against each other to make them most efficient, only employed for the exact time there is need and only remunerated for every single action they perform. It is the pinnacle of productive efficiency. In consequence, this ultimately fragments the future graduate workforce whilst being at university and makes them not only useful but

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<sup>12</sup> Foucault 1991: 141-154

<sup>13</sup> Deleuze 1992: 5

<sup>14</sup> Sørensen 2000

fully obedient to the disciplinary forces that govern meritocracy (what Deleuze calls 'corporations').

Merit is induced in us students as the aim that we rationally pursue, which makes us obey the leadership of those who define merit. The prisoners' dilemma of meritocratic competition is the 21<sup>st</sup> century mechanism that numbs any potential sentiment of a common 'class consciousness' among today's university students. Instead, each one preparing for later competition against others about jobs is seen as 'natural', making us students entirely conform to what those who define professional merit demand. To be sure, at the societal level, these are not those who give the individual students the skills to excel and offer grades in return, but these are those who have a natural economic interest in a highly efficient and useful labour force and offer employment as incentive. But the point is not to brand a subgroup of the citizenry as 'evil'; the point is to question an ideology that drives us towards accepting a full-fledged competition as natural and in our self-interest. Or to put it with Hannah Arendt: "The [ideological] preparation has succeeded when people have lost contact with their fellow men." Isolation, as in the prisoners' dilemma, keeps people politically weak while at the same time productive.<sup>15</sup> The result is the 'society of control'. The ideology of meritocracy and competition thus functions as a means of control in the (Neo-)Foucauldian sense: meritocratic society disciplines and shapes itself according to a norm created by those who have the power to define merit, making every student that aspires to employment and success, and every university that aspires to excellence and funding, perfectly calculable and hence controllable. What better way could there be to successfully calculate human behaviour by means of Rational Choice Theory than to shape their young minds accordingly?

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In conclusion, what does that mean for a university student of the 21<sup>st</sup> century? Are students thus subjected to a disciplinary society and instilled with an ideology? As has become clear, the Foucauldian concept of disciplinary power is a useful tool to question one's education. However, its shape has changed. As Gilles Deleuze announced in 1992, we do not have the disciplinary society anymore that acts through enclosed loci such as the university. Instead, students are subjected to something 'higher' and all-encompassing: the rules of the modern labour market and those who govern it. In this sense, students are disciplined to compete, to excel in order to be the best employable person and they accept the rules of the game because they internalised them as being natural. Ideology is instilled in them in the way that they are formed to be complicit with the "activities of a dominant social power" which is the rule of merit and its social meaning. Competition about jobs has succeeded – despite all the time spent on networking – to isolate students from each other as a group with a potential collective interest.

This potential collective interest could be to re-establish spaces that are deliberately 'closed off' from the pressures of the market society and that allow for a free formation of preferences, the pursuit of intrinsically valuable ends and the development of personality. At this point, it may be worth recalling an insight from German Romanticism that education

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<sup>15</sup> Ardent 1963: 474/75

(*Bildung*) is not only learning (*sich bilden*) but also it is the shaping of one's character (*bilden; formen*). Instead, I do not show my CV anymore and say 'This is who I am!' but I take a blank sheet of paper and ask 'Who do you want me to be?' The CV is not just a record of one's life anymore – it is one's 'crafted piece of art.' But to get out of this enclosure, students would be required to foster greater co-operation. After all, the ideal solution to the prisoners' dilemma would be to re-establish co-operation between the prisoners and to co-operate on their self-interests. But the individually rational pursuit of self-interest automatically leads this project to failure – we create, in fact, our disadvantages ourselves. As Rational Choice theorist Jon Elster himself puts it, sometimes, to be irrational is to be more reasonable than to be rational.<sup>16</sup>

The underlying problem is that students are being disciplined in a way that they cease to re-unite to oppose the dictate of those who define merit and to break out of the prisoners' dilemma that their generation is caught in. In this light, universities, which are likewise subjected to these rules of merit, are the institutions through which discipline operates, but they are not the disciplinary institution themselves. In fact, they are the institution that could liberate the students by teaching them to co-operate so that they can reverse the power relationship between the market and themselves. For it is that "isolated humans are powerless by definition", as Hannah Arendt pointed out, and 'rational' beings are easily isolated.

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<sup>16</sup> Elster 2007

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# Ana Luísa Amaral and the Portuguese Canon

Tom Stennett

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E ainda tenho escondidas neste bolso  
as jardas que sobraram do meu fio.

O que farei com elas? Uma corda?  
Enforco-me com ela e invento novo mito?

(And I still have hidden in this bag  
some leftover yarn from my thread.

What shall I make with it? A rope?  
To hang myself with and invent a new myth?)

The writing of myths is a violent process in the poetry of Ana Luísa Amaral. In her 2011 meta-poem *Próspero Morreu* (Prospero Died), the invention of a new myth is configured as violence against the body of a woman: Ariadne's bitterly ironic declaration of self-sacrifice, as she threatens to hang herself with her legendary thread. In *Próspero Morreu*, Amaral engages with multiple narratives: the myth of Theseus, Ariadne and the Minotaur; Shakespeare's *The Tempest*; the lyric poetry of sixteenth-century Portuguese writer Luís Vaz de Camões. This multiple engagement with different literary traditions is typical of her poetic works. One of Amaral's literary heroes, the Portuguese poet Fernando Pessoa (1888-1935), was also obsessed by myths. The line 'O mito é o nada que é tudo' ('Myth is the nothing that is everything'), underlines a fundamental tension in Pessoa's 1934 collection, *Mensagem* ('Message'):<sup>1</sup> although myths are potentially powerful and enticing narratives, they are also fragile constructs that have been foisted onto a perceived reality. Writers after Pessoa have scrutinised the myth, as enigmatic and self-consciously precarious as it may be, elaborated in *Mensagem*. Amaral's *Escuro* (Dark, 2014) is one such critical intervention that tackles Pessoa's mythic construction of Portuguese history. *Escuro* throws light on, or rather exposes the darkness of, the hidden sides of Portuguese history: 'the others', in the forms of women and colonised subjects, that have been relegated to peripheral zones — silence and submission. At the same time, Amaral questions a quasi-mythical narrative that has lionized the 'heroic' deeds of Portugal's empty — celibate or childless — fathers and destructive patriarchs: D. João, D. Henrique de Avis, and D. Sebastião.<sup>2</sup>

Pessoa is one of several poets with whom Amaral dialogues in her poems. Amaral's intertextualities include, but are not limited to, William Shakespeare, William Blake, and Emily Dickinson from the Anglophone sphere; from the Portuguese canon, Camões,

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<sup>1</sup> My translation. Words spoken by Ariadne in Amaral (2011).

<sup>2</sup> 'Ulysses', in Pessoa (2012, p. 48); 'Ulysses', in Pessoa, trans. Zentih (2006, p. 373). All English translations of poems by Pessoa are taken from Zenith's anthology. English renderings of quotations in French and Portuguese taken from published translations follow the original text in brackets, in single quotation marks. Where I have translated the original text myself, the English follows in brackets without quotation marks.

<sup>3</sup> I use here Phillip Rothwell's term to describe the series of celibate or childless patriarchs that have been enshrined in Portugal's historical narrative. Rothwell (2007, pp. 15-21).

Fernando Pessoa, and Maria Teresa Horta, one of the 'Three Marias' who co-authored the international feminist bestseller *Novas Cartas Portuguesas* ('New Portuguese Letters', 1972). Not all of these intertextual dialogues have survived the translation of Amaral's poems from the lusophone sphere to the anglophone world. In this article, I focus on the intertextual links between Fernando Pessoa's *Mensagem* and the poems from *Escuro* translated by Margaret Jull Costa in an English-language anthology of Amaral's poems, called *The Art of Being a Tiger*.<sup>4</sup> I understand translation in two principal senses:

- (i) What Jakoson terms 'translation proper', or 'interlingual translation'. That is to say, the replacement of verbal signs in one language with verbal signs from another language.<sup>5</sup>
- (ii) The physical sense of 'carrying across', or transplantation, from the latin *transferre*.<sup>6</sup>

With regard to the intertextual dialogues in Amaral's poetry, three interrelated processes have occurred in the translation of her poems into English.

- (1) Some intertextual dialogues with Portuguese writers have not made their way into English because certain of Amaral's poems have not been selected for translation into English.
- (2) Even within the poems that have been selected for Costa's anthology, some of the dialogues that are present in the original Portuguese versions have been lost through translation.
- (3) Amaral's intertextualities with English-speaking poets threaten to quash or overwrite those that her poems entertain with her Portuguese predecessors.

The first process has taken place because *The Art of Being a Tiger* is an anthology of selected poems by Amaral, and not a collection of her complete works. It is important to remember that the production of anthologies involves processes of both selection and omission on the part of the anthologist.<sup>7</sup> The second process has happened because the appreciation of intertextual dialogues on the part of the reader relies on prior knowledge of the literary or cultural traditions with which the poet engages. Whereas there is a chance that the anglophone reader of *The Art of Being a Tiger* may be familiar with the works of Amaral's English-speaking poetic heroes, they are less likely to have read the works of Portuguese poets like Camões and Pessoa. In order for an intertextual dialogue to survive translation — in the two senses outlined above — all parties in the dialogue must exist in some sense in the target language, and in the reader's mind. Thus, the only intertextual

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<sup>4</sup> All quotations from this collection are followed by the abbreviation *ABT* and a page reference.

<sup>5</sup> Jakoson (2000, p. 114). This sense corresponds to the first definition of 'translation' given by Oxford Dictionaries: 'The process of translating words or text from one language into another'. <https://en.oxforddictionaries.com/definition/translation> [accessed 5 July 2017].

<sup>6</sup> Reynolds (2011, pp. 3-4). This sense coincides with the second definition of 'translation' given by Oxford Dictionaries: 'The process of moving something from one place to another'. <https://en.oxforddictionaries.com/definition/translation> [accessed 5 July 2017].

<sup>7</sup> Baubeta (2007, p. 13).

dialogues that are vulnerable to translational loss are those with the Portuguese literary tradition. Related to the second process, the survival of intertextualities with English-speaking writers and the simultaneous loss of lusophone dialogues, has resulted in the overwriting of the latter by the former.

In this essay, I contextualize Amaral's engagement with the Portuguese poetic tradition, in particular her revision of the imperially-inflected, mythic conception of Portuguese history inscribed by Fernando Pessoa in *Mensagem*. I argue that such critical interventions in Portuguese culture and history are at the very least downplayed, and at worst totally lost, in the translation of Amaral's work into English. I draw on the theories of Portuguese sociologist Boaventura de Sousa Santos to argue that Amaral profits, in the Portuguese language, from her simultaneous contact with the cultural centres of England and North America, and the semiperiphery of Portugal. Amaral participates in a triple cultural engagement: with the English-speaking world, with a collective notion of Europe, and with Portuguese culture. Amaral's triple engagement in Portuguese is reduced to a double intervention in English, as her revision of canonical writings by Portuguese poets is mostly lost in the passage from Portugal to the Anglophone sphere.

### Ana Luísa Amaral's Centrifugal and Centripetal Manoeuvres

Nobel-prize-winning novelist José Saramago said that only a Portuguese reader would fully understand his 1984 novel *O Ano da Morte de Ricardo Reis* ('The Year of the Death of Ricardo Reis', trans. Giovanni Pontiero, 1992).<sup>8</sup> Like Amaral in her poetry, Saramago's prose works frequently represent engagements with Portuguese historiography and the Portuguese national literary tradition. The Ricardo Reis of the title of Saramago's novel is one of the literary alter-egos, or heteronyms, under which Fernando Pessoa published his work. In the novel, Saramago imagines a situation in which Pessoa's fictional alter ego Reis had existed in a literal and corporal sense. Literary allusions to Pessoa's life and works abound, but so do references to a host of other Portuguese canonical writers, including Camões. I would modify Saramago's claim that only Portuguese readers will understand his novel: only those readers well-read in Portuguese letters are best-placed to fully appreciate *O Ano da Morte de Ricardo Reis*.<sup>9</sup> Nevertheless, Saramago's comment highlights a key concern for the Portuguese writer whose works have been translated. How will a readership that is not familiar with Portuguese culture and literature be able to comprehend a Portuguese writer's engagement with a Portuguese national cultural tradition, when the necessary frame of reference is not readily available in the target language?

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<sup>8</sup> Pontiero (1992, p. vii).

<sup>9</sup> Herbert Mitgang gives the following advice to American readers of Saramago's novel in his review of *The Year of the Death of Ricardo Reis* for *The New York Times*: 'The conversations between the Ricardo Reis of the novel and Pessoa will have more meaning to students of Portuguese literature than to American readers. It can save time and research not to ponder too deeply about whether Ricardo Reis is Pessoa, or a figment of Jose Saramago's imagination: better to stick with the human instead of the literary puzzle in the story'. Mitgang's guidance to non-specialist readers that they do not engage with Saramago's interpretation of Fernando Pessoa's heteronymic scheme entails a great loss of the novel's richness, and its specificity. I argue later in this essay that the greatest loss in the translation of Amaral's poetry from Portuguese into English is that the non-specialist anglophone reader is unable to engage in the creative and challenging dialogues that Amaral holds with Pessoa, Camões and others. Mitgang (1991), <http://www.nytimes.com/books/98/10/04/specials/saramago-reis.html> [accessed 18 July 2017].

That Ana Luísa Amaral engages with non-lusophone writers as well as her Portuguese poetic heroes ensures that her work has some relevance (marketability) to a readership unfamiliar with Portuguese literature. Amaral's participates in a triple cultural engagement: (i) she tackles a Portuguese national tradition; (ii) she aligns herself to a collective notion of Europe, that itself represents a rewriting of the vision of Europe in *Mensagem*; (iii) she dialogues with English-speaking canonical poets. Thus, Amaral takes advantage of the semiperipheral status of Portuguese culture to align herself simultaneously with cultural centres (a collective notion of Europe and selected writers from the Anglophone sphere) and her native culture; that of Portugal, a nation that lies at the periphery of Europe.<sup>10</sup>

Portuguese sociologist Boaventura de Sousa Santos has defined Portugal's status in the world capitalist system as semiperipheral. Santos establishes a dichotomy between the 'Super-Prosperos' of European colonialism, of which Britain is the epitome, and inferior colonial powers such as Portugal, an incompetent colonizer: a Calibanized Prospero.<sup>11</sup> Santos argues that Portugal has been both colonized and colonizer at different points in its history, citing Portugal's 'informal' colonization by Britain during and immediately following the Napoleonic wars.<sup>12</sup> Linked to Portugal's semiperipheral status is the country's historic inability to forge its own distinctive national identity:

[...] Portuguese culture is a borderland culture. It has no content. It does have form and that form is the borderland zone. [...] My working hypothesis is that [...] the Portuguese culture always had trouble distinguishing itself from other national cultures, or always had a great capacity not to distinguish itself from other national cultures [...].<sup>13</sup>

Lacking in distinctive national content, Portuguese culture is eminently adaptable. Portuguese culture sits on a continuum between the centre and the periphery, on what Santos calls a 'correia de transmissão' (transmission belt).<sup>14</sup> The position of Portuguese culture along that continuum is not determined by its contributors (Portuguese artists, writers, or critics), but rather by external agents, who determine the relative centrality or peripherality of a given Portuguese writer or artist. This situation has led to the development of strategies by authors and publishers to position the Portuguese writer as a hybrid individual, whose specificity or singularity resides in their simultaneous contact with the centre and periphery.

In the marketing of Amaral's work, much has been made of her ties to the literatures of the England and North America. Amaral is a professor of Anglo-American literature, and she wrote her doctorate on Dickinson, whose poetry Amaral has translated, along with Shakespeare's sonnets. Amaral herself has emphasized her connection to the literatures of England and North America, whilst underlining her allegiance to Portugal. Amaral declared in an interview with newspaper *Público*: 'Não quero mudar de país. Portugal

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<sup>10</sup> The idea that Portugal sits at the periphery of Western Europe is a leitmotif in Portuguese literature.

<sup>11</sup> Santos, like other postcolonial theorists before him, draws on the power relations between the characters Prospero and Caliban from Shakespeare's *The Tempest* (1611).

<sup>12</sup> See Birmingham (2003, pp. 99-102).

<sup>13</sup> Santos (2006, p. 145).

<sup>14</sup> Santos (1994, p. 59).

precisa das pessoas aqui, para tentarmos resistir' (I don't want to leave my country. Portugal needs people here, so that we can resist').<sup>15</sup> However, in positioning herself as an anglophile, Amaral's sustained engagement with Portuguese canonical writers, such as Camões and Pessoa, is severely downplayed. Her cultural specificity threatens to be lost through a process of cultural overwriting, whereby the dominant target culture (English) suppresses the semi-peripheral source culture (Portuguese) — as Shakespeare quashes Camões, and Dickinson effaces Pessoa. In the final section of this article, I analyse Amaral's revision of the mythic conception of Europe in Fernando Pessoa's *Mensagem*. Through no fault on the part of the translator, the subtleties of Amaral's re-vision are lost in the translation of selected poems from her collection *Escuro* into English.

### **An Overwritten Genealogy, or an Obscured Revision of a Portuguese National Tradition**

*Escuro* has been described as Amaral's most modernist poem to date, as she makes use of the form utilized in *Mensagem*. Whereas Pessoa's collection is a 'long poems-made-of-poems', *Escuro* is a 'poem-made-of-poets',<sup>16</sup> because in it Amaral reinvents the poetic visions of the multiple masculine authors who have been allowed to hold a monopoly over the construction of Portuguese history through literature. *Poets* in the plural, because Amaral engages with *Mensagem*, a text in which Pessoa obliquely rewrites Camões's national epic *Os Lusíadas* ('The Lusiads', 1578). In *Escuro*, Amaral re-vises Portuguese history by imagining alternative historical narratives in which figures who have been relegated to the margins or peripheries of the dominant narrative assume central roles. Adrienne Rich defines 're-vision' thus in the seminal essay 'When We Dead Awaken: Writing as Re-Vision':

Re-vision — the act of looking back, of seeing with fresh eyes, of entering an old text from a new critical direction — is for women more than a chapter in cultural history: it is an act of survival. Until we can understand the assumptions in which we are drenched we cannot know ourselves. [...] We need to know the writing of the past, and know it differently than we have ever known it; not to pass on a tradition, but to break its hold over us.<sup>17</sup>

The poems that make up Amaral's collection frequently take place in an alternative or subjunctive mode, where the poet suggests a version of events that questions the problematic foundations on which prevailing dominant historical narratives are founded. Canonical poets like Camões and Pessoa have been instrumental in the writing of these dominant narratives. By working within the same skeletal structure as Pessoa, Amaral interrogates the premises of *Mensagem* by pointing to what is absent or out of sight in Pessoa's text.

In *Escuro*, Amaral evades two genres that are typically associated with intertextual rewriting: pastiche and parody. Both modes exist in that liminal zone between faithful imitation and playful recreation, in which the rewriting is in danger of becoming, reinforcing, or simply not adding anything to, the genre, culture, or work that serves as the

<sup>15</sup> Ribeiro (2011), <https://www.publico.pt/tema/jornal/ana-luisa-amaral-nao-sabe-ser-cautelosa-23546482> [accessed 26 May 2017].

<sup>16</sup> Ramalho (2014, p. 161).

<sup>17</sup> Rich (1980, p. 35).

impulse for the pastiche or the parodic text. Amaral's reimaginings seem to represent a different mode altogether, as she evokes alternative worlds where colonialism and the narratives that legitimised it are reimagined. One such moment occurs in the poem 'Outras Vozes' (Other Voices), where the alternative mode is announced by the idea of backwards time, heralded by the Portuguese word 'avesso', a word much favoured by Amaral.<sup>18</sup> Like several poems from *Escuro* that engage directly with Portuguese colonial narratives, 'Outras Vozes' does not appear in Costa's English anthology. At the end of the text, the poet dismantles and then reconstructs the colonial emblem of the ship. The ship's banner is 'dismembered', its mainsail adorned with brightly coloured feathers. The sunken boat is not a symbol of imperial failure in Amaral's poem. Rather, the ship's vacant hull is a space in which new, creative possibilities are imagined: 'um barco novo habitado de peixes/ brilhantes como estrelas' (a new boat, inhabited by fish/ shimmering like stars).<sup>19</sup> The new ship is not searching, unlike the royal 'we' in 'Prece' ('Prayer', from *Mensagem*), for that universal sea frequently invoked in Pessoa's *Mensagem*: 'E outra vez conquistaremos a Distância —/ Do mar ou outra, mas que seja nossa!' ('And once again we will conquer the Distance —/ Of this sea or another — what matters is that it be ours!').<sup>20</sup> Amaral creates her own formula, reworking the colonial discourses that Pessoa appropriated to conjure his mythic, poetic empire.

Amaral's scope is not limited to Portugal, even if Pessoa is the point of entry for one of *Escuro*'s most excoriating critiques of mythical conceptions of Western Europe. In the second 'Europe' poem, Amaral takes *Mensagem*'s opening poem as her point of departure. In Pessoa's text, Europe appears as a reclining woman who

Fita, com olhar sphyngico e fatal.  
O Ocidente, futuro do passado.

O rosto com que fita é Portugal.

([...] stares with a fatal, sphinxian gaze  
At the West, the future of the past.

The staring face is Portugal.)<sup>21</sup>

These lines are scathingly reworked in the first stanza of Amaral's 'Europa (poema 2)':

Pouco fita a Europa, a não ser mortos  
por múltiplos disfarces: química luz,  
os lumes tão reais, os nomes amputados  
pelos números, mesas de número fartas (ABT, p. 192)

(Does not have much to gaze at, only people murdered

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<sup>18</sup> The Portuguese word 'avesso' is not easily rendered into English. It can mean 'reverse', 'backwards', and 'inside out'.

<sup>19</sup> Amaral (2014, p. 27).

<sup>20</sup> 'Prece', in Pessoa (2012, p. 84).

<sup>21</sup> 'O dos Castellos', in Pessoa (2012, p. 44); 'Coat of Arms: The Castles', in Pessoa, trans. Zenith (2006, p. 371).

By multiple disguises: chemical light,  
blazing fires, names amputated  
by numbers, tables crammed with numbers.' *ABT*, p. 193)

In these lines, Amaral exposes the underlying mechanisms of Pessoa's myth: its reliance on language to seduce the reader and to cover over the violence of Western Europe's present and past. Pessoa's Europe-made-Grecian-sculpture is undone one body part at a time, until the poet declares:

[...] Não tem olhos, nem mãos,

nem fita nada, a Europa. Nem cotovelos tem  
que possam suportar justiça e bondade.

([...] She has no eyes, no hands,

Europe sees nothing. She does not even have elbows  
to hold up justices or goodness.

The mystery that lies behind Pessoa's sphinx-like Europe is revealed to be an artificially constructed illusion. Were Europe to look to its peripheries, 'nada veria/ a não ser outros gritos' ('she would see nothing,/ Only more screams'). The only aspect of Amaral's Europe that is linked to that riddle-telling figure from ancient mythology relates to that other meaning of 'sphyngico': the murderous callousness with which the Sphinx is said to have devoured any traveller to Thebes who could not answer her riddle. At the poem's end, Europe-the-myth is left a voiceless and dismembered construct: 'Sem voz. Sem sul. / Sem esfinge que deslumbre' ('No voice. No south. / No dazzling sphinx').

In the poem 'Intertextualidades' ('Intertextualities'), Amaral describes the anagnorisis (moment of recognition) of an intertextual echo as the discovery of a breadcrumb in a book. An intertextual mode of writing is framed as the layering of mute readings across time, connected by the breadcrumbs left by each reader:

Fiquei com a migalha,  
Desconhecida oferta do leitor,  
mas por jogo ou consumo  
deixei-lhe uma migalha minha,  
não marca de água, mas de pão também:  
uma tema posterior a decifrar mais tarde  
em posterior leitura  
alheia (*ABT*, p. 16)

I was left with the crumb,  
an unexpected gift from the reader,  
but as a joke or as a possible snack,  
I left a crumb of my own,  
not a water mark, but a bread mark:

an alternative theme to be deciphered later  
at a later reading  
by someone else (*ABT*, p. 17)

For Amaral, intertextuality is added value; a modest gift that does not fundamentally change the texture of the original work. The quandary for the English-language translator is that this conception of the translational process cannot be replicated by the translator herself. A contextualising translation would require the translation of the entire national tradition that Amaral interrogates in her poetry. Most non-Portuguese-speaking readers will not be able to appreciate the creative relationships that Amaral's poems entertain with Portuguese texts. There can be no dialogue if one speaker is muted.

Paulo de Medeiros suggests that Margaret Jull Costa's anthology offers the opportunity for a new kind of interaction — the dynamic relationship between the Portuguese original and the English rendering: 'It is one of the privileges of a facing bilingual edition to allow the reader to enjoy all of the permutations the poem undergoes as one reads it first in one language, then in the other, then again in the first one and so on'.<sup>22</sup> The benefits of a bilingual edition are lost on the Anglophone reader who does not read Portuguese; Paulo Medeiros's imagined reader is a speaker of both the English and Portuguese languages. Although Medeiros underlines the subversive quality of Amaral's poetry in his introduction,<sup>23</sup> it is not enough to be *told* that Amaral is a subversive poet. As Medeiros notes, subversion alone does not make for challenging poetry. The brilliance of 'Europa: Poema 2' resides in the ways in which the text undermines a Portuguese poetic tradition from within. The overwriting of Camões and Pessoa is not the great loss of Amaral's translation into English: the tragedy lies, rather, in the irretrievable loss of her creative dialogue with her illustrious compatriots.

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<sup>22</sup> Medeiros (2016, p. 8).

<sup>23</sup> Medeiros (2016, p. 7).

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# A Modern-Day Dystopia: Can We Avoid the Post-Antibiotic Era?

Oliver Adams

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Its 2050. Long predicted, the rise of antibiotic resistance (ABR) following inadequate antibiotic stewardship, now accounts for 10 million extra deaths per year, surpassing cancer, and has inflicted some \$100 trillion worth of global GDP losses. Antibiotics were once a cornerstone of modern medicine, saving countless millions of lives. They are now only sporadically effective. Most infections encountered in the clinic are caused by multi-drug (MDR) or extremely-drug (XDR) resistant bacterial strains. Many medical interventions (e.g. invasive surgery, organ transplantation, immunity-compromising chemotherapy), as well as childbirth, consequently carry a greatly increased risk of mortality. A news headline announces the death of an elderly woman following an opportunistic *Klebsiella pneumoniae* infection. Usually considered an innocuous commensal gut bacterium, this “superbug” was resistant to all 26 US-approved antibiotics — including those of last resort — and was thus untreatable.

The dystopian post-antibiotic future envisaged above is constructed from predictions set out in the “Review on Antimicrobial Resistance” [1], an independent report into the implications of escalating levels of ABR, commissioned by the UK government in 2014. Unfortunately, the news report is not fictionalised. It was released in January of this year [2]. Whilst such pandrug resistance (PDR) remains thankfully rare, an epidemiological and economic crisis of global proportions continues to emerge; ABR currently estimated to account for ~700,000 deaths, and cost the US health system an excess \$20 billion, per annum [3].

This article will start with a brief historical overview of antibiotic discovery. It will go on to look at the biochemical processes targeted by our current antibiotic armory, the multitudinous factors contributing to the increasing incidence of ABR, and the bacterial mechanisms responsible for said resistance. Finally, discussion of a range of novel approaches aimed at combatting ABR will be presented. The question is, can we avoid the post-antibiotic era?

## A Historical Introduction to the Antibiotic Armory

First conceptualised as a possibility by German Immunologist and Nobel Laureate Paul Ehrlich at the beginning of the 20th century, antibiotics — or what he appealingly termed “*Zauberkegel*” (“Magic Bullets”) — are small molecules that possess selective bactericidal (i.e. bacterial killing) or bacteriostatic (i.e. bacterial growth inhibiting) activity without causing collateral damage to host tissues. In search of a “Magic Bullet” capable of treating sexually transmitted *Treponema pallidum*, the causative agent of syphilis, Ehrlich’s lab began systematically screening over 600 organoarsenic compounds for activity in infected rabbits. By 1909 they had identified Salvarsan (also known as Arsphenamine), the first successful antisyphilitic. This marked the beginning of the “antibiotic era”. Notably,

variants of their pioneering high-throughput screening methodology are now standard practice in contemporary drug development pipelines [4].

The following decades saw the famous discovery (Sir Alexander Fleming, 1928), and subsequent mass production (Howard Florey & Ernst Boris Chain, 1940s), of penicillin from the fungus *Penicillium notatum* as well as identification of the first Sulfonamide (Prontosil); a class of synthetic bacteriostatic antibiotics derived from research into cellular dyeing compounds (Gerhard Domagk, 1930s). All four men would go on to receive the Nobel Prize in Physiology and Medicine for their achievements. Unlike Sulfonamides, but akin to penicillin, the majority of modern-day clinical antibiotics (~90%) are appropriated natural microbial products or derivatives thereof. Such molecules are part of a heterogeneous collection of specialised secreted microorganismal compounds termed “secondary metabolites”. Whilst some are known to function as bioweapons, antagonizing the growth of competing bacterial species, the ecological role of many antibiotic precursors remains to be characterized. In 1941 the term “antibiotic” was coined by microbiologist Selman Waksman, again a Nobel Laureate, to describe these inter-microbe small molecule antagonists [5].

Discovery of novel antibiotic classes — families of compounds related to one another by both chemical structure and a common antibacterial mechanism of action (see below) — then peaked in the so-called “Golden Era” between ~1940-1970. During this period the secondary metabolite profiles of readily culturable microbes (predominantly soil-dwelling bacteria of the *Actinobacteria* phylum) were screened for antibacterial activity by Waksman and colleagues. This natural product mining proved highly fruitful, yielding now widely prescribed antibiotics such as streptomycin (the first antitubercular agent, effective against *Mycobacterium tuberculosis*), tetracycline, vancomycin and chloramphenicol [4]. As the success of the “Waksman Platform” began to decline in the mid-1960s, medicinal chemistry took up the mantle. Synthetically tweaking previously isolated microbial scaffolds; chemists optimised antibacterial activity, expanded efficacy to additional pathogens, reduced toxicity and attempted to surmount the accumulating resistance to first-generation compounds. Whilst effective, the focus on pre-existing drug modification has contributed to a dearth in discovery of truly novel compounds, extending to the present-day. Despite numerous technological advances, with potential to expedite the drug development process (e.g. genome sequencing, high-throughput robotics, improvements in structural biology etc.), no new FDA (Food and Drug Administration) approved class has made it into the clinic in the past three decades [6]. This only serves to compound the ABR issue.

### **Mechanisms of Antibiotic Action**

Antibiotics act by interfering with essential (i.e. required for microbial viability), bacterially conserved, biochemical processes and/or cellular structures. The perturbation of these triggers the associated bactericidal or bacteriostatic activity. In general, an ideal antibiotic will selectively bind and inhibit the action of one or more bacterial proteins which are absent from, or sufficiently different in, eukaryotes. This minimises off-target, side-effect inducing, activity within the patient. Despite the many hundreds of theoretically targetable aspects of bacterial physiology, our current roster of antibiotics predominantly act by only one of four mechanisms. These are: (1) compromisation of protein synthesis

through inhibition of the bacterial ribosome (e.g. Aminoglycosides, Macrolides), (2) disruption of nucleic acid (i.e. DNA or RNA) associated processes (e.g. genome replication, transcription) through inhibition of RNA polymerase or DNA-maintenance enzymes (e.g. Quinolones, Ansamycins), (3) perturbation of cell wall biosynthesis, or cell membrane integrity, as to promote bacterial lysis (e.g. Beta-Lactams, Glycopeptides) and finally, (4) disruption of folate metabolism, a key molecular precursor of both DNA and amino acids (e.g. Sulfonamides, Antifolates) [4,7]. Expanding the mechanistic repertoire of our antibiotic arsenal, as to target novel bacterial processes (e.g. fatty acid biosynthesis, quorum sensing), is an obvious goal for future drug discovery initiatives. With the above mechanisms of action in mind, ABR can now be properly explored.

### **Mechanisms of Resistance**

ABR can be defined as the capability of a given bacterium to persist and survive at therapeutic doses of otherwise species appropriate antibiotics, rendering them useless in a clinical setting. As one may expect, given the natural origins of the majority of our antibacterial compounds, ABR is a ubiquitous biological phenomenon; having evolved over nearly 4 billion years of microbial warfare [4]. ABR therefore greatly pre-dates the comparatively recent appropriation of antibiotics by humans. It is almost certain that this ancient “resistome” — the reservoir of ABR-causative genetic determinants in the global bacterial population — features resistance mechanisms for drugs we are yet to discover [8,9]. Multiple findings from the burgeoning field of paleomicrobiology support such dispiriting conclusions. For example, sequencing of ancient bacterial DNA preserved in Canadian permafrost identified penicillin resistance pre-dating Fleming’s discovery by some 30,000 years [10]. Comparable studies of bacteria cultured from a pristine New Mexican cave system, isolated for over 4 million years, uncovered resistance to a staggering 14 contemporary antibiotics [11]. It may be unsurprising therefore, that resistance to every licensed antibiotic has now been observed, often less than five years following initial regulatory approval. Thus the impending ABR crisis can be largely understood as the widespread human application (>70 billion clinical doses administered in 2010 [12]), and simultaneous mismanagement (see below), of antibiotics as providing a strong selective pressure for the mobilisation of diverse resistance mechanisms which have accumulated on an evolutionary timescale.

At the molecular level, ABR is achieved by at least one of three principal mechanisms, these being: (1) reduction of intracellular antibiotic concentration to below therapeutic levels, (2) modification and/or protection of the antibiotic target protein, and (3) direct enzymatic modification and/or degradation of the antibiotic. In the first instance, bacteria enact measures to reduce antibiotic permeability (e.g. down-regulating outer-membrane porins — substrate non-specific protein channels) or actively remove intracellular antibiotic through overexpression of cell surface efflux pumps. The latter proteins are often competent at transporting more than one class of antibacterials, thus promoting MDR. In the second case a point-mutation (a single amino acid substitution) or post-translational modification (an enzyme-catalysed chemical alteration) of an antibiotic target protein induces a structural change; this prevents high-affinity association with the antibiotic without detrimentally compromising the protein’s endogenous function. Alternatively, a target protein may simply be overexpressed as to prevent full inhibition on antibiotic exposure. In the final

situation, bacterial enzymes catalyse the hydrolytic breakdown (e.g. extended spectrum Beta- lactamases), or inactivating chemical modification (e.g. Chloramphenicol Acetyltransferase), of the offending drug. Many thousands of such enzymes have been identified to date, often being seen to evolve altered substrate spectra to keep pace with newly synthesised antibiotic derivatives [13].

Whilst some above ABR mechanisms can be triggered by mutations within the bacterial chromosome, many are encoded on mobile genetic elements (e.g. plasmids, integrons etc.). These are capable of being exchanged between, often unrelated, bacteria by the processes of horizontal gene transfer (HGT, i.e. conjugation, transformation or transduction) and thus ABR can be rapidly spread throughout a bacterial community assuming sufficient selective pressure (i.e. antibiotic presence). Worryingly, HGT may also facilitate the accumulation of multiple resistances in a single organism; as seen in MDR, XDR and PDR bacterial strains.

### Causes of Rising Antibiotic Resistance Incidence

As alluded, the increasing spread of ABR has arisen from a combination of prolonged antibiotic overuse alongside antibiotic misuse. However, humanity has long been warned about perils of ABR. Notably, clearly aware of the issue over 70 years ago, Fleming himself said:

*“The thoughtless person playing with penicillin treatment is morally responsible for the death of the man who succumbs to infection with penicillin-resistant organism. I hope this evil can be averted [14].”*

In addition to sizeable human antibiotic dispensation (>3 million kilograms in the US in 2009), a key issue remains the mass prophylactic and growth-promotional (i.e. non-therapeutic) application of antibiotics within agricultural industries (i.e. domestic livestock, aquaculture, apiculture etc.). The farming industry accounted for 80% of all antibiotic consumption in the US in 2010 (>13 million kilograms). Many of these drugs are concerningly also used in conventional medicine; risking expedited flow of agriculturally selected ABR into human pathogens via HGT [8].

In terms of therapeutic antibiotic use, ABR has been exacerbated by both inadequate regulation and reprehensible prescribing practices. For example, approximately a fifth of all antibiotic use outside of the US and EU operates on a non-prescription “direct-to-consumer” model. This lacks all the hallmark attributes of successful antimicrobial therapy; promoting improper drug choice, under-dosing and poor regime compliance. Even in prescription-based systems, physicians are often pressured by patients into inappropriately administering antibiotics when they are evidently not required (e.g. for viral infections) [15]. Up to ~30% of US prescribed antibiotics are thought to fall into this category [16]. Noted previously, the effects of ABR are being compounded by a stagnation in the release of new antibiotics (e.g. 16 antibacterials were FDA approved between 1983-1987, only 2 between 2008-2012). In recent years, the pharmaceutical industry has redirected investment into more profitable areas; the limited treatment duration, low cost per dose, ABR-influenced market longevity and stewardship practices (e.g. restricted prescription of new compounds)

associated with antibiotics making novel antibacterial development an unattractive prospect [15].

### Avoiding a Medical Dystopia

If humanity is to continue to retain the immense medical benefits bestowed by antibiotics over the past century, a concerted and sustained global approach will undoubtedly be required. This must involve interdisciplinary cooperation between the pharmaceutical and agricultural industries, the research community (e.g. microbiologists, medicinal chemists, epidemiologists), policy makers, NGOs, healthcare professionals, and educationalists; to list but a few [3]. It is beyond the scope of this piece to consider in detail all ongoing initiatives to combat ABR, but broadly, solutions fall into three main categories: (1) efforts to extend the lifespan of our current antimicrobials (i.e. antibiotic stewardship), (2) development of new antibiotics and/or therapeutic alternatives, and (3) methods to reduce the incidence of bacterial infection (i.e. reducing the need for antibacterial intervention in the first place).

Key to extending the functional lifespan of already licensed antibiotics is a move towards a system of reduced misuse and minimised consumption; ideally eliminating the non-medicinal application of antibacterials in agriculture. Whilst the EU banned growth-promotional antibiotic use in livestock in 2006, the US only recently followed suit through the FDA's Veterinary Feed Directive in January 2017. Globally the practice remains rife [15]. Readily complementing such a worldwide ban would be implementation of systems to sever other routes responsible for environmental anthropogenic antibiotic contamination; the breakdown of antibiotic compounds in sewage, for example. By reducing the environmental antibiotic load, we should in theory lessen the selection for ABR determinants in natural bacterial ecosystems and thus the potential for ABR transfer to human pathogens. Likewise, essential to maintaining our current antibacterial roster is an improvement in prescribing practices; ensuring antibiotics are only administered when required and that an effective antibiotic is always prescribed first time. Both could be achieved through development of rapid-ABR diagnostics. Currently, the ABR-profile of a patient's infection is determined using culture-based techniques (i.e. growing clinical isolates in the presence of various antibiotics at multiple concentrations); requiring days-to-months to complete depending on microbe growth rate. As a result, physicians are pushed to empirically prescribe broad-spectrum antibiotics before the ABR-profile is known; risking initial treatment failure. If, however, the ABR-profile could be determined in significantly less than 24 hours the physician would be empowered to both withhold antibiotics from patients with inappropriate infections as well as pick an effective drug first time [4,8]. Although such diagnostics remain far from widespread clinical release, a frontrunner is the use of bacterial whole-genome sequencing (WGS) to directly identify the genetic determinants of ABR in a patient's sample [17]. A successful example of this is the WGS approach recently adopted by Public Health England reference laboratories for *Mycobacterial* infections (e.g. tuberculosis, leprosy) [18].

Even with improvements in antibiotic management, discovery and licensing, new antibiotics — preferably exploiting novel biochemical mechanisms — will be vital to combat resistance. Microbial evolution will always supply new ABR mechanisms to

outmanoeuvre our armory. Reminiscent of the “Golden Era” of antibiotic discovery, an effective strategy would be to explore the secondary metabolite profiles of bacterial populations in previously untapped ecological niches (e.g. marine microbes). Contemporary technologies (e.g. the iChip) are also allowing screening of soil bacteria previously unculturable during Waksman’s time, an approach having yielded Teixobactin — the first antibiotic discovered with a novel mechanism of action for over three decades. It is still in early development [19]. To ensure new compounds continue to be found it is clearly essential that governments and funding bodies make efforts to re-incentivise antibiotic development. A good example is the FDA’s GAIN (Generating Antibiotic Incentives Now) legislation, which is expediting the regulatory approval, and extending the patents, of novel antimicrobials in the US. Similar incentives must be applied on an international scale [15]. Simultaneous with the search for new antibiotics are research avenues pursuing therapeutic alternatives to conventional drugs, potentially acting by mechanisms with diminished ABR-inducing potential. Such future therapies may include bacteriophage treatment (i.e. exploiting naturally antibacterial viruses for medicinal purposes), anti-virulence compounds (i.e. targeting bacterial-produced factors responsible for pathogenesis without bactericidal activity), host-targeted drugs (i.e. compounds quelling the immune response a bacterial infection, often responsible for the majority of clinical symptoms) and live biotherapeutics (e.g. introduction of bacterial populations to decolonize patients infected with MDR species). Unfortunately, the majority of these advances remain at the basic research phase. Finally, initiatives aimed at minimising the incidence of bacterial infection will always be beneficial at maintaining antibiotic viability. Broadly, technologies improving disinfection and replacing invasive healthcare practices (e.g. alternatives to intravenous drug delivery) are likely to be effective. Vaccines against ABR-strains also hold great potential [8].

In conclusion, ABR is arguably one of the greatest threats to the future of humanity alongside climate change and nuclear warfare. If we are to win the arms race against our microbial foes, it is key that we act now. We can only avoid the impending dystopia if we introduce responsible regulatory practices, unearth novel antibiotics, pioneer antibiotic-alternatives, and reduce antibiotic consumption on a global-scale.

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## Nuclear Fusion:

### How Difficult Is It and Why Is It Taking So Long?

Alexander Leide

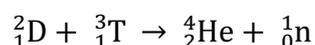
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The Sun has always been an object of wonder for humans; it has represented deities riding chariots with hawk-heads, monuments have been built to worship it such as Stonehenge and the pyramid of Kulkulkan in Mexico, and its absence during eclipses struck fear around the world. Ancient astronomers studied its motions across the sky, estimated its distance from Earth to within a few percent, and predicted heliocentric models for the solar system centuries before Copernicus, Galileo and other modern scientists moved these heretical ideas into mainstream thought. As well as being wondrous, the Sun is profoundly useful. It provides light, and as 18<sup>th</sup> century scientists began to discover, is required for photosynthesis and for all life to exist. The quest to understand how the Sun works is also the beginning of the story of nuclear fusion.

Spectroscopy beginning with Newton's glass prism showed that sunlight was made up of many different colours, and the observation of absorption lines in the solar spectrum began to reveal the elements which make up the Sun; mostly hydrogen and helium. Various theories for how the Sun burned based on conversion of gravity into light followed, but the age of the Sun predicted by these ideas was far shorter than the more robust calculations of the age of the Earth based on geological formations. The equivalence of mass and energy ( $E=mc^2$ ) derived by Einstein in 1905 would provide the theory to explaining where these elements came from, and how stars emit energy, but the key would be more accurate experimental observations of elemental masses. In 1920, F. W. Aston measured the masses of hydrogen and helium nuclei which revealed that helium was slightly lighter than four individual hydrogen nuclei (Aston). Sir Arthur Eddington was the one to combine Einstein's theory with Aston's experiments to propose that hydrogen nuclei were "fusing" into helium, and the lost mass was being transformed into an equivalent amount of energy. With remarkable foresight, Eddington predicted the quest to exploit stellar energy on earth, and sadly the destructive power of nuclear weapons:

*"If, indeed, the sub-atomic energy in the stars is being freely used to maintain their great furnaces, it seems to bring a little nearer to fulfilment our dream of controlling this latent power for the well-being of the human race---or for its suicide."* (Eddington)

The easiest fusion reaction to achieve is between deuterium ( $^2\text{D}$  "heavy" hydrogen) and tritium ( $^3\text{T}$  "super-heavy" hydrogen) nuclei to form helium plus an extra energetic neutron. This is demonstrated in the reaction equation shown below and in Figure 1. The small mass loss is turned into 17.6 MeV of energy, 14.1 MeV of which is the kinetic energy of the neutron, the rest goes into kinetic energy of the He ion. To put this energy into context, 1 kg of deuterium and tritium fusion fuel is equivalent to 1 million tons of coal.



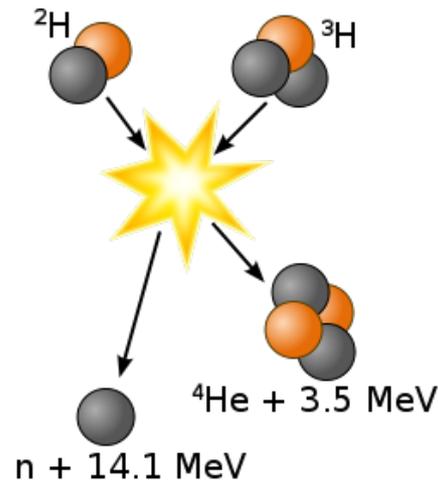


Figure 1: Fusion reaction between deuterium and tritium to form helium and an energetic neutron. Image by Wykis distributed under a CC-BY 2.0 license.

Very pessimistic predictions suggest that for the D-T reaction there is 750 years' worth of fusion fuel, with the possibility of extending this by extraction from seawater. With foreseeable technological advances, more difficult fusion reactions between deuterium nuclei alone could become possible and the fuel supply could last beyond the predicted life of the Sun. These reactions do not produce radioactive waste, nor any greenhouse gases or other harmful pollutants. Indeed, helium is a very useful gas which is in short supply because it literally floats away, and the neutron is the means of extracting energy from the fusion reaction. This sounds very simple, and desirable, so why has it not been achieved?

Simply, fusion is very difficult to achieve. For the purposes of this essay most of the problems are conveniently condensed into the "Lawson Parameter" proposed in 1955 by John D. Lawson (Lawson). This consists of the triple product of plasma density ( $n$ ), confinement time ( $\tau$ ), and temperature ( $T$ ) as the parameters for achieving viable fusion, where more energy is produced than is put in. The current record of  $n\tau T$  is held by the JT-60 Tokamak in Japan at  $1.53 \times 10^{21} \text{ m}^{-3} \text{ s KeV}$  which is close to the target of  $n\tau T \geq 5 \times 10^{21} \text{ m}^{-3} \text{ s KeV}$  (Ushigusa). Improvement of the triple product had been growing faster than Moore's Law until the late 1990s when it stalled. Nuclear fusion has been achieved; the Joint European Torus (JET) in Oxfordshire, was regularly breaking records between 1991 and 1997 for releasing fusion energy, and will begin again in 2018 after upgrades to the heating systems, first wall, and divertor. But even with significant improvements, the existing machines are no longer big enough to make significant progress.

To achieve fusion, the most conventional and successful way is to contain a super-hot plasma in a donut-shaped magnetic field created by a machine called a Tokamak (Figure 2). To improve the triple product towards achieving the Lawson criterion, one can increase the magnetic field strength or make the plasma bigger. The aim is to increase confinement time,  $\tau$ , which is the length of time plasma particles remain in the plasma before being circulated to the outside and ejected. This gives more chance for fusion reactions to occur by ions colliding, and the longer the particles stay inside, the less heat is lost, so thermal efficiency is improved as well as plasma temperature,  $T$ . Other types of fusion using laser implosions to compress the fuel aim to massively increase the density  $n$ , which also has the

effect of increasing  $\tau$  and  $T$  by making matter so dense that particles struggle to escape and are confined for a longer time. This inertial confinement technique is nowhere near achieving viable fusion and is mainly used for military research and fundamental physics, but is an alternative way to think about solving the triple product challenge.

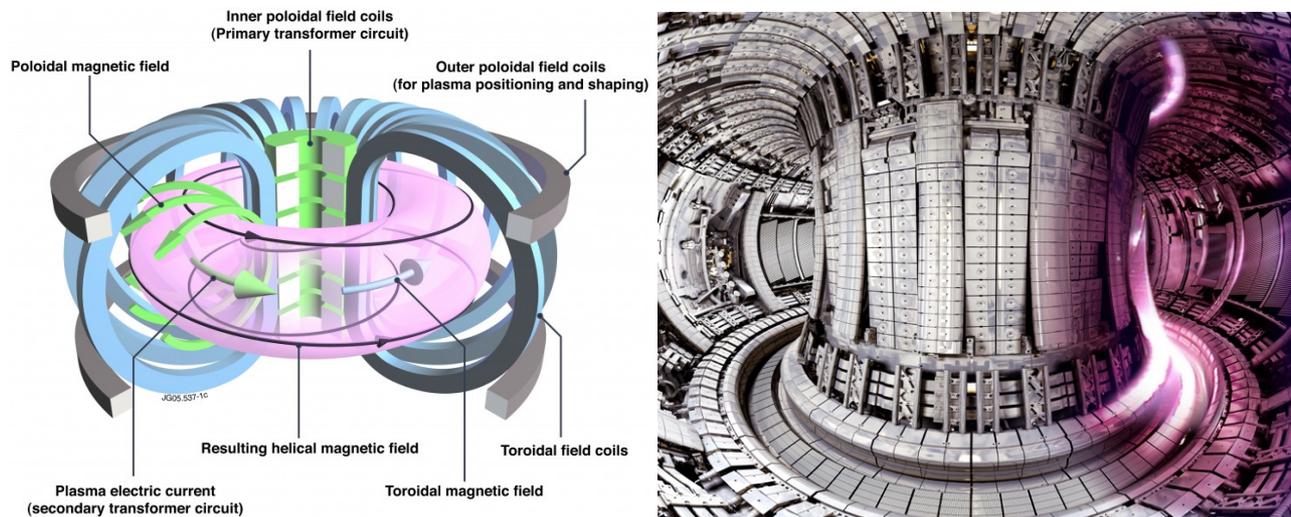


Figure 2: (Left) Schematic of the Tokamak principle for confining a plasma. Toroidal and poloidal magnetic coils create a net helical magnetic field. (EuroFusion)(Right) Inside JET showing the plasma superimposed over the right-hand side of the image (EuroFusion)

This problem of improving  $\tau$  was known in the early 1980s when JET was beginning operations, and plans were already in motion to improve it. As the Cold War was beginning to cool, fusion research was heating up. The Soviet Union were world leaders in Tokamak design having invented them, while the West had been pursuing dead ends such as linear magnetic mirrors to hold a plasma, and pinch devices which use a very high current through the plasma to produce Lorentz forces compressing the plasma to high pressures. With the commissioning of JET and other advanced Tokamaks the USSR was falling behind. At the Geneva Superpower Summit in 1985, Reagan and Gorbachev proposed a collaboration between American and Soviet scientists on fusion energy which led to ITER (International Thermonuclear Experimental Reactor). Over 30 years have passed, in which time half the world's population have become represented in the project. Its membership consists of China, the European Union, Russia, Japan, South Korea and India, and the fluctuating involvement of America.

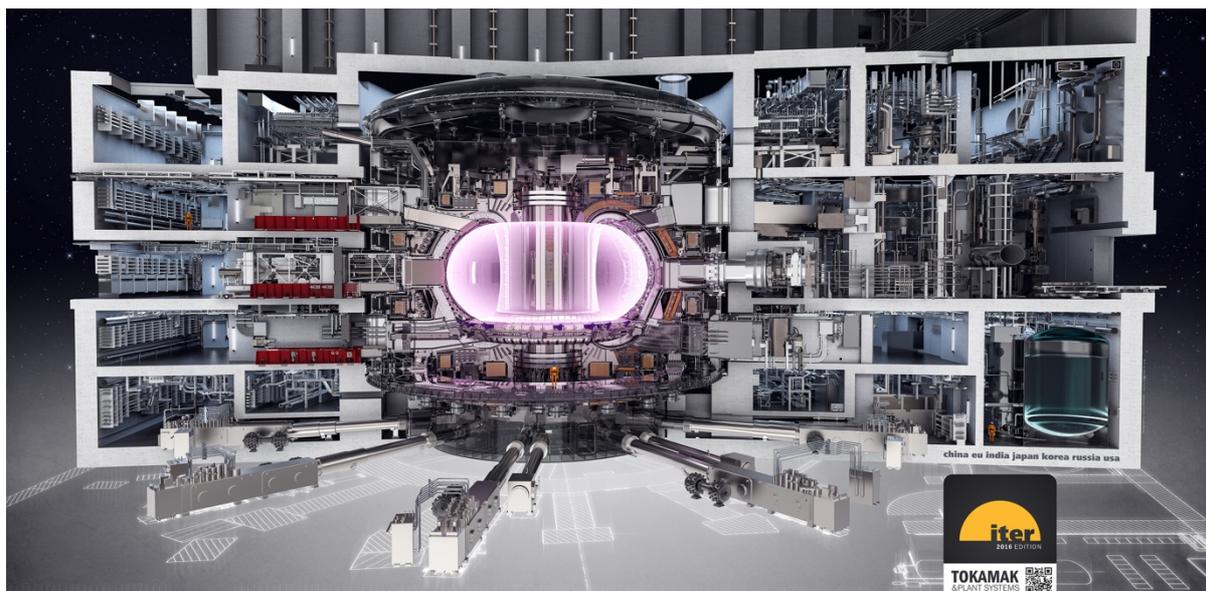


Figure 3: Computer rendering of ITER showing certain auxiliary equipment, and human figures (orange) for scale. Credit © ITER Organization, <http://www.iter.org/> (Iter organisation)

Initial designs for ITER began in 1988 and were finalised in 2001 based on technology available at the time, or which was near availability. Further alterations such as vertical adjustment coils, have been made based on new research from JET and other Tokamaks, but the basic design was set. The result is a machine more complicated than anything else ever created (Figure 3). More unique parts are involved than in the Large Hadron Collider or even the International Space Station. It is a hugely complex, expensive machine which is over-budget and over-due, and has become too big to fail. The machine which was already out of date before being completed.

With so many government agencies involved in ITER, politics has had more of an impact than would be desired. The plan was that the components would be built by countries with the most expertise in that technology area, informed by research on existing fusion experiments around the world, then shipped for assembly at the building site in southern France. However, the harmonious ideal of scientific research is in conflict with nationalistic industrial strategy. Some members feared that if one country developed manufacturing expertise in a particular key component, for example by making all the superconducting magnetic coils, when commercial reactors come to be built that country would have an insurmountable head-start in capability that would result in a monopoly on that technology. The result is duplication of efforts plus an extra stage of testing to make sure that both countries are making parts to the same specifications. Bureaucracy associated with many agencies each serving their own self-interests has mostly been overcome with a better management structure, but caused significant hold-ups especially during the early manufacturing procurement stage. This kind of complication has contributed to the lumbering inefficiencies with which ITER has become synonymous.

The construction cost is split between the partners (China, the European Union, Russia, Japan, South Korea, India, and America), with Europe footing the largest proportion, as it would receive the biggest benefit from ITER being situated in France. The

construction cost estimate at the time of finalising the initial plan was €5 billion. This is now estimated to be €20 billion (Iter organisation). In 2010, when building work at the Cadarache site was in the early stages and the cost was increasing, the entire project came to a halt when additional EU funding did not initially appear. Combined with US funding coming and going with different administrative policies, ITER finances have fluctuated wildly causing delays and jeopardising the entire project. As a display of scientific collaboration, it is a success. As a project management exercise, it is a failure. That is not to say the experiment will fail. Although much bigger than any other fusion machine, the design is fairly conservative and based on well understood principles developed by thousands of scientists over many decades. Everyone expects it to work, and to demonstrate fusion energy gain by releasing ten times more energy than it uses while providing useful information to design other big machines, if they are ever built.

Large engineering projects, especially in the USA and Europe are becoming unfeasible as governments are often unwilling to finance them. This is demonstrated well by Hinckley Point C nuclear fission power plant struggling to get private financing. Only with reassurance of a guaranteed price of electricity from the UK government, and Chinese government investment did it become possible to fund the project. It is unlikely that once the current generation of large nuclear reactor projects are finished, including Moorside and Wylffa, that any other large reactors will be built in the UK. It is also unlikely that any private utility company could afford a large commercial fusion power station the size of ITER, let alone DEMO, (DEMONstration Power Station) the commercial scale demonstrators which will be built based on learnings from ITER. The industry trend with fission power stations is towards Small Modular Reactors (SMRs) producing less than 300 MWe, with various affordable designs waiting for approval by regulators. These machines are simpler, and with the benefits of mass production and multiplicity could be cheaper and faster to produce. Multiple SMRs being built on one large site, or being deployed individually in remote places with high power demands, such as military bases, mines, or after natural disasters, is likely to be the picture of nuclear power in the future.

In 2001, the small fusion reactor was considered impossible, and not necessary: increasing size was the only feasible way to achieve the Lawson criterion, the electricity grid was designed around having few large power stations, and finance had never been an issue before. But now technology is becoming available to shrink the size of fusion power plants. The key lies in high temperature superconductors (HTS) which are able to sustain a higher magnetic field than low temperature superconductors as used in ITER and other existing experiments. Instead of increasing the plasma size as with ITER, the HTS materials allow higher magnetic field strength to target the critical Lawson Parameter. At the time of designing ITER, these HTS materials didn't exist outside of theory and small lab samples, and it was considered too risky to use them in the design. Of course, there are still challenges to using these materials, specifically joining them, but their theoretical benefits are enticing enough that research into them has been faster than expected.

One of the key benefits is the reduction in size of machine which high temperature superconductors would allow. Smaller machines are cheaper; cheap enough that private companies are able to develop them, of which Tokamak Energy, based in Oxfordshire, is one of the leading companies. They promise "a faster way to fusion" making electricity by

2025, and on the grid by 2030 (Tokamak Energy). This claim should be taken lightly. Scientists have often promised fusion within 20 years and have failed to achieve it in this timeline. What makes Tokamak Energy different to academic research institutes is that their existence as a private company relies on meeting milestones agreed with their investors. The team, originating from Culham Centre for Fusion Energy (CCFE) who run JET, and the Mega Amp Spherical Tokamak (MAST), have expanded rapidly and have built various small devices achieving all of their milestones to date. Through small stepping stones and separating challenges to be solved individually, they hope to take advantage of new technology and be more flexible, rather than aiming for a huge leap as ITER is doing. Now on their third of five targets, fusion relevant experiments are beginning to take place. Will Tokamak Energy be making economical fusion electricity, ahead of the mainstream scientific community? The key will be whether the HTS works as expected, and whether it can be manufactured reliably and incorporated into a machine. Criticism of Tokamak Energy has primarily consisted of their reliance on mainstream science to do the expensive hard work of designing new materials and techniques, and developing an industry to build them. This includes appropriate structural materials resistant to radiation damage and the critical HTS materials themselves. This is changing through sponsorship of university-based research to accelerate progress and improve collaborations. Additionally, Tokamak Energy are not able to use tritium fuel in their devices since it is radioactive and highly controlled. Until they have a machine in a suitably secure location, such as CCFE, they won't be able to demonstrate D-T fusion.

Although private companies are flexible, and some have access to significant funding, they are short of political muscle when it is needed. Getting hold of tritium and navigating regulatory issues where the regulations don't yet exist are areas where government labs can exploit their public connections. The relationship between mainstream science and private companies has also been somewhat fraught. They are often founded by ex-mainstream scientists whose ideas have been rejected, leaving under a cloud. Countless times private companies have announced commercial fusion in the next few years with wacky designs which have never been near achieving the necessary conditions. With each announcement, public hopes are raised based on no evidence. Each time questions are asked about whether public money is being well spent on fusion research. Why bother? History shows a continual stream of failures and broken promises; cost over-runs and delays. That is partly why ITER has become so conservative in its approach, and is too big to fail. The reputational damage caused by broken promises has made fusion research unpopular compared to other fields of science.

As well as Tokamak Energy with its fairly conventional approach, a few other companies have unconventional, but well-funded research programs. Tri-Alpha Energy use a cylindrical plasma configuration with fast colliding plasma fronts heated by ion beams, and are funded by Goldman Sachs and Microsoft co-founder Paul Allen (Tri-alpha energy). Peter Thiel, co-founder of PayPal, along with NASA are investing in Helion Energy with a similar device to Tri-Alpha but without the ion beams (Helion Energy). General Fusion funded by the Canadian and Malaysian government sovereign wealth funds, plus private investors including Jeff Bezos, founder of Amazon, inject plasma into a vortex of liquid lithium-lead alloy, and compress this with shockwaves from powerful mechanical hammers (General Fusion). The impressive claims emanating from these companies are enticing, but

the technology is mostly based on old theories previously rejected by academia, and not supported by published results.

If one of these alternative approaches does turn out to work, the mainstream fusion research community would be left embarrassed with difficult questions to answer. This is unlikely to happen. Nothing other than a Tokamak has reached useful fusion-relevant conditions, and the tricks these companies promise to exploit have been repeatedly debunked. The real competition is between large conservative Tokamaks and small advanced HTS Tokamaks. Tokamak Energy's success is being noticed in the mainstream world. Rather than being disengaged, they are now collaborating with universities. MIT have worked closely with them on HTS development and have a student-led design class for a compact Tokamak, and leading UK universities are hosting PhD research linked to Tokamak Energy. This private-public hybrid approach is in everyone's best interests for achieving fusion. The ivory towers of academia are opening up to capitalist profit-driven research in a positive way. Based on current ideas the future of nuclear energy is small affordable reactors. Tokamak Energy are working towards this, and combined with the engineering experience from ITER, and academic research they can achieve this. There is no question there will be hurdles to clear before fusion is available on the grid, but working together will be the best way to clear them with a sight on commercial realisation rather than just a scientific endeavour.

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# **An Investigation of Dyspraxia: What We Know and Why the Research Is So Far Behind**

Emily Meachon

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Developmental Coordination Disorder (DCD), also known as dyspraxia, is a condition prevalent in approximately 10% of the population, with a prevalence rate of 1 in 10 students in the United Kingdom (Colley, 2006; HDCD, 2017; DSM, 2013). DCD is marked primarily by a delay or disorder in movement execution and planning, however it is often associated with additional deficits in attention and perception (Colley, 2006). In the UK, DCD is categorized as a specific learning difficulty (SpLD) alongside Attention-Deficit Hyperactivity Disorder (ADHD), dyslexia, and dyscalculia, a disorder of arithmetic (Malpas, 2012). Unlike other SpLDs, the causes of DCD are unknown and the condition is not well understood. In fact, research on DCD has been observed to be significantly behind by comparison to similar developmental disorders and SpLDs (Bishop, 2010; Gomez & Sirigu, 2015). More specifically, SpLDs like dyslexia and ADHD are recognizable to the public and more popular in research despite their prevalence rates to be about the same as DCD in the United Kingdom (Malpas, 2012; Bishop, 2010; Holden et al., 2013). This begs the question: why is the research so far behind when it comes to Developmental Coordination Disorder?

There are several existing features which may explain the lack of interest and likely discouragement in the research of DCD. Primarily, DCD is highly complex, often interacting with other SpLDs, mood disorders and more, and each case of DCD can be unique (Dyspraxia Foundation, 2017). The complexity of the condition and variation in symptom presentation makes it quite difficult to examine and treat. Additionally, a lifelong prognosis for those affected by dyspraxia has led many to seek treatment for individual symptoms and a unified cure is unlikely to exist (Colley, 2006). Thus, clinicians have settled into a pattern of treating affected people with respective symptom-by-symptom interventions. These temporary solutions, though often costly, may provide the façade that research on the condition is not as warranted. Furthermore, a general lack of public awareness about the disorder, likely a result from ambiguous nomenclature for the condition among medical professionals, prevents people from joining forces to encourage and fundraise for research on DCD. For example, ADHD is well-known to the public and receives significant attention in funding and research despite the condition having a similar prevalence rate as DCD. Other factors, such as an under-diagnosis for the condition, and variation in diagnostic criteria across cultures could also explain some of the gaps in research on DCD.

The purpose of this paper is to delve into the inconsistencies and ambiguities of DCD in order to highlight the gaps currently existing in the understanding of the condition with regard to affected populations in the United Kingdom. The reasons for lack of research interest in DCD will be explored in greater detail and several solutions will be proposed. This investigation can serve as a guide for future research, inform others about a lesser understood condition, and assist those who are in search of a comprehensive outline of DCD.

## **Inconsistencies**

### **Nomenclature**

Developmental Coordination Disorder can be a difficult condition to explore in research due to numerous inconsistencies in its nomenclature, prevalence and epidemiology. In nomenclature, there has been significant debate among medical professionals on the precise term to be used for DCD, which has been referred to with phrases and names such as 'motor learning difficulties,' 'developmental dyspraxia,' 'sensory integrative dysfunction,' 'disorder of attention motor control and perception (or DAMP),' 'clumsy child syndrome' and more (Carlsaw, 2011; Colley, 2006).

The significant confusion caused by the lack of a universal term for the condition pushed scientists and medical professionals to create a single specific title for the condition, now known as Developmental Coordination Disorder (DCD). DCD became the official name for the condition in 1994 and is now the most common term for the condition, appearing in the Diagnostic and Statistical Manual in the USA (Carlsaw, 2011). However, some confusion still exists because the terms 'Developmental Dyspraxia' or simply 'Dyspraxia' are still common in the mental health sector, especially in the UK (Dyspraxia Foundation, 2017). The disparity of nomenclature and subsequent spread in the literature on DCD can contribute to a weaker understanding of the condition compared to the more consistently-named related SpLDs and disorders.

### **Prevalence & Comorbidity**

It is a challenge to classify the prevalence of DCD, because like many other psychological disorders, it is prevalent far beyond the finite number of people who are able to be diagnosed with the condition. In the United Kingdom, the prevalence rate for DCD ranges between 1.4 and 19% with the variation dependent upon the particular diagnostic criteria used by practitioners (Carlsaw, 2011).

Furthermore, DCD has high comorbidity – or presence of at least two health concerns- with several disorders. In a review of cases of comorbidity to DCD, Visser (2003) found that symptoms of ADD/ADHD, reading disability (RD) and specific language impairments (SLI) most frequently coexist with DCD. The most significant case of co-occurrence is observed for ADHD, which is estimated to have an overlap of approximately 50% with DCD (Goulardins et al., 2015). In other words, about half of those who have DCD also have ADHD. It has also been observed that many with Autism Spectrum Disorder exhibit symptoms often comorbid with dyslexia and DCD (Caeyenberghs et al., 2017; Gooch et al., 2014). The precise comorbidity rates with other disorders remain rather unclear. This gap could be due to the lack of proper assessment for DCD in past screening methods for SpLDs as well as a general lack of knowledge of DCD among the medical professional populations (Wilson et al., 2012). It is clear that increasing awareness of DCD among physicians, paediatricians, and generally across the medical community would assist in proper and timely diagnoses for those suffering from DCD.

## **Etiology**

The precise origins, or etiology, of DCD remain unknown however certain biological patterns exist. In rare cases, DCD might be acquired through brain injury such as stroke. Primarily, DCD has been observed to be inheritable and is speculated to be linked to the underdevelopment cells in the brain known as neurones (Colley, 2006). The genetic etymology and continuous nature of the disorder signifies that sufferers will be affected by symptoms of DCD throughout their lifetimes (Gomez & Sirigu, 2015). However, current research has not found a single clear explanation of DCD through any neurological abnormalities (Dyspraxia Foundation, 2017). Overall, the literature on the etiological features of DCD is largely lacking and future research should consider investigating this area in greater detail.

It has been argued by Goulardins et al. (2015) and Lange (2017) that DCD and ADHD may have a similar if not the same etiology due to their high overlap, but the researchers concluded that the two disorders require distinct treatment even if they stem from similar genetic causes.

## **Diagnosis and Treatment**

The diagnosis of DCD must be performed by psychologists. Neurologists and paediatricians with specialisation in DCD also can assess and diagnose potentially dyspraxic patients. Often the signs of DCD are noticed in school settings when children begin formal learning and perform numerous activities which can be demanding on fine and gross motor skills. Thus, the diagnosis often takes place between six to twelve years of age. However, in some cases it can be diagnosed earlier (Carslaw, 2011). There is some debate over the causes of DCD, and the symptoms of the condition are extensive, often overlapping with many other conditions necessitating an intensive diagnostic process. Those who have DCD are frequently affected by comorbid disorders such as ADD/ADHD, dyslexia, anxiety, depression, and more (Colley, 2006). Given that DCD and related disorders have symptoms across modalities of perception, mood, attention, learning, and more, it can be incredibly difficult to treat the symptoms at once. Currently, the treatment for DCD is on a per-symptom basis as there is no cure nor synchronised treatment for all symptoms of DCD alone.

## **Symptoms**

Overall, those affected by DCD often experience symptoms involving the lack of coordination in motor functions, resulting in the difficulty or inability to execute smooth gross and/or fine movements. Though many affected by DCD also experience symptoms involving perception, memory, and more, the presence of DCD varies greatly across intelligence levels, signifying that it is unlikely intelligence is significantly different due to having DCD (Dyspraxia Foundation, 2017). More specifically, studies of IQ levels of children with DCD concluded that there is some weakness in working memory and processing speed however, this deficit could be further explained by motor difficulties (Sumner, Pratt & Hill, 2016). The literature and understanding of the cause of DCD in the

context of motor functions is not yet extensive enough to properly explain its full range of effects on other cognitive processes.

Symptoms of DCD are presented in various stages depending on the age of the afflicted person and can arise in countless variations. Though the condition is not reversible, it is possible for the symptoms of an individual with DCD to change overtime based upon environmental factors (Dyspraxia Foundation, 2017).

Most diagnostic criterion sustain several major categories of DCD symptoms, in the UK this includes primary symptoms such as: gross motor coordination, fine motor coordination, speech and language, eye movements, perception, learning, thought and memory (American Psychiatric Association, 2013). Furthermore, secondary symptoms, or those which may arise as a result of struggling with primary symptoms, include emotional and behavioural reactions (Colley, 2006).

Symptoms in the realm of gross motor coordination, or large and more holistic movements could include difficulties with balance, poor posture and fatigue, a lack of rhythm in activities such as dancing, and an overall clumsy demeanour (Colley, 2006). The fine motor coordination symptoms, or those involving precise movements, include trouble with handwriting and typing, difficulty with grooming procedures, and a general lack of manual dexterity (Dyspraxia Foundation, 2017). Manual dexterity in particular can affect tasks like cooking, cleaning, and crafting, causing certain academic and professional skills to be a great challenge for dyspraxics. Speech and language symptoms include difficulty controlling the volume, tone and pitch of one's voice, and trouble organising speech in order and content. Furthermore, those with DCD may have trouble visually tracking or relocating objects (Colley, 2006). In perceptual symptoms, those with DCD may exhibit oversensitivity to light, touch, and smells, and might generally lack an awareness of their body in space such that they could bump into and trip over objects (Dyspraxia Foundation, 2017). Finally, in the sector of learning, thought, and memory, dyspraxics could be slow to complete tasks, struggle to maintain concentration, have poor short-term memories, and have trouble following more than one instruction at a time (Colley, 2006). Some have noted that there are several positive aspects of DCD in that many affected people learn to develop sophisticated coping techniques, resulting in creativity and determination in their demeanours (Colley, 2006; Dyspraxia Foundation, 2017).

Presentation of the numerous symptoms of DCD can also vary based on the age of the sufferer. For example, a toddler with DCD may exhibit signs of the condition by being late in reaching certain milestones for motor functions such as crawling and walking, they may have difficulties walking up and down stairs, and might exhibit trouble in sorting games (Dyspraxia Foundation, 2017). At a young school-age, an affected child may avoid physical education activities, perform poorly in a classroom but significantly better when working on an individual basis, and could struggle copying notes from the blackboard (Dyspraxia Foundation, 2017). Some of these symptoms may shift or manifest uniquely into adulthood.

These symptoms are merely the beginning of the extensive lists of difficulties experienced by those with DCD. Often, several symptoms are relatable to those in the

general population, but this does not necessarily signify an individual is affected by DCD. In order to be diagnosed with DCD, a high majority of the primary symptoms in the full list of diagnostic criteria must be exhibited on a frequent basis.

## **Treatment**

Frequently the treatment for DCD involves a multifaceted approach with several professionals involved in various forms of therapy and training. Additionally, depending on the age of the affected person, family, teachers, and employers may be involved in the treatment to assist in creating more accessible environments for work, study, and daily life.

Primarily, a psychologist will work with individuals affected by DCD to further their understanding of the condition and relieve any emotional troubles which may be related to coping with DCD. The professionals who are further involved in treatment are dependent upon the symptoms presented by an affected individual and can include speech therapists, occupational therapists, behavioural optometrists and physiotherapists in addition to the psychologists involved in the diagnosis (Colley, 2006).

## **Conclusion**

There is a wide gap in the research on DCD, as the etiology of the condition is still unknown, and much disparity in nomenclature over the years continues to affect the accessibility and interest in DCD. The general research interest gathers around buzzword disorders such as ADHD and dyslexia, while DCD is lacking in research despite its presence in the same family as these disorders (SpLDs) and equal prevalence rate. This is problematic because those affected by the condition are treated on a symptom-by-symptom basis and with a lifelong prognosis, overcoming many symptoms can be costly and a time-burden. Those with DCD who are fortunate enough to be diagnosed, might find trouble in sustaining long-term multi-faceted treatment plans and would benefit from a stronger understanding of their condition by medical professionals.

The vast number of people affected by DCD may face significant trouble in the workplace, school, and in daily life on an ongoing basis. The emotional toll on dyspraxics and economic toll in their respective industries could be reversed significantly with a better understanding of DCD. The understanding of DCD can be increased through raising awareness among the general public through campaigns and charities. Furthermore, a stronger inclusion of DCD in the school curriculum for students in studying education, psychology, and other related courses could be beneficial.

It is important that research delves much deeper into the causes of the condition so that it can be determined with confidence if it has a biological or environmental root such that adjustments to the influence can be made by means of prevention and treatment. We have countless tools to examine these areas in psychology and neuroscience, however research interest is lacking. Increasing knowledge on DCD among the general population would support widened interest, as well as the disorder becoming a stronger focus point in the general psychological education.

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# Superconducting Materials and Technologies: From Magnets to Quantum Computers

Harry Orchard

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## Introduction

Since mankind first discovered electricity, we have sought to harness it to power machines and makes our lives easier. As technology has improved, our devices and machines have become more powerful and efficient, but still one thing thwarts us – electrical resistance. This property of a material means that a some of the electrical energy we generate is lost as heat, purely through transmission of electrical current from one place to another. In an ideal world we would have cables with zero losses, greatly improving the efficiency of our grid networks and helping to reduce the energy needs of the globe.

In the early 20<sup>th</sup> century, materials that lost their electrical resistance at low temperatures were observed for the first time, and while these initial materials were not particularly useful, lots of progress has been made in creating and improving new materials whose properties are able to meet those needed for engineering and scientific applications. Termed “superconductors”, these materials are not only infinitely conductive, but also exhibit some unusual behaviour when interacting with magnetic fields. Nowadays, superconductors are used for a large number of applications, from the medical industry to fundamental science research and also quantum computing. Here we will cover a brief history of superconductivity, the unique properties of superconductors and their current and future applications

## Discovery of Superconductivity

Thermal energy of atoms is the cause of resistivity in metals as the atomic lattice vibrations impede the flow of electrons through the material. It may therefore seem obvious that the best way to reduce this resistivity of a metal is to reduce the temperature. Up until the beginning of the 20<sup>th</sup> century, the electrical behaviour of metals at low temperatures was unknown, and therefore different hypotheses existed to predict what would be seen. These included the resistance dropping linearly to zero at 0 K or a plateau to a constant value as absolute zero is approached (figure 1).

It was this gap in our knowledge that spurred Kammerlingh Onnes, a Dutch physicist, to study this area. In 1908 he successfully liquified helium for the first time, which later won him the Nobel prize and would allow to him to study the behaviour of metals at temperatures approaching absolute zero. Later, in April 1911, while studying the resistance of mercury he noted that “Kwik nagenoeg nul”[1], or “Mercury almost zero”, which contrasts with the behaviour seen with other metals. He later published his work, which demonstrated the first observation of superconductivity [2].

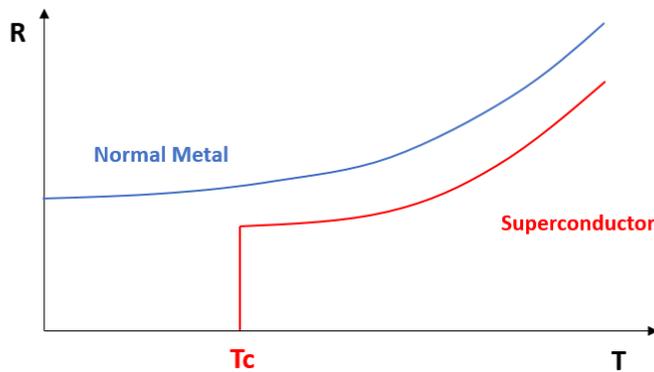


Figure 1: Schematic demonstration of the temperature dependence of resistance in a superconductor and normal metal.

## Properties of Superconducting Materials

### $T_c$ , $J_c$ & $H_c$

As Onnes noted, superconducting materials are only superconducting below a certain *critical temperature*, known as  $T_c$ . There are two other parameters that were found to determine whether the material is superconducting – *critical current density* (current per unit area),  $J_c$ , and the *critical magnetic field*,  $H_c$ . This means that even if the temperature is less than  $T_c$ , if the current being carried or the magnetic field is too high, then the material will ‘quench’ out of the superconducting state and become resistive like an ordinary material. These parameters define a 3D critical surface (figure 2) that illustrate when a material will be in the superconducting state. We will see later that this picture is not entirely true for all superconducting materials.

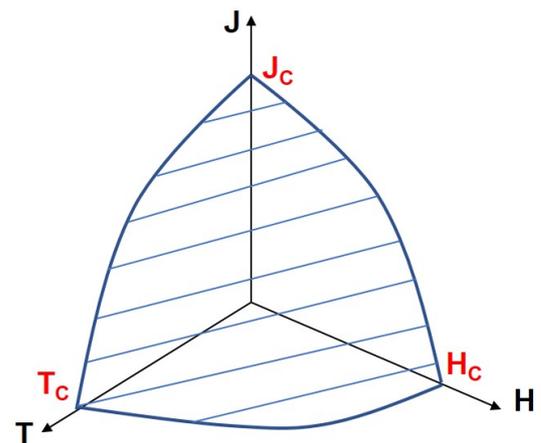


Figure 2: 3D surface defining the conditions for superconductivity in a superconducting material.

## Meissner Effect

When you expose a normal metal to an external magnetic field the magnetic flux penetrates straight through the metal. In 1933, Meissner and Ochsenfeld discovered that the behaviour of a superconductor was much different [3]. They found that when you apply a magnetic field to a superconducting material below  $T_c$ , the magnetic field is mostly expelled from the material as shown below (figure 3).

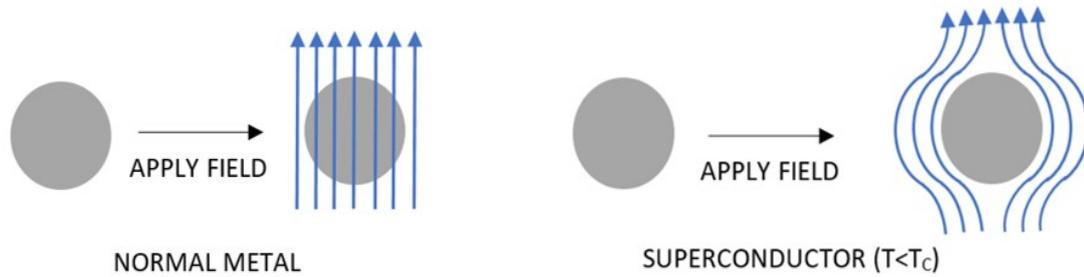


Figure 3: Effect on magnetic field lines when applying a field to a normal metal and a superconductor.

Due to electromagnetic induction, surface currents that screen the inside from the magnetic field would be expected for any perfectly conducting (zero resistance) material, resulting in similar behaviour to that seen from the superconductor above. What separates superconductors from perfectly conducting materials in this regard is the behaviour seen when cooling in an applied field. In such a field-cooling scenario, the superconductor once again expels all field as soon as  $T < T_c$  whereas the field continues to penetrate the perfect conductor. This phenomenon is known as the Meissner effect, and is a demonstration of perfect diamagnetism in superconductors (figure 4).

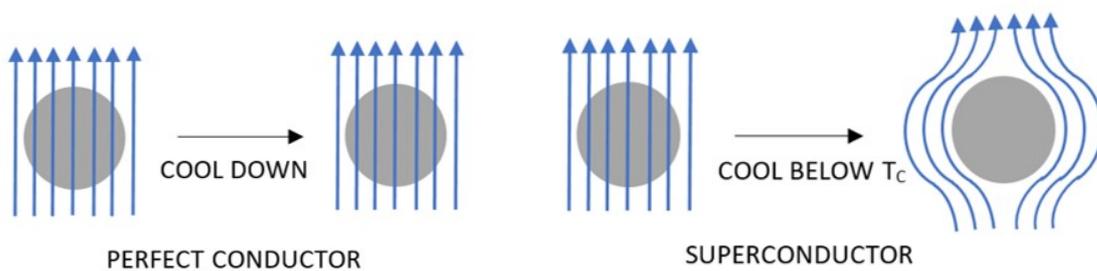


Figure 4: Effect on magnetic field lines when field-cooling a perfect conductor and a superconductor.

## Type I and Type II

In reality, not all superconductors behave exactly as described above, and their behaviour falls into one of two categories, Type I or Type II. Ideal Type I materials behave as described above, and expel all magnetic field when in the superconducting state, undergoing a sharp first order superconducting transition when increasing the field. As such, there is a single defined value of  $H_c$ . In Type II materials, flux is able to penetrate the sample at a generally lower field strength known as  $H_{c1}$ . As the field is increased, the amount of magnetic flux that penetrates increases until a second critical field,  $H_{c2}$ . At this point the material loses its superconductivity, like how a Type I material would at its  $H_c$ . Why this distinction occurs will be explained shortly, but it is primarily explained by the surface energy between superconducting and normally-behaving areas of the material.

## Type I

Relatively few of the known superconducting materials are actually Type I, and of those the majority are pure metals such as aluminium and the first ever discovered superconducting material, mercury. In such a material, the response to a magnetic field is heavily dependent on the sample geometry due to the demagnetizing effect [4]. Put simply, this effect describes how some areas of a sample surface may have a higher local magnetic field than others and, as a result, some parts of a superconducting sample can be above  $H_c$ , while others are not. Some parts of the sample will therefore be superconducting while other parts act normally, with the material considered to be in the *intermediate state* [5]. As described by the Ginzburg-Landau theory [6], in a Type I material, the aforementioned surface energy is positive, meaning that a high surface area between the superconducting and normal areas is energetically unfavourable. The balance between demagnetization energy, which favours many divided superconducting areas, and the surface energy means that the normal areas are usually in the form of tubes or lamellae of normally-behaving material that allow flux to penetrate the sample [7]. This can be demonstrated by coating the surface with magnetic particles, as demonstrated in figure 5.

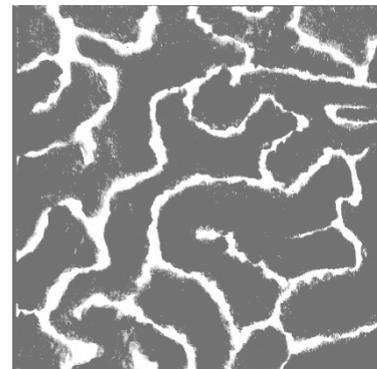


Figure 5: Sketch showing how the intermediate state in aluminium is seen when decorating the surface with magnetic particles. The superconducting areas are dark.

## Type II

Most superconductors are of the Type II variety. For these materials, the surface energy is negative, and so it is energetically favourable for high surface areas between the superconducting and normal regions. To minimise the energy the flux is therefore separated into many small regions of normal material within the superconductor, and this is referred to as the mixed state. The lowest energy configuration of flux lines was predicted to be a periodic lattice by Abrikosov [8]. Despite incorrectly predicting a square lattice, Abrikosov shared the Nobel prize with Ginzburg and Leggett in 2003. In reality, the lattice is triangular in a pure material, and can be nicely demonstrated using a scanning-tunnelling microscope (figure 6).

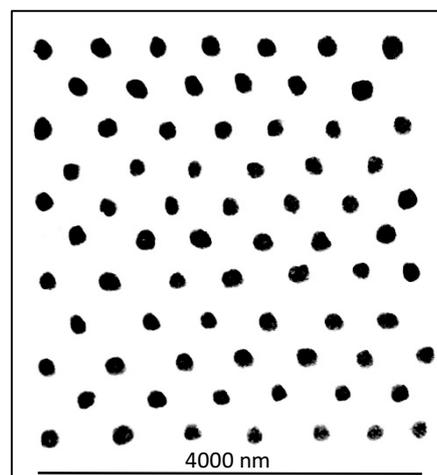


Figure 6: Sketch of how the triangular flux lattice expected in  $NbSe_2$  would be seen in a scanning-tunnelling microscope.

When a current flows it generates its own magnetic field. The interaction between the magnetic field and a flux line via the Lorentz force ( $\mathbf{F} = \mathbf{J} \times \mathbf{B}$ , where  $\mathbf{F}$  is the force per unit volume,  $\mathbf{J}$  is the critical current density and  $\mathbf{B}$  is the magnetic flux density vector [4]) would mean that in the presence of any current, the flux lattice would move and the critical current would be zero.

It is therefore necessary to include flux pinning centres in a material to have a non-zero  $J_c$ . Flux pinning can be due to defects, or features, in a material or artificial additions.

### Alternating Current Operation

Most electrical current transportation is done using an alternating current (AC) as opposed to direct current (DC). In AC, as the current direction reverses the magnetic field direction also reverses causing the flux lines in a Type II material to move. This generates a voltage and results in the loss of energy, but the effect can be minimised in a few ways. Generally in superconducting wires, superconducting filaments are imbedded in a conductive matrix (e.g. copper or silver) to aid with stability [9] (see figure 7). One way to reduce the losses would be to decrease the size of the filaments. Coupling losses, due to the filaments touching each other at the ends of the wires can also be reduced by either twisting the wire or by increasing the resistivity of the conductive matrix, although this latter method reduces the stability.

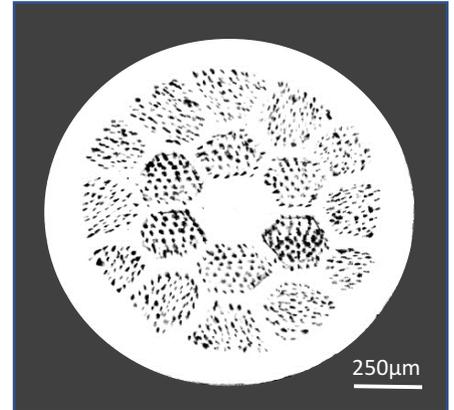


Figure7: A sketch of a cross-section of a BSCCO-2212 wire, showing the silver matrix (light) and the BSCCO-2212 filaments (dark spots).

### A Brief Quantum Description

As we have seen, the properties of superconductors are quite weird, but we have not touched upon why exactly these properties are exhibited by these materials. The reason is quantum mechanical in nature and so will not be described in detail here, but the overall effect is that we see coupling of electrons into *Cooper pairs* at the superconducting transition. Cooper pairs do not act as fermions, like electrons, but as bosons, with the two electrons separated by a distance known as the *coherence length*. These bosons do not obey the Pauli exclusion principle and so can call occupy the same energy level. BCS (Bardeen, Cooper & Schrieffer) theory describes how this process occurs, and predicts all the phenomenon described above [10], [11]. It was such an important theory that the three were awarded the Nobel Prize for Physics as a consequence.

### Which Materials are Superconducting?

A wide range of materials have been shown to superconduct since the discovery of this in mercury. A good demonstration of the improvements in superconducting properties over the years is shown in figure 8. Particularly exciting developments occurred during the late 1980s when Yttrium Barium Copper Oxide, or YBCO for short, was first produced. A ceramic superconductor, it was the first found to have a  $T_c$  above the temperature of liquid nitrogen [12]. The operating costs associated with a high  $T_c$  material could be potentially much lower than if liquid helium was used. While there are many interesting materials that we could explore, we will only cover a few of the most important ones here.

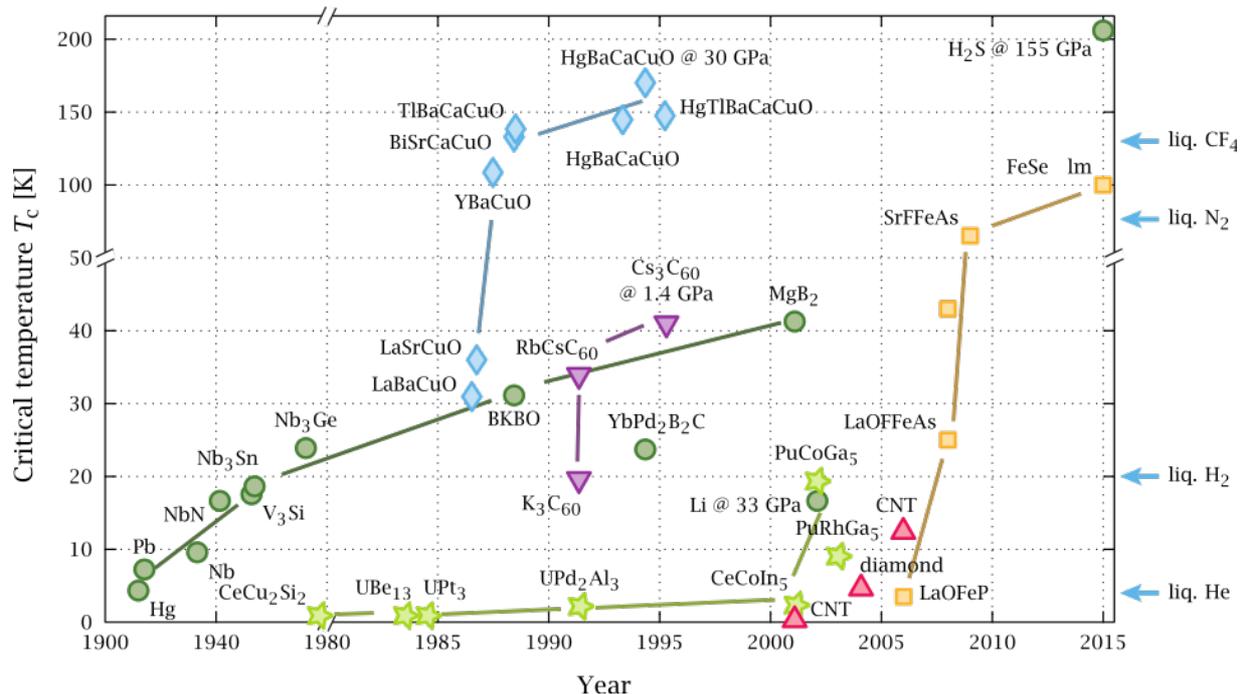


Figure 8: Timeline showing the progression in  $T_c$  in superconductors. Image by PJRay licensed under CC BY-SA 4.0 [29]

## NbTi

Perhaps the most important superconductor in use at the moment is NbTi. With an optimised composition of Nb – 47wt% Ti, NbTi is the workhorse material for most superconducting applications. It has a  $T_c$  of only 9.8K, but its good ductility makes it an excellent candidate for wires, and the manufacturing process of NbTi has led to a microstructure that is excellent for flux pinning. Filaments are usually made of NbTi alloy ingots sheathed in Nb (to prevent diffusion between Ti and Cu) which are placed in Cu tubing. These are then stacked within a larger Cu tube before a complex series of heat treatments and drawing stages are used to form the wire. The final microstructure contains ribbons of  $\alpha$ -Ti precipitates [13] which are spaced at approximately the distance equal to that expected for the flux lattice, resulting in very effective flux pinning and therefore high critical currents.

## Nb<sub>3</sub>Sn

Nb<sub>3</sub>Sn is another commonly used alloy based on Nb. It has a higher  $T_c$  than NbTi at 18.3 K and can be produced by several manufacturing methods. The first method is called the *bronze process* [14] and involves placing Nb filaments in a bronze matrix before various drawing and annealing stages and the final reaction heat treatment. A second common method is known as the *internal tin process* [15] in which a tin rod is used as the source of tin to react with Nb filaments in a Cu matrix. Finally, the *powder-in-tube process* (PIT), uses Nb-Sn intermetallics as the source of Sn. Here the Nb-Sn powder is packed in small Nb tubes, spaced by a Cu lining, and are then further stacked in a copper tube before the heat treatments and drawing stages.

Unfortunately, the material is much less ductile than NbTi, complicating the manufacturing processes, but the material is more suitable to generate the highest magnetic fields that are used in some applications. Internal tin wires are commonly used for high current applications whereas the bronze process is cheaper and is used when persistent currents are necessary. PIT wires are less common due to their higher production costs.

## High-Temperature Cuprates

The class of high-temperature superconductors became realised with the discovery of the cuprates [16]. With complicated crystal structures (e.g. in figure 9), these materials are very oxygen sensitive, adding complications with processing, and their superconducting properties are often anisotropic, meaning that the properties can be poor when current travels in one direction but excellent in a perpendicular direction. One example of this is the Bi-Sr-Ca-Cu-O system [17]. There are multiple forms of BSCCO including BSCCO-2223 (meaning  $\text{Bi}_2\text{Sr}_2\text{Ca}_2\text{Cu}_3\text{O}_{10+x}$ ). This material has a remarkable  $T_c$  of 110K [18], making it suitable for operation at liquid nitrogen temperatures. While this material can be produced in tapes, another material known as BSCCO-2212 can be produced in wire form using a powder-in-tube method. Its  $T_c$  is lower at 95 K, making it a bit less suitable for liquid nitrogen operation ( $T_c$  is usually desired to be much higher than the operating temperature for a material to be useful).

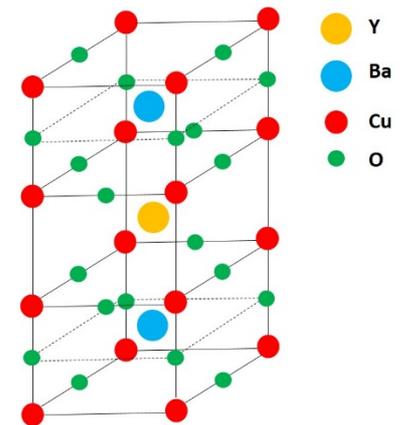


Figure 9: The crystal structure of YBCO

YBCO ( $\text{YBa}_2\text{Cu}_3\text{O}_{7-x}$ ), mentioned previously, requires a particular crystal orientation in order to get good superconducting properties, resulting in the coating conductor method as the preferred manufacturing process. Here, YBCO is grown on a substrate that influences the growth of the YBCO. The YBCO itself can be grown by pulsed laser deposition in a research scenario, but for a higher production rate metalorganic chemical vapour deposition (MOCVD) can be used. YBCO is not used in many applications due to poor properties in polycrystalline samples and issues associated with processing the material.

## Common Applications

### MRI and NMR (Nuclear Magnetic Resonance)

The vast majority of superconducting wires that are currently produced are used in Magnetic Resonance Imaging (MRI) scanners. These machines require very high magnetic fields of several Tesla (for comparison, the magnetic field generated by a typical fridge magnet is 0.01 T[19]), as well as high stability and a uniform field to give high resolution data. Good stability is achieved using wires with a high percentage of copper conductor, and the magnets are operated in persistent current mode whereby the circuit is detached from the power supply and the current is left flowing around the superconducting loop – MRI scanners are therefore nearly always left on. Nuclear Magnetic Resonance (NMR) spectroscopy is another application with very similar superconductor requirements, however the relative amount of superconductor is generally higher as generally lower

stability is required. It is also possible to achieve very high fields of  $\sim 9$  T using Nb<sub>3</sub>Sn [20] rather than NbTi.

## High Energy Physics

High energy physics is also a large consumer of superconducting wires, although the demand for them is less regular. The Large Hadron Collider (LHC) is one such example, which uses mostly NbTi-based magnets to control the high energy particle beam path [21]. These parts are crucial to some of the most exciting physics experiments being performed today, including the discovery of the Higgs boson in 2012. Experimental fusion reactors also employ superconductor-based magnets to control the plasma during the reaction [22]. Here the required fields are higher than can be achieved by NbTi so Nb<sub>3</sub>Sn is often used instead.

## Josephson Junctions

In a much different application, superconductors can be used to produce Josephson junctions. These devices are made up of two superconductors separated by a non-superconducting material. Cooper pairs can flow (or tunnel) from one superconductor to the other by the Josephson effect [23], [24], an effect which has application in SQUIDs (superconducting quantum interference devices) [25] for precise magnetic field measurements among other things, including the potential for use in quantum computers.

## Looking to the Future

### Room Temperature Superconductivity

One of the main goals of research into superconducting materials is developing a material that is able to superconduct at room temperature. While the high-temperature cuprates are a promising set of materials,  $T_c$  is still 100 K away from room temperature. In 2015, Drozdov *et al* [26] demonstrated the highest ever recorded  $T_c$  of 203 K in H<sub>2</sub>S. While this a further amazing step towards room temperature superconductivity, this was also achieved at a pressure of 155 GPa (atmospheric pressure is  $\sim 101$  kPa) and so is still far from superconductivity at ambient conditions. Another promising set of candidate materials is the iron pnictides. Discovered in 2008 [27], these materials are similar in their layered structure to the cuprates. However, the anisotropy in properties is less pronounced, resulting in the potential for easier processing methods.

## Quantum Computing

In current computing technologies, progression is becoming limited by the reduced size of our current transistor technologies. Eventually we will hit a point where it is no longer possible to improve processing power this way and we might want to look at a different form of computer altogether. Quantum computers are a popular option, using quantum phenomena such as superposition to perform their calculations. In theory, these types of computers would be much faster than classical computers at solving particular tasks. While the technology is still in its infancy, superconducting materials have the potential for use as superconducting qubits (quantum bits) using Josephson junctions [28].

## Conclusion

Over the course of this article we have covered the basics of superconductivity, from its discovery all the way to current day uses. The basic properties of a superconductor have been discussed, with a brief description of the differences between Type I and II, and examples of important technological superconducting materials and their applications. Aside from electrical current transport and magnetic field generation, there are many other interesting applications for superconductors including quantum computing and many more that have not been discussed here. Superconducting materials will become increasingly important as we try to meet the world's energy and technological demands and so the motivation for finding better materials is stronger than ever. So, while we are still far from usable room temperature superconductors, hopefully it is not too long before we see a paper announcing the discovery of superconductivity at 298 K.

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# Does the End Justify the Means?

## Should Humanitarian Needs Render the Use of Force Lawful?

Eirini Fasia

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### The Prohibition of the Use of Force in a Nutshell.

The prohibition of inter- state use of force is the cornerstone of contemporary international law. The rule is enshrined in Article 2 paragraph 4 of the Charter of the United Nations and urges all member states to “refrain from the threat or use of force against the territorial integrity or political independence of any state, or in any other manner inconsistent with the purposes of the United Nations.”

Only two exceptions with respect to this rule are incorporated in the system of the Charter. The first being, Article 51 which allows states to use of force by virtue of their inherent right of individual or collective self- defence in response to an armed attack against them. The second exception is the Security Council authorization under Chapter VII of the UN Charter. The Security Council under this chapter of the Charter is enlisted with the task to undertake any action, including military action, in the event of threat to the peace, breach of the peace or act of aggression. Such authorization had been given, inter alia, for the action taken in Somalia, Rwanda, Bosnia- Herzegovina, East Timor and Côte d’ Ivoire.<sup>1</sup>

Lastly, we shall mention that a state’s use of force in the territory of another state is perfectly lawful if it has the consent of the other’s state. This is not considered an exception to the rule of article 2 paragraph 4 since it does not fall within the ambit of the prohibition. It is clear that in such cases where the host state gives consent to other states to intervene, the latter do not really use force against a third state. Accordingly, the action is considered to be outside the ambit of the Charter’s prohibition. Of course, the consent given must meet certain conditions in order to be valid.<sup>2</sup> An example of consent- based use of force are the so-called Peacekeeping Operations, at least, in their early days. They are conducted by the United Nations or under other regional bodies and must always fulfill the criteria of consent, impartiality and deployment of exclusively defensive force.<sup>3</sup>

### The Doctrine of Humanitarian Intervention

The question which naturally stems from the above analysis is whether there is a right of states to unilaterally use force against other states in order to achieve humanitarian ends, ie when neither the SC has so authorized nor the territorial state has consented to such action nor there is basis for a lawful exercise of the right of self- defence. In other words is there a right to the so- called humanitarian intervention? Dealing exhaustively with the

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<sup>1</sup> SC Res 794 (1992); SC Res 929 (1994); SC Res 1031 (1995); SC Res 1264 (1999) and SC Res 1464 (2003) respectively.

<sup>2</sup> For the validity of consent see Art. 20 ILC Articles on State Responsibility (2001).

<sup>3</sup> <http://www.un.org/en/peacekeeping/operations/peacekeeping.shtml> .

definitional difficulties of this doctrine is beyond the spatial confines of the present article; Briefly, according to the International Commission on Intervention and State Sovereignty (ICISS) the doctrine of humanitarian intervention refers to “*action taken against a state or its leaders, without its or their consent, for purposes which are claimed to be humanitarian or protective [...]*.”<sup>5</sup> For the purpose of our question we can assume the best- case scenario- that the purposes are actually humanitarian, i.e. to end grave human rights abuses or to manage humanitarian catastrophes. To assess whether use of force is lawful, even in such a scenario, we may examine the pertinent rules of international law as they stand today.

All legal arguments supporting the existence of a right to humanitarian intervention revolve around the nature and the interpretation of article 2 (4) of the UN Charter and are the following:

#### **Narrow interpretation of article 2 (4).**

Article 2 (4) prohibits the “*use of force against the territorial integrity or political independence of any state.*” It has been argued that this part of the wording of the article is crucial for the determination of the scope of the prohibition imposed. The UK, for instance, claimed in the *Corfu Channel* case (UK vs. Albania) that its use of force against Albania did not violate article 2 (4) because it did not threaten the territorial integrity or the political independence of Albania. The International Court of Justice rejected this argument.<sup>6</sup> Israel has also used this line of argumentation with respect to Entebbe’s incident in 1976, finding though no acceptance by other states.<sup>7</sup> Such a view would allow states to use force against other states claiming abusively that the force used turns against an alleged humanitarian crisis and hence not against the territorial integrity or political independence.

This *a contrario* interpretation of article 2 (4) is rather weak and has been widely isolated among scholars.<sup>8</sup> Besides other theoretical and historical considerations, this position seems to ignore both the object and purpose of the article, which is clearly to flatly prohibit any interstate use of force. It is true that the Charter contains also other objectives such as protection of human rights (preamble). However, the balancing of the various objectives has been done by the Charter itself and is not left to the judgment of the member states.

#### **ii. Non- peremptory nature of the prohibition of the use of force.**

It is widely accepted that the prohibition of the use of force as enshrined in article 2 (4) of the Charter reflects customary international law. What is more a great majority of scholars endorse the view that the prohibition enjoys also a peremptory character. Nevertheless, this view is not uncontested. It is thus argued that a rule subject to exceptions

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<sup>4</sup> On this see, *inter alia*, A. Hehir, *Humanitarian Intervention: An Introduction* (Palgrave Macmillan 2013), at chapter 1.

<sup>5</sup> ICISS Report, *The Responsibility to Protect* (2001), at 8.

<sup>6</sup> *Corfu Channel*, ICJ Reports (1949), at 34.

<sup>7</sup> SC 1942<sup>nd</sup> meeting (1976), at 102.

<sup>8</sup> See for relevant bibliography in O. Corten, *The Law against War*, at 498; See also UN Charter’s Commentary, art. 2 (4) (Simma *et al.* eds), at 37, where stated that “*the terms “territorial integrity” and “political independence” are not intended to restrict the scope of the application of the prohibition of the use of force.*”

does not qualify for acquiring a *jus cogens* status and that recent developments of the rule prove that it is not frozen in time as a peremptory nature would require (see for example the new concept of cyber-attacks).<sup>9</sup> A less stringent view supports that only the very core of the prohibition constitutes *jus cogens*, ie the one referring to aggression.<sup>10</sup>

The legal nature of the prohibition is crucial for our question. If article 2 (4) is to be considered a peremptory rule of international law, it can never be overruled by a new rule of customary or conventional nature. Article 53 of the VCLT is clear on this by saying that a peremptory norm “*can be modified only by a subsequent norm of general international law having the same character.*” Conversely, if article 2 (4) is not a *jus cogens* rule -at least in its entirety- this would mean that a new customary rule regarding humanitarian intervention could emerge overruling or operating along with article 2 (4).

### iii. Customary law rule on humanitarian intervention.

In the case that the *jus cogens* character of the norm is rejected or only the prohibition of aggression is to be considered as such, then there is room for a new customary rule on humanitarian intervention to emerge. State practice complemented by *opinio juris* becomes therefore necessary.

Occasionally, states have relied on the doctrine of humanitarian intervention. As it will be shown however below, state practice on this respect is rather sparse. The UK is actually the leading state supporting the existence of such a right. The UK Foreign and Commonwealth Office endorsed in 1992 the doctrine of humanitarian intervention by saying that “*international intervention without the invitation of the country concerned can be justified in cases of extreme humanitarian need.*”<sup>11</sup> In 2000 the UK Foreign Secretary submitted to the UN SG a guidance to intervention in response to massive violations of humanitarian law and crimes against humanity. In the case before the ICJ regarding the *Legality of the Use of Force (Yugoslavia v. Belgium, UK and others)* the UK and Belgium were the only countries to expressly endorse the doctrine of humanitarian intervention. In the words of the UK: “In the exceptional circumstances of Kosovo it was considered that the use of force would be justified on the grounds of overwhelming humanitarian necessity, without Security Council authorization.” The other respondents of the case did not invoke it in their line of argumentation, whereas some had even previously explicitly rejected it.<sup>12</sup> What is more, Group of 77 (an organization that speaks for 132 UN Member States) adopted in 1999 a foreign ministers’ declaration stating that the Ministers rejected the so called right of humanitarian intervention, which has no basis in the UN Charter or in international law.

A similar declaration was also adopted by the 115 States of the Non-Aligned Movement in 2000 and in the same year by the 57 Member States of the Islamic Conference

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<sup>9</sup> For an extensive analysis of the relevant debate see J. Green, “Questioning the Peremptory Status of The Prohibition of The Use of Force” (2011) 32 *Michigan Journal of International Law* 215. See also *Nicaragua*, Merits, ICJ Rep. 1986, at 190.

<sup>10</sup> See for example the Report of the ILC 53<sup>rd</sup> Session (2001), at 283 (4) and GA Res 3314 (1974) which excluded considerations of political, economic, military and other nature as justification only for aggression, not referring generally to use of force.

<sup>11</sup> UK Materials on International Law, 63 BYIL (1992), at 826.

<sup>12</sup> See for example Germany’s Declaration in the GA in 1999, A/54/PV.8, at 12.

Organisation. Generally, it is apparent that, NATO action against Yugoslavia is still strongly controversial and considered by the majority of states and commentators as illegal.<sup>13</sup>

All the above documents of course, except for the SC Resolution, are of soft law nature. This is indicative of the lack of consensus in the area. These documents present the general trend regarding the doctrine, which is a general reluctance of explicitly endorsing it. Even scholars who seem to believe that a right to humanitarian intervention should be legal because of its moral value, confirm that under contemporary international law such right does not exist.<sup>14</sup>

### **The Relevance of Humanitarian Needs in the SC Decision-making Procedure.**

Humanitarian Intervention may have not been recognized by international community but humanitarian considerations are very often part of the international political agenda. The Security Council and more generally the United Nations being a political rather a legal organ takes into account humanitarian needs that exist in various incidents. In a political speech the Secretary General of the United Nations mentioned in 2000 that: "Humanitarian intervention is a sensitive issue, fraught with political difficulty and not susceptible to easy answers. But surely no legal principle - not even sovereignty - can ever shield crimes against humanity." This statement foreshadowed the emergence of the "Responsibility to Protect" context. In 2001 the ICISS published a report on this. "Responsibility to Protect" usually refers to military action taken within the humanitarian concept, through the SC authorization though. As far as unauthorized intervention is concerned, the ICISS left open the question whether and under what circumstances such an intervention would be valid in legal terms and seemed to propose a balancing exercise by wondering: "*where lies the most harm: in the damage to international order if the Security Council is bypassed or in the damage to that order if human beings are slaughtered while the Security Council stands by?*"<sup>15</sup>

In 2004 the UN High-Level Panel on Threats, Challenges and Change in its report focused rather exclusively on the collective responsibility of states always associated with action by the Security Council. Its reference to the "*responsibility to protect of every state when it comes to people suffering from avoidable catastrophe [...]*"<sup>16</sup> does not suffice for us to extract a conclusion for the allowance of humanitarian intervention. The 2005 Report of the Secretary General did not explicitly reject unilateral action nor however accepted it.<sup>17</sup> At the same year, the participants of the World Summit emphasized each state's responsibility to protect populations from genocide, war crimes, ethnic cleansing and crimes against humanity. However, they declared that they are "*prepared to take collective action [...] through the SC, in accordance with the Charter, including Chapter VII, on a case-by-case basis [...]*"<sup>18</sup> The SC Res. 1674

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<sup>13</sup> UN Press Release GA/SPD/164 (1999); See also Byers and Chesterman, Changing the rules about rules? Unilateral humanitarian intervention and the future of international law in Holzgrefe and Keohane (eds.), *Humanitarian Intervention* (CUP 2003) at 184.

<sup>14</sup> *Inter alia*, A. Peters, "Humanity as the A and Ω of Sovereignty" (2009) 20 (3) *EJIL* 513.

<sup>15</sup> *Ibid.* at 6.37.

<sup>16</sup> UN Report of the SG's High Level Panel, *A More Secure World: Our Shared Responsibility* (2004), at 201.

<sup>17</sup> UN Doc. A/59/2005, In *Larger Freedom: Towards Development, Security and Human Rights for All*, at 111-113.

<sup>18</sup> UN World Summit, Outcome Document, at 138- 139.

(2006) reaffirmed these provisions of the Outcome Document. The UN Security Council has in recent years demonstrated its capacity and willingness to intervene in internal conflicts. It has already done so with respect to Libya where authorized a no-fly zone and protection of civilians (SC Res 1973/ 2011).

## **Conclusion**

In the light of the above, it is submitted that international law as it stands today does not allow humanitarian intervention outside the framework of the UN Charter. Even those who support the moral value of it, do recognize that positive international law contains no pertinent right. What is more, state practice shows that humanitarian reasons are always a complementary and fall back justification accompanying classical legal reasoning. State's consent or SC authorization remain the only two possible ways for third states to initiate military action serving humanitarian objectives.

# Pay or Play: The Varoufakis Negotiations from a Game-Theoretical Perspective

Anselm Küsters

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## Introduction

In February of 2015, the newly-elected finance minister of Greece, Yanis Varoufakis, made an official visit to Berlin to renegotiate his country's bailout programme. Years of austerity policies had not led to economic recovery in Greece, but instead resulted in mass demonstrations and growing debt. Varoufakis describes the first meeting with his German counterpart, Wolfgang Schäuble, as being like a High-Noon standoff from a classic Western: 'The elevator door opened up onto a long, cold corridor at the end of which awaited the great man in his famous wheelchair.'<sup>1</sup> As Varoufakis approached Schäuble, his extended hand was refused.

The shunned hand dramatically illustrated the Eurozone split between Northern surplus countries and Southern deficit countries, with the former group of countries demanding strict austerity rules.<sup>2</sup> Moreover, the politicians were separated by personal and ideological differences. Whereas 'Schäublenomics'<sup>3</sup> defines a rule-based framework for the state, explaining Germany's focus on balanced budgets, price stability and structural reforms,<sup>4</sup> Varoufakis highlights the role of aggregate demand and global imbalances.<sup>5</sup>

However, the history of the bailout negotiations was more complicated than a pure 'battle of ideas' between two individuals. Foremost, Varoufakis and Schäuble were representatives of their respective countries' interests and aimed for the most beneficial negotiation outcome for their respective nation. Game Theory, a discipline of Economics, tells us that outcomes in such a bargaining situation are determined by the decision-makers' interacting opportunities, their preferences, as well as their perceptions of the other.<sup>6</sup> After describing the context in which the Greek bailout negotiations took place, I will motivate and establish a game-theoretical model which allows us to better understand the negotiations' outcomes.

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<sup>1</sup> Varoufakis, Y., *And the weak suffer what they must? Europe, austerity and the threat to global stability* (London 2016), pp. x-xi.

<sup>2</sup> See Young, B., 'German ordoliberalism as agenda setter for the euro crisis: myth trumps reality', *Journal of Contemporary European Studies*, 22/3 (2014), p. 276.

<sup>3</sup> Schierit, M., 'Gut instincts: the world according to Wolfgang Schäuble', *Die Zeit* (09.10.2015), <http://www.zeit.de/wirtschaft/2015-10/economics-wolfgang-schaeuble-point-of-view-austerity-policy> (12.12.2016).

<sup>4</sup> See Zuleeg, F., 'The Eurocrisis response: towards a German Europe?', in G. Bratsiotis and D. Cobham (eds), *German macro: how it's different and why that matters*, EPC Discussion Paper (2016), pp. 93-9.

<sup>5</sup> Varoufakis, Y., *The global minotaur: America, the true origins of the financial crisis and the future of the world economy* (London 2011) and Varoufakis, *Weak*.

<sup>6</sup> See Hirshleifer, J., 'Peace or war: an economic approach to appeasement', *University of California Los Angeles Working Paper*, 817 (2002), p. 1.

## Short history of the Greek bailout negotiations

The debt accumulated by Greece since its Euro debut reached the unmanageable size of €300 billion in 2009.<sup>7</sup> To avoid default, a tripartite committee led by the European Commission with the European Central Bank (ECB) and the International Monetary Fund (known as 'Troika') provided Greece with €110 billion in May 2010, but in return demanded cuts in public spending, higher taxes, and privatisation. A second bailout package was necessary in early 2012, providing an additional €130 billion, but thereby also containing harsher austerity measures. In late January of 2015, the left-wing challenger party SYRIZA, founded only in 2004 and led by Alexis Tsipras, achieved an electoral triumph in Greece by promising to end this crisis (mis)management.<sup>8</sup> SYRIZA's 'miraculous rise' has been explained by the party's pluralistic and diverse composition and its close alignment to important social movements.<sup>9</sup> However, cancellation of austerity policies required renegotiation of Greece's bailout loans.

This ambitious task fell into the hands of Varoufakis, who quickly became dissatisfied with the policy options given to him by the Troika.<sup>10</sup> He believed that Greece could achieve a significant debt relief, his *conditio sine qua non* for any compromise, only through tough negotiation. In contrast, the majority of Tsipras' inner circle expected that if Greece made greater concessions, it would finally achieve a better deal.<sup>11</sup> In his most recent book, Varoufakis describes at length how SYRIZA's inner circle became increasingly ready to accept less ambitious deals, thereby 'drifting into the mentality of the famous Brussel fudge.'<sup>12</sup> Tellingly, his book is dedicated to all 'who eagerly seek compromise but would rather be crushed than end up compromised.' Unlike Tsipras' inner circle, Varoufakis clearly favoured Grexit over a third bailout without debt restructuring. Nevertheless, the party leader's willingness to compromise enabled the extension of the Master Financial Assistance Facility Agreement (MFFA) on 20<sup>th</sup> February 2015. Although the agreement avoided controversial terms like 'Troika,' it was in effect based on the earlier bailout programme and thus heavily criticized by some far-left SYRIZA members.<sup>13</sup> The compromise secured Greece's access to short-term liquidity, while the Troika promised to review its bailout conditions.

In contrast to this promising start, the relationship between the negotiators gradually started to deteriorate. In April, at a meeting of Eurozone finance ministers in Riga, the other politicians accused Varoufakis of failing to deliver 'credible' proposals and described him as a time-waster, gambler and amateur.<sup>14</sup> In the evening, Varoufakis skipped the traditional dinner with his colleagues, thereby causing negative media coverage. After the Riga

<sup>7</sup> Figures from: Bistis, G., 'From Karamanlis to Tsipras: the Greek debt crisis through historical and political perspectives', *Mediterranean Quarterly*, 27/1 (2016), pp. 36-9.

<sup>8</sup> Hobolt, S. and Tilley, J., 'Fleeing the centre: the rise of challenger parties in the aftermath of the euro crisis', *West European Politics*, 39/5 (2016), p. 972.

<sup>9</sup> See Spourdalakis, M., 'The miraculous rise of the "phenomenon SYRIZA"', *International Critical Thought*, 4/3 (2014), pp. 358-9.

<sup>10</sup> Varoufakis, *Weak*, p. 311, ft. 26.

<sup>11</sup> See Munevar, D., 'Why I've changed my mind about Grexit', *Social Europe* (23.07.2015), <https://www.socialeurope.eu/2015/07/why-ive-changed-my-mind-about-grexit/> (05.12.2016).

<sup>12</sup> Varoufakis, Y., *Adults in the room. My battle with Europe's deep establishment* (London 2017), p. 322.

<sup>13</sup> See Roar Magazine, 'Glezos denounces Greek loan agreement as illusion' (22.02.2015), <https://roarmag.org/essays/glezos-greek-bailout-illusion/> (06.12.2016).

<sup>14</sup> Varoufakis, *Adults*, p. 388.

meeting, Tsipras started to side-line Varoufakis, indicating that the latter went too far by ignoring the internal strategy of seeking a compromise. Additional irritation spread in May when Varoufakis announced that he had recorded parts of the meeting with his mobile phone<sup>15</sup> – a clear violation of tacit diplomatic rules. Mutual suspicion peaked in June, when SYRIZA unexpectedly called for a referendum on the creditor's bailout conditions, fuelling the Europe-wide perception that SYRIZA was not truly willing to compromise. Of all SYRIZA ministers, Varoufakis was by far the most vigorous and most visible supporter of the 'No' campaign, thereby further accentuating the differences between him and the party leadership.<sup>16</sup> Meanwhile, the ECB limited its emergency liquidity assistance, causing uncertainty to rise and balance sheets of Greek banks to worsen. SYRIZA had to impose capital controls, meaning Greek citizens could withdraw only a limited amount of money from their banks. Nevertheless, 61% of the population voted 'No', thus rejecting the Troika's bailout conditions.<sup>17</sup>

The chaotic situation led to a 'rude awakening' for many Greeks and a 'U-turn' by the government, which had few alternatives to stabilize the country's banks.<sup>18</sup> Tsipras asked for the resignation of Varoufakis, who later complained: 'I was made aware of a certain preference by some Eurogroup participants [...] for my absence from its meetings; an idea the prime minister judged to be potentially helpful to him in reaching an agreement.'<sup>19</sup> Varoufakis was replaced by Euclid Tsakalotos, who, on the 13<sup>th</sup> July, signed an agreement for a third bailout package of €86 billion, accomplishing 'in just a few hours what almost six months of earlier negotiations had failed to achieve.'<sup>20</sup> What had happened?

## Getting the game started

During Varoufakis' time as finance minister, it became widespread to speculate whether the author of a Game Theory textbook<sup>21</sup> would apply his academic knowledge in the negotiations.<sup>22</sup> Given a specified action space and game structure, Game Theory derives rational decision patterns, shaped by the respective preferences of the 'players.' The negotiations on the extension of the bailout package for Greece can be seen as a game between the Greek government and the European creditors.<sup>23</sup>

Most prominently, the negotiations have been characterized as a 'chicken game'<sup>24</sup>: lenders advocate a reformist programme which they believe will lead to a repayment of their loans. The argument goes that the Greek government believes that austerity precludes economic growth and therefore resists the implementation of such reforms. If neither is

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<sup>15</sup> See Varoufakis, Y., 'The truth about Riga', *Blog 'thoughts for the post-2008 world'* (24.05.2015), <https://yanisvaroufakis.eu/2015/05/24/the-truth-about-riga/> (07.12.2016).

<sup>16</sup> See Varoufakis, *Adults*, pp. 443-73.

<sup>17</sup> See Erik Jones, E. and Torres, F., 'Using interdisciplinary analysis to shape a policy agenda', *Journal of European Integration*, 37/7 (2015), pp. 876.

<sup>18</sup> Both quotes: Bistis, *Crisis*, p. 52.

<sup>19</sup> Varoufakis, Y., 'Minister No More!', *Blog 'thoughts for the post-2008 world'* (06.07.2015), <https://yanisvaroufakis.eu/2015/07/06/minister-no-more/> (10.12.2016).

<sup>20</sup> Bistis, *Crisis*, p. 51.

<sup>21</sup> Hargreaves-Heap, S. and Varoufakis, Y., *Game theory: a critical text* (New York 2004).

<sup>22</sup> His latest book includes an Appendix describing a 'game' he designed for students in 2012 to analyse the negotiations between Greece and the Troika. See Varoufakis, *Adults*, pp. 492-5.

<sup>23</sup> I assume a homogeneous player 'Creditor.'

<sup>24</sup> See Varian, H., *Grundzüge der Mikroökonomik*, 7<sup>th</sup> edn (New York 1987), p. 625.

willing to change its course of action, the game will result in a 'collision' (involuntary Grexit). However, it is more likely that the two sides defer from their optimal option and reach a last-minute compromise.<sup>25</sup>

Others argued that SYRIZA was in a dominant position: if creditors would not agree to Greek demands, Greece would leave the Euro, redenominate debts into a new devalued currency, impose currency controls, and subsequently force losses onto German banks.<sup>26</sup> Interestingly, Varoufakis seemed to share this perspective. Already in 2011, he said that the demands of the EU creditors should be seen as an 'incredible threat,' because if Greece left the Euro the whole currency union would collapse.<sup>27</sup> Four years later, Varoufakis told the same story stating that '[t]he euro is fragile; it's like building a castle of cards. If you take out the Greek card, the others will collapse.'<sup>28</sup>

But unlike the early years of the Eurozone crisis, European leaders now generally did not expect economic contagion, not least due to the ECB's Quantitative Easing, a non-standard monetary policy programme designed to buy assets from commercial banks.<sup>29</sup> In 2015, European banks only had minimal exposure to Greek debt, while a domestic unemployment rate of 27% increased the political pressure on the Greek government to deliver fast results.<sup>30</sup> Given these changed power relations, Varoufakis' insistence on not extending the bailout programme was an 'incredible threat' of his own.<sup>31</sup>

### A new model and how it fits the story

Models like 'chicken game' assume *complete information*. This is unrealistic given two facts: first, SYRIZA had no record in power. Second, the internal cohesion of the party was uncertain. Already on its founding congress in July 2012, discussions created a polarization between a pragmatic majority and an influential minority: the 'left platform.' The latter, making up approximately 30% of the support, was composed of former members of Greece's communist party, former PASOK members of nationalist orientation and Trotskyists – all held together by their clear euro-scepticism.<sup>32</sup> Moreover, SYRIZA was closely interlinked with various social movements, such as environmental movements, immigrant groups, and the new rank and file trade union movement. After electoral success, SYRIZA's internal differences were to become more dysfunctional, in particular because, as noted by observers, the party's leadership was not 'very effective in fully incorporating [these differences] into the party structure.'<sup>33</sup>

<sup>25</sup> See Scanlon, D., 'The application of game theory to the Greek debt crisis' (Unpublished paper, 11.12.2015), <http://myslu.stlawu.edu/~nkomarov/450/DaniPaper.pdf> (12.12.2016), p. 11.

<sup>26</sup> See Price, T., 'The Varoufakis game is not chicken', *openDemocracy* (16.02.2015), <https://www.opendemocracy.net/can-europe-make-it/tony-curzon-price/varoufakis-game-is-not-chicken> (12.12.2016).

<sup>27</sup> See Mike Bird: 'What Greek finance minister Yanis Varoufakis used to believe about 'game theory' and the 'incredible threat' to Europe', *Business Insider* (17.02.2015), <http://uk.businessinsider.com/greece-yanis-varoufakis-using-game-theory-2015-2> (05.12.2016).

<sup>28</sup> Jones, G., 'Greek finance minister: The euro will collapse if Greece exits', *Business Insider* (09.02.2015), <http://uk.businessinsider.com/greek-finance-minister-the-euro-will-collapse-if-greece-exits-2015-2> (05.12.2016).

<sup>29</sup> See Brunnermeier et. al., *Battle*, p. 232.

<sup>30</sup> See Coppola, F., 'High-stakes European poker: a reply to Curzon Price', *openDemocracy* (07.03.2015), <https://www.opendemocracy.net/can-europe-make-it/frances-coppola/highstakes-european-poker-reply-to-curzon-price> (12.12.2016).

<sup>31</sup> See Bird, *Threat*.

<sup>32</sup> See Spourdalakis, *SYRIZA*, p. 362, ft. 6.

<sup>33</sup> *Ibid.*, p. 363.

Confronted with such a Black Box, European leaders decided for a rather friendly strategy: initially, they promised help and avoided discussions about ‘Grexit,’ but they also insisted on implementation of reforms.<sup>34</sup> Such an approach was reasonable given the structure of the EU, whose complex governance system depends on the premise that rules and common behaviour cannot change every time a new government is elected.<sup>35</sup> However, as rational players, European leaders stayed sensitive to any ‘signals’ sent by Athens in an attempt to identify their underlying intentions, thus constantly reviewing their current strategy.

<p><b>Greece Payoff for t = Compromise</b>                      4: Promise Reforms, Help                      3: No Reforms, Help                      2: Promise Reforms, No Help                      1: No Reforms, No Help</p>	<p><b>Greece Payoff for t = Grexit</b>                      4: No Reforms, Help                      3: No Reforms, No Help                      2: Promise Reforms, Help                      1: Promise Reforms, No Help</p>
<p><b>EU Payoff for t = Compromise</b>                      4: Promise Reforms, Help                      3: Promise Reforms, No Help                      2: No Reforms, Help                      1: No Reforms, No Help</p>	<p><b>EU Payoff for t = Grexit</b>                      4: Promise Reforms, No Help                      3: No Reforms, No Help                      2: Promise Reforms, Help                      1: No Reforms, Help</p>

Table 1: Payoff Structures for both players, with payoffs depending on type of Greece

Such a story, in which the identity of a player is known but his preferences are unknown, can be modelled with so-called *Bayesian games*. Player 1 is allowed to have some private information that affects the overall game play, while player 2 has beliefs about this private information.<sup>36</sup> In our case, this information reflects the internal consensus of the SYRIZA leadership ( $p$ ), which is known to Varoufakis and his advisors, but not to others, and is modelled by adding a third player, called *Nature*, to the game structure. EU’s guess of SYRIZA’s credibility ( $\hat{p}$ ) is initially based on tacit rules of EU diplomacy, and later on their experiences with Varoufakis. After *Nature*’s initial move, both players decide simultaneously how to negotiate: Greece can ‘Promise reforms’ or, with reference to SYRIZA’s campaign, refuse to do so. The EU, confronted with time-pressure and an illiquid member state, can decide to give fresh money (‘Help’) or refuse to do so. We can represent the payoffs with an ordinal utility value, based on the (revealed) preferences of the two players (Table 1).<sup>37</sup>

What is the reasoning behind the concrete sequences? First, ‘compromise willing’ Greece actively seeks a deal with the EU, therefore receiving more utility from a negotiating strategy which can promise some reforms. However, since they are running out of money, outcomes including ‘Help’ are strictly preferred to outcomes without fresh money. Second,

<sup>34</sup> See Brunnermeier et. al., *Battle*, p. 232.

<sup>35</sup> See Bistis, *Crisis*, p. 49.

<sup>36</sup> See Nurmi, P., ‘Bayesian game theory in practice: A framework for online reputation systems’, *University of Helsinki Series of Publications C*, C-2005-10 (2005),

[https://www.cs.helsinki.fi/u/ptnurmi/papers/nurmi\\_bayesian\\_games\\_reputation.pdf](https://www.cs.helsinki.fi/u/ptnurmi/papers/nurmi_bayesian_games_reputation.pdf) (12.12.2016), p. 3.

<sup>37</sup> See Fürstjes et. al., *Scheitern*, p. 544; Hirshleifer, *Appeasement*, p. 2.

‘Grexit loving’ Greece feels deeply bound to its campaign, which promised an end to reforms in uncompromising terms. Third, the EU, facing a compromise-seeking SYRIZA, prefers to offer ‘Help’ to rescue its member state and avoid financial instability. However, since the situation no longer threatens the whole system, creditors strictly prefer a deal which includes reforms. Fourth, EU would immediately stop all negotiations with a ‘Grexit loving’ Greece, which makes empty reform promises to buy time or tries to prepare a future ‘blame game.’<sup>38</sup> This means strict preference for ‘No help’ negotiations.

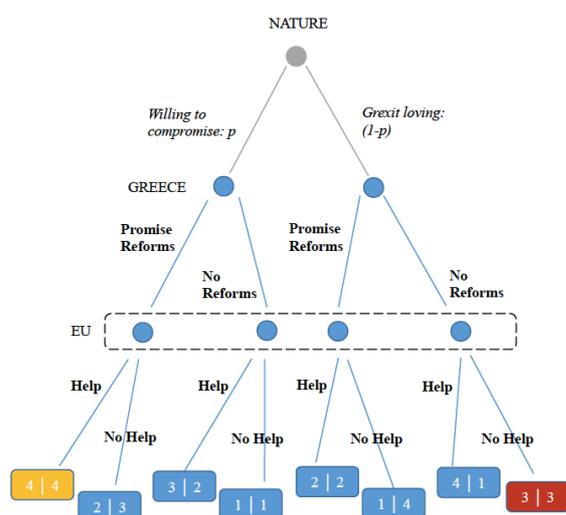


Figure 1: The Two Type Game in Extensive Form

		Compromise (p)	
		Help	No Help
GREECE	Promise Reforms	4   4	2   3
	No Reforms	3   2	1   1

		Grexit (1-p)	
		Help	No Help
GREECE	Promise Reforms	2   2	1   4
	No Reforms	4   1	3   3

Figure 2: The Two Type Game with Matrices

We can solve this static game (Figure 1) via the concept of *Bayesian Nash Equilibrium* (BNE). A BNE is the combination of a specific strategy profile with beliefs about the types of the other players, which maximizes the expected payoff for each player.<sup>39</sup> Greece knows its type and therefore plays its dominant strategy: if there is an internal consensus for compromise, it promises reforms, otherwise not. As can be seen from Figure 2, EU’s choice depends on its expectation concerning the unknown type of Greece: if Greece is ‘willing to compromise’, EU’s best response is ‘Help’. If Greece secretly plans for Grexit, the EU’s best response is to stop the money. The EU attaches probability  $\hat{p}$  to Greece being compromise-seeking, which allows us to calculate EU’s expected payoff from both strategies. The model predicts two BNEs: EU plays ‘Help’ if  $\hat{p} > \frac{2}{3}$ , and ‘No Help’ otherwise.

How did  $\hat{p}$  evolve during the negotiation process outlined above? Initially, the EU welcomed the new negotiation partner in a cooperative way (high  $\hat{p}$ ). Since Tsipras and his inner circle were also interested in a compromise, this enabled the MFFA extension in February. However, the EU’s perception of SYRIZA’s credibility changed dramatically from April onwards. At the Riga meeting, Varoufakis clashed with the other ministers and did not participate in the diplomatic protocol. Mistrust spread further when media reported that Varoufakis had recorded the meetings. The surprising call for a referendum finally

<sup>38</sup> See Wodak, R. and Angouri, J., ‘From Grexit to Grecovery: Euro/crisis discourses’, *Discourse & Society*, 25/4 (2014), p. 418.

<sup>39</sup> See Gibbons, R., *Game theory for applied economists* (Princeton 1992), p. 151.

decreased  $\hat{p}$  below the threshold (in our model:  $\frac{2}{3}$ ). Playing the same game again,<sup>40</sup> the EU now concluded that playing 'No Help' was their dominant strategy, reflected by the temporary end of negotiations, uncertainty and a Greek banking crisis.

Why did Varoufakis allow for such a development? He seems to have approached 'the Eurogroup negotiations in the same way [...] as he thought about them in 2011.'<sup>41</sup> He acted in another game – a game which centred around the supposedly dominant position of Greece and which he was determined to play until the end. But in 2015, Greece's position had changed and the EU's demands were anything but 'incredible' – unlike Varoufakis' public statements, which changed  $\hat{p}$  in such a way that it led to the chaos of June 2015. Varoufakis' crucial role in increasing  $\hat{p}$  is clearly illustrated by a leaked email, in which the financier George Soros wanted 'to communicate with [Tsipras] to urge him to remove [Varoufakis] from [government] as [he was] the impediment to the agreement.'<sup>42</sup>

The model also implies that Tsipras had incentives to restore SYRIZA's perceived credibility ( $\hat{p}$ ). By asking Varoufakis to resign and introducing the friendly Tsakalotos as a 'new face' to the creditors, he was signalling to the EU that Greece wanted an agreement. Although Tsakalotos shares many of Varoufakis's views, he is ideologically committed to the Euro – a disposition expected to be helpful for new negotiations.<sup>43</sup> The increased  $\hat{p}$  resulted in a new bailout programme<sup>44</sup> that was at the same time more generous (larger sums of assistance) and more rigorous (greater constraints on Greek policy) than ever before, thereby being the logical consequence of this game.

To sum up, in this essay I used a game-theoretical approach to emphasise how Varoufakis' actions increased the uncertainty surrounding the Greek bailout negotiations, which finally led to their chaotic collapse in June 2015. To Varoufakis' credit, the general Eurozone conflict reaches far beyond the actions of a single actor. However, a crucial political prerequisite for overcoming the various structural, cultural and political differences is a stable perception of the other player involved in the negotiation game. In early 2016, Varoufakis himself admitted his failure during the negotiations by confessing that he 'would do a lot of things differently.'<sup>45</sup>

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<sup>40</sup> Note, this is not a dynamic model: As  $\hat{p}$  changes, EU uses the same (static) game again to determine actions.

<sup>41</sup> See Bird, *Threat*.

<sup>42</sup> Reported in: Brunnermeier et. al., *Battle*, p. 267.

<sup>43</sup> See Bistis, *Crisis*, p. 48-9.

<sup>44</sup> See Jones/Torres, *Agenda*, p. 876.

<sup>45</sup> Ekathimerini, 'Varoufakis speaks about Plan X and its rejection' (20.01.2016), <http://www.ekathimerini.com/205218/article/ekathimerini/news/varoufakis-speaks-about-plan-x-and-its-rejection> (06.12.2016).

# Revisiting Roman Contracts:

## Justinian's Treatment of the Contract *Verbis* and *Litteris*

Kal Leung

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### Introduction

The contracts *verbis* and *litteris* were two of the four categories (*genera*) of contracts recognized by both the Institutes of Gaius and of Justinian in their classification of Roman legal obligations.<sup>1</sup> The existence of both categories of contracts can be traced back to the earliest periods of Roman law,<sup>2</sup> but the popularity in practice of each diverged from the classical period up until the time Justinian's Institutes were published in 533 AD.

The contract *verbis*, epitomised by the *stipulatio*, became a cornerstone of Roman contract law, playing an important role in the world of Roman commerce and finance, whilst the contract *litteris* fell into disrepute.

This article will compare and contrast the two Institutes' treatment of the contract *verbis* and the contract *litteris*, and examine the possible reasons why Justinian retained the contract *litteris* as a category of contract despite its practical obsolescence. By doing so, this article firstly demonstrates that the diverging fates of the two contracts reflect broader changes in Roman legal and social life as the Empire grew in area and importance (before its eventual decline) and secondly, that the inclusion of the contract *litteris* in Justinian's Institutes should be considered as part of Justinian's wider attempts to return the Roman empire to its former greatness.

### Background on Justinian's Institutes

From the outset, we notice a desire for structure and order in Justinian's Institutes. Even in his commission of the Digests, we are aware that the compilers were to abridge and to alter as much as was necessary to avoid repetitions, contradictions and anything that was obsolete.<sup>3</sup>

This desire for order carries over into the Institutes and his treatment of contracts. Indeed, as will become evident, the oral requirement of the *stipulatio*, as well as the preservation of the contract *litteris* as a distinct type of contract, should best be viewed as Justinian's attempt at an appearance of structured and undiluted legal principles reminiscent of classical Roman law (cf. the rise of vulgar law) as opposed to a faithful description of common practice.

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<sup>1</sup> F de Zulueta, *The Institutes of Gaius Part I*, (OUP 1958) at §3.89; P Birks & G McLeod, *Justinian's Institutes*, (Cornell University Press 1987) at §3.13.2.

<sup>2</sup> The contract *litteris* existed as early as the end of the second century BC: A Watson, *The Law of Obligations in the Later Roman Republic*, (Oxford Clarendon Press 1965) pp. 16; the *stipulatio* is believed to have predated the Twelve Tables: P du Plessis, *Borkowski's Textbook on Roman Law*, (OUP 2015) pp 297.

<sup>3</sup> B Nicholas, *An Introduction to Roman Law* (OUP 1990) pp. 40.

### 3. Treatment of the Contract *verbis*

#### 3.1 Institutes of Gaius

Contract *verbis* (“contracts by words”) were contracts made by word of mouth as suggested by the descriptive classification *verbis*. Whilst the *stipulatio* was by far the most important verbal contract, Gaius mentions that there are two other instances where obligations can be contracted verbally, namely the *dotis dictio* (“declaration of dowry”) and the *iusiurandum liberti* (freedman’s oath).<sup>4</sup> The *dotis dictio* was a solemn declaration of dowry whereas the *iusiurandum liberti* was a solemn oath made by a freedman immediately after manumission to render services for his patron; these were both niche applications of the contract *verbis*. As Birks confirms, these other two verbal contracts were both highly specialised and by Justinian’s time, were obsolete and understandably excluded from the revised Institutes.<sup>5</sup> These two types of contract *verbis* help contrast and demonstrate the oddity of Justinian’s inclusion of the contract *litteris*, which equally had become obsolete long before the time of Justinian’s reign as one of the categories of contracts within the new Institutes.

The *stipulatio* was of enormous importance within the Roman law of contract and arguably the most important type of Roman contract. The *stipulatio* required a communication between the contracting parties and specifically a question and an answer which had to correspond with each other during Gaius’ time. Gaius provides us with an example of questions and answers that would give rise to a *stipulatio*.<sup>6</sup> It is important to note that Gaius remarks that *dari spondes? spondeo?* were a part of the *ius civile* and peculiar to Roman citizens.<sup>7</sup> This certainly may, as noted by commentators, be reflective of the *stipulatio*’s religious origins from as early on as the times of the Twelve Tables. Yet as Gaius explains, the other examples are a part of the *ius gentium* and are valid between all men. The acceptance of other words such as *dabo* and *promitto* for the purposes of the *stipulatio* can perhaps be seen as an important inroad into and evolution away from the formalities emphasised by the *ius civile* even during Gaius’ time, a trend that further accelerates in the later classical period (circa 200 AD onwards).

Gaius lastly qualifies circumstances that might render a *stipulatio* void. For example, if the object of the conveyance cannot be conveyed, (e.g. a free man whom one believed to be a slave) or if the object cannot exist at all (e.g. a hippocentaur), the *stipulatio* would be void.<sup>8</sup> At §3.105 and §3.106, Gaius explains that a deaf man (and implicitly, a mute man) cannot enter into a *stipulatio* as the *stipulatio* requires a correspondence of speaking and hearing between the two parties. This is a rigid and seemingly overly formal requirement that serves as a useful comparison with Justinian’s description of the *stipulatio* approximately three centuries later.

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<sup>4</sup> Institutes of Gaius §3.95a

<sup>5</sup> P Birks & E Descheemaeker, *The Roman Law of Obligations*, (OUP 2014) pp. 52

<sup>6</sup> Institutes of Gaius § 3.92

<sup>7</sup> *ibid* §3.93

<sup>8</sup> *ibid* §3.97-3.99

Another important point to note is that Gaius explains that the *stipulatio* is also void if the promisor (one who makes a promise) does not answer the question put to him at §3.113.

### 3.2 Institutes of Justinian

Justinian's treatment of "obligations by words" at §3.15 of the Institutes is surprisingly similar to Gaius's treatment and seemingly anachronistic given the changes in practice of the past centuries. For example, the core requirement of the *stipulatio*, namely a question and answer spoken orally remains a prominent requirement. There are however nuanced differences in Justinian's treatment such as the relaxation of the exact words used for the creation of a *stipulatio*, (as originally listed by Gaius: *spondere, promittere, fidepromittere, fideiubere, dare, and, facere*) as well as the relaxation of the spoken language so long as both parties understand each other's meaning and the words used.<sup>9</sup>

The reader might be surprised by the continued existence of the same oral requirements given the historical evidence that common practice tended to push Roman law away from its traditional formalistic approach.

Firstly, we are aware that even as early as the late Republic, circa first century BC, there had been a rise of written records (*cautiones*) used as evidence of *stipulationes* (i.e. evidence that the question-and-answer had been followed). Birks and Descheemaeker mentions Cicero's writing in *Topica* 26.96 as an example of the use of such written records.<sup>10</sup>

Secondly, it was provided by a rescript of Severus that if the *cautio* alleged a *stipulatio*, even if a *cautio* was defective (in that it spoke of the *promissor* having promised but did not record the question being asked) an actual *stipulatio* was to be presumed. Indeed, given the influence of Greek law where writing was common, (as well as from a practical evidentiary standpoint), it is highly plausible that the written record *cautiones* did become common practice alongside the oral *stipulatio*.

Certainly, with the enactment of the *constitutio Antoniniana* circa 212 AD, when all peregrine ("foreign") free men within the Empire were afforded Roman citizenship, the practice of using *cautio* in lieu of the oral *stipulatio* would have been solidified. This is because many of these foreigners followed the Greek practice of written contracts. Indeed, a written document with the stipulatory question and answer, by all appearances, seemed sufficient to satisfy the Roman law requirement for the *stipulatio*.

Nicholas explains this development of writing by likening it to "...the case of the *mancipatio*, what originates simply as evidence of an oral act comes eventually to take place of that act".<sup>11</sup>

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<sup>9</sup> Justinian's Institutes §3.15.1

<sup>10</sup> The Roman Law of Obligations pp. 56

<sup>11</sup> An Introduction to Roman Law pp 194

The Constitution of Leo in 472 AD would surely have provided the final dagger to the oral *stipulatio*, where it was provided that a *stipulatio* should be valid so long as the intention of the parties was clear. Riccobono argues, and most modern scholars accept, that the need for an actual question and answer would have been formally abandoned by this ruling, a recognition of the prevalent practice.<sup>12</sup> It is thus beyond a doubt that the *stipulatio* had significantly changed since the beginning of the Empire.

Nevertheless, Justinian refused to accept such a “degeneration” of the traditional Roman *stipulatio* into a written contract both in principle and in practice. Instead, we see Justinian hoping to reconcile the principles of classical Roman law and contemporary practice by strengthening the evidentiary weight of the *cautio*.

Justinian thus emphatically repeats the oral nature of the *stipulatio* at §3.19.7 by imposing the rule of incapacity on those who could not speak or hear the words, similar to what Gaius did at §3.105, as mentioned earlier. He also insists on the traditional congruency requirement: “Next, a stipulation is ineffective if the answer fails to match the question”,<sup>13</sup> a requirement that is repeated earlier in the Institutes of Gaius at §3.113.

To reconcile the widespread practice of using *cautio* (likely in lieu of an oral *stipulatio* altogether), Justinian introduces a strong presumption that the parties were deemed to be present when evidenced by a *cautio*: “We there provided that documents which indicate that the parties were present are to be regarded as conclusive...”<sup>14</sup>

Such a presumption was rebuttable only by clear proof that one or the other party was absent, from the place at which it was dated, for the whole of the day on which the *cautio* was made. It is clear that Justinian and his draftsmen went to great lengths to preserve the traditional requirements of the *stipulatio* whilst attempting to give the formal law an inkling of resemblance to actual practice.

#### 4. Treatment of the Contract *litteris*

##### 4.1 Institutes of Gaius

Our knowledge of the contract *litteris* primarily derives from a brief account by Gaius from §3.128-134 and there is certainly a want of detail. The contract *litteris* in Gaius’ time was a contract formed by writing where each *paterfamilias* (“head of the household”) kept a ledge of transcriptive entries in which one of two types of entries was recorded: either a *re in personam* or a *persona in personam*.<sup>15</sup> The former converted an existing contract obligation into writing, to benefit from the certainty of writing, whilst the latter transferred a debt from one person to another. We know that the contract itself was called *nomina transscriptitia*. Thus even in the classical period, the contract *litteris* was a subsidiary or derivative form of contract and not necessarily a source of an original obligation in its own right.

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<sup>12</sup> S Riccobono, *Stipulation and the Theory of Contract* (Balkema 1957)

<sup>13</sup> Justinian’s Institutes §3.19.5

<sup>14</sup> *ibid* §3.19.12

<sup>15</sup> Institutes of Gaius §3.128

Most commentators agree that the brevity of Gaius's treatment suggests that the contract was becoming obsolete, if it was not already so, even at the time of the publication of Gaius' Institutes.<sup>16</sup>

By Justinian's time, the contract *litteris* was obsolete. This was largely due to the emergence of large-scale banking and state involvement in the economy reducing the economic role of the *paterfamilias* and the need for a family ledger. The practice of accounting ledgers was efficient in the agrarian society of early Rome where dealings were primarily between neighbours with little state intervention, but became inefficient as the expanses of the Roman Empire grew. Another reason for the decline of the contract *litteris* was the rise of the *stipulatio* and the widespread practice of using *cautiones* as mentioned above.

#### 4.2 Institutes of Justinian

Similar to Justinian's treatment of the contract *verbis* and the *stipulatio*, emphasis is placed on form over substance, leading to a departure from an accurate reflection of legal practice of the time. For example, in the new Institutes, there is still oddly a reference to obligations by writing (*de litterarum obligatione*)<sup>17</sup>.

For Justinian, the inclusion of the contract *litteris* seems awfully artificial, especially given that contract *litteris* were of marginal importance even in Gaius's time. Briefly, the contract *litteris* under Justinian was one that served a conclusive evidentiary purpose as opposed to itself being a source of contractual obligations. As Nicholas writes about Justinian's treatment of the contract *litteris*: "the facts are exceptional and unimportant. To erect them into an independent class of contract unnecessarily complicates and distorts the law."<sup>18</sup>

A better way of understanding Justinian's inclusion of the contract *litteris* might be his enthusiasm for order and to follow the fourfold pattern throughout the new Institutes: four types of contracts, four delicts, four real contracts, four consensual contracts. This rather pedantic style of draftsmanship can be seen in turn as part of Justinian's desire for perfection at the microlevel of Rome's formal legal system, and part of his larger goal of bringing back the beauty and prosperity of the early Roman Empire.

We can further see the artificiality of *de litterarum obligatione* if we recall our discussions on the *dotis dictio*, and the *iusiurandum liberti*, the two other forms of the declining contract *verbis* mentioned earlier in our discussions of how Gaius treated contracts by words. It can safely be assumed with equal certainty that by the post-classical period (i.e. 350 AD onwards), neither the *dotis dictio* or the *iusiurandum liberti* were in active use. Thus, it is no surprise (and in stark contrast to the inclusion of obligations by

<sup>16</sup> See n5 P Birks & E Descheemaeker, n2 A Watson.

<sup>17</sup> Justinian's Institutes §3.21

<sup>18</sup> An Introduction to Roman Law pp. 198

writing) that they are completely omitted from Justinian's Institutes without even a single mention of their application in the classical period.

## 5. Conclusion

Having examined the similarities and differences of treatments between the two Institutes, it undoubtedly seems that Justinian's treatment of the contract *verbis* and contract *litteris* was highly influenced by his desire for an appearance of an organised system of the law of obligations, indeed, one reminiscent of the glories of Classical Roman law when the Empire was at its peak.

The fortunes of the two types of contracts also reflect the economic and historical development of the Empire. As the Empire matured, Roman contract law moved away from its early roots where village life predominated interaction between private citizens towards a vast and complex commercial focused system where the *stipulatio* with its flexibility could flourish over the much more restricted contract *litteris*.

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# **A Somewhat Brief History of Research on Scientific Thinking and Reasoning**

Diana Ng

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## **Introduction**

The cognitive abilities of the mind have been of great interest and have been subjected to much scrutiny since the emergence of early modern-day science in Europe during the sixteenth and seventeenth centuries. This period in the history of science, popularly described as the 'Scientific Revolution', witnessed a complete overhaul of the existing metaphysical knowledge from the Middle Ages, leading to a collective social and intellectual transformation. Since then, historians have recorded how scientists and non-specialists alike have routinely and vigorously debated the most appropriate scientific methods and attendant thinking. However, systematic studies of how scientists reason as they engage in their activities have only been traced back to the early twentieth century with Gestalt psychologist Wertheimer's methodical investigation of Einstein's thought processes. From then on, there have been multiple scientific thinking and reasoning perspectives. Some of these perspectives have significantly impacted teaching and assessment approaches.

This essay is an account of the research on scientific thinking and reasoning. It presents the argument that despite long-standing interest in science research and education, there is limited understanding about the specific nature of the higher-order cognitive proficiencies valued by the scientific community. A novel conceptualisation of scientific thinking and reasoning, based on emerging philosophical, psychological and cognitive perspectives, is briefly described.

## **Conceptions of Scientific Reasoning in the Antiquity and Middle Ages**

Science is a uniquely human endeavour. A key distinguishing feature of humankind is a scientifically engaged mind (Huff, 2003). Surviving off the land and the sea were the practical reasons that led to the beginnings of science in the early literate cultures of antiquity around 3000 B. C. Understanding and predicting the seasons and weather with mathematical tools and detailed records required the development of new ways of thinking and abstraction (Lindberg, 2007). However, evidence suggests that focus on the cognitive abilities underlying scientific pursuits only started about 2,500 years ago in ancient Greece (Feist, 2006). The teachings of philosophers such as Socrates and Aristotle broke from traditional supernatural assumptions and attributed the origins of material and sensory observations to forces of nature (Cohen, 2010). The Greek form of science or natural philosophy sought more to know and describe than to create and invent (Huff, 2003). Besides accruing and organising knowledge about the natural world, Greek philosophers developed novel mathematical principles, as well as expounded original criteria and techniques for logical analysis of theories (Crombie, 1994). The Greeks initiated the methodical use of various reasoning forms in their scientific arguments, chief of which were deduction, induction and abduction (Folger & Stein, 2017). Greek accomplishments in

science also expanded into the area of scientific experimentation and demonstrated an awareness of epistemic notions such as the value of a control variable and the difference between correlational and causal conclusions (Cohen, 2010).

Although Greek culture fell sharply into decline with the rise of the Roman empire, its philosophy continued to dominate and influence the subsequent work and ideas of later philosophers (Cloud, 2007). For instance, from the 900s till around the 1200s, Arab scholars translated Greek writings and actively extended Greek philosophical ideas and reasoning (Huff, 2003). From the twelfth century onward, there was more extensive dissemination of key ideas and philosophy from Greek and Arabic sources by medieval European universities (Grant, 1984). The next four hundred year period in western history – the Middle Ages – witnessed some innovative development and inquiry of both scientific activities and the thinking required. Contemporary commentators argued that some medieval thinkers substantially modified prevailing Greek or Aristotelian views of science, without intellectual and cognitive compromises on syllogistic inferences, logical reasoning, mathematical postulations, and the use of theoretical and experimental investigations (Lindberg, 2007; Perler, 2015).

### **Conceptions of Scientific Reasoning from the Sixteenth to the Eighteenth Centuries**

However, scrutiny of the mental processes required for scientific experimentation and discoveries only came to the forefront with the emergence of early modern science during the sixteenth and seventeenth centuries (Dunbar & Klahr, 2012). Commonly referred to as the ‘Scientific Revolution’ (Butterfield, 1962), this epochal period witnessed the inauguration of “a great social and intellectual transformation” (Huff, 2003, p. 5). Many of the prevalent Aristotelian and medieval views of science were dismantled and replaced with a brand-new science conception that focused on methodical observations and systematic experimentation for constructing knowledge or confirming theories (Hatfield, 1990). Important and wide-ranging scientific discoveries such as the heliocentric view of the universe, laws of motion and gases, mechanics, and taxonomical rules, were established. Besides the growth of knowledge, there was a proliferation of quantification methods in fields such as astronomy and physics. This ‘mathematisation of nature’ (Henry, 2008, p. 18) signified the primacy of the language of logic, shape and quantity, not just as a tool for calculation, but also as a means of symbolically representing how nature works. Aiding the increasing adoption of empirical measures in the scientific discovery process was the creation of various innovative instruments and techniques such as telescopes and liquid thermometers (Hall, 1983). Assisted by these technical advances, philosophers and scholars of this scientific era expounded the ‘experimental method’ – a system of rules and processes for the investigation of phenomena (Henry, 2008). The rules and processes were not just solution-seeking devices; they were also the means to generate further questions and theories. In this significantly different world-view, new ways of scientific thinking were articulated to organise and account for original ontological, epistemological, mathematical and methodological propositions and constructs (Hall, 1983).

In particular, at least five radical forms of reasoning linked to this new science world-view are prominently studied and debated. They are induction, experimental-abstraction, hypothetical modeling, taxonomic and evolutionary reasoning. The earliest reasoning form

to be noted is induction – the inference of common principles or axiomatic ‘truths’ applicable to a population from observable instances in a sample. Francis Bacon (1561-1621) was the first to explicate its working mechanism and importance to scientific inquiry in the *Novum Organum* in 1620 (Bortolotti, 2008). Although Bacon’s pioneering insights on inductivism were ground-breaking, it was the synergistic power of his methodology with the well-established deductive arguments that has come to characterise the scientific breakthroughs and knowledge that the scientific revolution is reknown for (Crombie, 1994). The following sections will briefly discuss the four other novel forms of reasoning which precipitated the discoveries and inquiries from the scientific revolution period until the beginning of the twentieth century. As will be obvious from the ensuing discussion, induction and deduction are crucial mental components of more complex forms of reasoning (Reichertz, 2014).

The experimental work of Galileo (1564-1642) and Newton (1642-1727) exemplified the first of the four complex forms of reasoning. A distinctive hallmark of their work is an empirically-focused epistemology which commonly featured a pragmatic use of instruments and incorporated a heavy quantitative emphasis (Hall, 1983). There are two typical stages to this form of reasoning. In the first inductive-inference stage, users discern consistent patterns or non-random features from observational or experiential data. Subsequently, in the next abstraction stage, there is manipulation of theoretical mathematical structures to notionally describe or account for these inferences. The outputs of the manipulations are then deductively used to explain or predict other physical or conceptual phenomena (Crombie, 1994).

Discerned from the inquiry efforts of philosophers such as Descartes (1596-1650) and Hooke (1635-1703) is yet another form of reasoning prominently studied between the sixteenth and the eighteenth centuries. The cognitive historian A. Crombie (1994) described this form of thinking as ‘hypothetical modeling’. Distinctive to this reasoning is the ubiquitous construction of scale or analogical models to isolate and represent key features of complex phenomena or multi-faceted scientific processes which would otherwise have been impossible to study. In contrast to a scale model, an analogical model extracts non-physical commonalities from a situation based on some criteria or assumptions. Modelling aims to offer explanatory or predictive insights. For example, Decartes creatively envisaged the human form as a mechanistic hydraulic model, an ‘automaton’ (Kwa, 2014b). Using the model, he analysed the physiological workings of various biological and sensory processes and provided various perceptive hypotheses which anticipated the actual mechanisms. Although this form of reasoning proved useful for generating possible conjectures, it also involves a high likelihood of excluding other causal conditions as factors are necessarily limited in a theoretical model.

From the 1800s onwards, the next major form of scientific reasoning associated with the scientific revolution arose to prominence in Europe (Kwa, 2014c). Curiosity and interest in natural history – the study of the natural world – were fuelled by expeditions to exotic lands by travellers who sent unusual plant and animal specimens back to Europe (Huxley, 2003b). The great increase in the number of hitherto unknown flora and fauna prompted communities of naturalists to consider more methodical and efficient ways of organisation and classification (Huxley, 2003a). This reasoning about the placement of scientific subjects

or objects into categories in accordance with pre-determined criteria is referred to as taxonomic thinking (Crombie, 1994).

One particularly influential classification method was Linnaeus's hierarchical system (Eddy, 2010). This system firstly involved the identification of a rational basis for distinguishing between two categories of organisms. Within a single category, the process of sub-division reiterated until no differences between the remaining organisms could be detected. At this juncture, the commonalities that united these organisms are noted and described (Kwa, 2014c). Over time, taxonomic methods, whose criterion of comparison signify 'natural' or true biological differences or similarities, came into favour for their prognostic powers (Crombie, 1994). Meanwhile, the discoveries of fossils and concurrent developments in embryology and comparative structures in the early 1800s unearthed striking patterns in morphology, suggesting a mechanism for the systematic transmission of characteristics from common ancestral sources (Huxley, 2003a). The last of the reasoning types from the late nineteenth century arose from this context (Kwa, 2014a).

Attributed to the pioneering efforts of Charles Darwin and Alfred Wallace, evolutionary reasoning is thinking and theorising about the formation process of a species (Crombie, 1994). The Darwinian theory ascribed the diversity of organisms over time to competitive forces. As species take on different forms, they split from their parental stock in a manner described as a 'branching, tree-like pattern' (Ridley, 2004, p. 5). Identifying the characteristic(s) that definitively delineate a species from another species – the point of branching – is an important facet of evolutionary reasoning. Interestingly, constructing a representation of the biological lineages between species as a corollary of using demarcation criteria is similar to the systematic process of sub-dividing subjects on grounds of morphological differences in taxonomic reasoning discussed above (Crombie, 1994).

In conclusion, various forms of reasoning preceded the inquiry efforts and discoveries of scientists from the scientific revolution era. Although correspondences and written records showed that intense self-reflections and vigorous debates were occurring over the most appropriate scientific methods and reasoning to undertake, there was no systematic examination of the specific mechanisms involved (Bortolotti, 2008; Dunbar & Klahr, 2012; Hall, 1983).

### **Conceptions of Scientific Reasoning from the 1900s Onwards**

Methodical investigations into the mental schemes of scientists began with the Gestalt psychologist Wertheimer's seminal investigation of Einstein's thought processes and Roe's descriptions of personality traits of scientists in the middle of the twentieth century (Roe, 1953; Tweney, Doherty, & Mynatt, 1981; Wertheimer, 1945). After the 1950s, research into scientific reasoning was largely based on cognitive science and had its greatest impact on science education (Klahr et al., 2001; Klahr & Simon, 1999). While there is broad consensus that scientific reasoning is a set of cognitive, meta-cognitive and meta-strategic skills, different specific definitions exist depending on the research literature and the predominant thought milieu about learning in science education (Kind, 2013; Morris, Croker, Masnick, & Zimmerman, 2012; Sodian & Bullock, 2008). What follows is an account of the various significant scientific reasoning conceptions from the educational perspective.

For over thirty years since the 1950s, science educators frequently referred to the psychological model of formal operations proposed by Piaget for insights on the nature and development of scientific reasoning (Lawson, 1983). In the same period, Gagne's 'science as process' (Sanderson & Kratochvil, 1971) proposition, with a set of processes and attendant reasoning, became influential in science education (Finley, 1983). Though the two ideologies have impacted science research, curriculum development, and instruction in different ways, they both emphasised the use of reasoning faculties and posited that cognitive strategies are content-independent and transferable across learning contexts (Kuhn, Amsel, & O'Loughlin, 1988).

### **Scientific Reasoning as Logical Reasoning**

Jean Piaget's proposal of combinatorial logic is part of a broader developmental theory describing intellectual growth from birth to maturity (Inhelder & Piaget, 1958; Kuhn et al., 1988). Of interest in his theory is the culminating stage in the cognitive development process: the period of formal operations (11-15 years). An individual in this stage is postulated to be able to deal effectively not only with reality but also with contemplation of abstractions and hypothetical scenarios. It is this unique quality that characterises formal thought and suggests that the underlying basis for cognitive strategies is of a hypothetico-deductive nature (Flavell, 1963). Significantly, the young adolescent builds on the abilities of the earlier concrete stage to organise information, casting the products as propositions and then proceeding to manipulate these further by drawing different logical relationships amongst them. In effect, formal operations are second-order operations conducted on the results of the previous concrete operations. An implication of the adolescent's ability to differentiate between reality and possibility is that he is now capable of combinatorial analysis – a method of testing various scenarios (or hypotheses) by isolating variables appropriately in problem solving situations (Flavell, *ibid*). These postulated cognitive strategies (and in particular control of variables) are of particular interest to science educators as efforts are sought to nurture these abilities in students (Kuhn et al., 1988). Overall, Piaget's theory contributed greatly to insights about children's thinking. However, doubts were cast both on the methodology employed by Piaget and on the replicability of results. There is also a substantial amount of literature which strongly suggests that mental developments are not universally attained in the stages as postulated by Piaget (Keating, 1980).

### **Scientific Reasoning as Inductive Reasoning**

In his process approach, Gagné proposed activities for building cognitive abilities in an increasingly complex hierarchical fashion (Gagné, 1968). One well-known application of his theory to science education was the re-design of a large-scale American curriculum project which introduced process skills as 'intellectual tools of science' (Sanderson & Kratochvil, 1971, p. 6) to enable pupils to learn scientific knowledge (Fields, 2000). There are two types of processes: basic and integrated. According to Finley (1983), Gagné's processes or 'generalisable intellectual skills' (p. 48) are hierarchical; simpler processes build up to enable the use of more complex processes. The process approach with its inductive and empiricist roots was heavily criticised by researchers and science educators alike, based on

philosophical, psychological and pedagogical grounds. In sum, critics largely disapproved of its underlying theoretical and pedagogical posits that situate the processes as constituting the reasoning and intellectual outcomes of instruction rather than as means to educational goals (Millar & Driver, 1987). From the late 1970s onwards, the collective dissatisfaction with the nature of scientific reasoning expounded by Piaget's cognitive development theory and Gagné's process approach led the science research and education communities to respond in three important and distinctive ways. The remaining section of this essay describes these responses.

## **Post-Piagetian and Post-Process Scientific Reasoning: Three Research Responses**

### **Scientific Reasoning as Conceptual Change**

This first response to address the lack of a satisfactory rationale for scientific reasoning drew focus away from how pupils are reasoning to the subject of their reasoning processes (what they are reasoning). Conceptual change research investigates learning which requires a substantial revision of prior knowledge and the acquisition of new concepts, usually under conditions of systematic instruction (Vosniadou, 2013). This research is of particular interest since the early 1980s because children's conceptions of the natural and physical environment impact their subsequent learning in science classrooms and incorrect conceptions are particularly resistant to change by instruction (Driver & Easley, 1978; Osborne & Wittrock, 1985).

### **Scientific Reasoning as Procedural Knowledge Interacting with Conceptual Knowledge**

The second research response focussed on modifying the rationale for scientific reasoning underlying Gagné's process approach (Kind, 2013). To differentiate from terms such as 'skills', 'processes', and 'process skills', this understanding has been termed 'procedural knowledge' to signal the significant role of knowledge (Millar, Lubben, Gott, & Duggan, 1994). This response posited scientific reasoning as theory-laden with a focus on procedural knowledge.

### **Scientific Reasoning as Evidence Evaluation and Coordination, with Epistemic Knowledge**

More recently, there is general agreement from diverse fields (e.g. philosophy, sociology, linguistics) that science is a social entity constructed from the products of enquiry and normative practices adhered to by the scientific community (Garcia-Mila & Anderson, 2008). These normative practices, also known as epistemic practices, include reasoning and coordinating between evidence and dialogic, as well as dialectic and discursive processes such as evaluating alternatives, weighing evidence and evaluating claims (Garcia-Mila & Anderson, 2008; Sandoval & Reiser, 2004).

Concurring, Duschl & Osborne (2002) added that cognitive and psychological research now view "thinking and reasoning as socially-driven acts which are language dependent, and governed by context or situation" (p. 47). They concluded that science education should seek to engage pupils beyond the declarative realm of knowledge to

further encompass procedural and strategic aspects. The aim is to support the development of reasoning and meta-cognitive reflectivity. In essence, the scientific reasoning conceived in this strand moves away from the 'positivist perspective' characterised by a set of irrefutable facts, uncontroversial theories and confirmed outcomes (Driver, Newton, & Osborne, 2000). Instead, scientific reasoning is honed by discourse-based tasks that support the social construction of knowledge – exposing pupils' thinking to critique, debate and argumentation around competing ideas, contending theories, methodologies and claims (Newton, Driver, & Osborne, 1999). Scientific discourse, and in particular argumentation, has been promoted as an ideal language tool for the construction of explanations, models and theories (Jiménez-Aleixandre & Erduran, 2008; Siegel, 1995).

### **Science as a Practice-based Activity**

Notably, taken as a whole, the three aforementioned responses describe key scientific practices in a scientific investigation cycle (Kind, 2013). Specifically, in any cycle, the three scientific practices are theory development, collection of empirical data, and coordination and evaluation of evidence. Kuhn (2011) has further characterised the investigation cycle as consisting of four major phases: enquiry, analysis, inference, and argument. The enquiry phase involves formulation of investigative goals and questions, and adoption of strategies to address the goals and questions. This phase encompasses the two scientific practices of hypothesis (theory) generation and collection of empirical data to test theories. The remaining three phases of data analysis, inference, and argument entail justifying claims, as well as understanding the implications of evidence as supporting or disconfirming one's theories. These remaining three phases thus correspond to the scientific practice of coordinating and critically evaluating evidence.

### **Scientific Reasoning as Evidence Evaluation and Coordination with Conceptual, Procedural, and Epistemic Knowledge in Science Practices**

The discussion in the earlier sections provides a picture of an emerging conception of scientific reasoning; that it is an evaluation of evidence and coordination with theories involving three types of scientific knowledge bases – conceptual, procedural and epistemic while engaged in science practices (Kind, 2013; Osborne, 2013). This perspective of scientific reasoning aligns with the broader notion of scientific reasoning as a set of cognitive, meta-cognitive and meta-strategic skills.

In conclusion, up until the middle of the last century, research in the specific nature of higher-order cognitive proficiencies for achieving scientific experimentation and discoveries was limited. Developments in science education during the five decades after the 1950s suggested that there existed a weak consensus about the nature of scientific reasoning. This essay presented a novel conceptualisation of scientific thinking and reasoning, consolidated from insights in emerging philosophical, psychological and cognitive science literature.

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## What is “religion” in East Asia?

### With special reference to the role of place in “religion” in China and Japan before the nineteenth century.

Chui-Jun Tham

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#### Religion

Secularisation and the rise of comparative research on religion has resulted in two shifts in how scholars define religion. The first is what Jason Ānanda Josephson denotes as the shift from a theocentric to a hierocentric conception of religion. Between the seventeenth and twentieth centuries, European and North American conceptions of religion as the worship of a Christian-esque supreme entity in different cultural forms, were replaced by the conception of religion as ‘an established set of beliefs and tenets defining the relationship between man and the sacred’.<sup>1</sup> The “sacred” was a vaguer concept than the anthropomorphic deity, and thus supposedly more globally relevant. However, not only do hierocentric definitions of religion preserve a Christian-esque division between the world of man and the world of the sacred, they also generally fail to clarify what the “sacred” is, thus failing to illuminate, much less divorce the term, from the Christian, European context in which it was developed.<sup>2</sup> In other words, whilst scholars have attempted to divorce definitions of religion from Christian doctrine and practice, the new definitions they seek are still developed and articulated within a conceptual framework derived from Christian doctrine and practice. Even when definitions of religion are revised to accommodate systems of belief other than Christianity, and even when it is recognised as an etic concept (an external analytical scheme imposed on the source material) as opposed to an emic concept (a term that actors within a society or era under study themselves espoused), these definitions retain two fundamental assumptions. The first is that there is a division between the secular and the supernatural. The second is that beliefs and practices are most usefully analysed as an integrated whole.

The second shift in how scholars have defined religion recalls the pre-seventeenth-century, pre-Protestant conception of religion. The Reformation brought about an emphasis on a personal relationship to God. Before the Reformation, the standard European usage of “religion” (*religio*) was in terms of the performance of ritual obligations, particularly the state of life bound by monastic vows, and the pre-Christian Roman usage of the term to refer to prohibitions or obligations that did not necessarily relate to the supernatural.<sup>3</sup> That is to say, whereas theocentric definitions of religion emphasise *belief*, hierocentric definitions emphasise systems, doctrinal or institutional. The shift amongst scholars to a hierocentric definition of religion is likely due to the need for a means of identifying candidates for inclusion in the category of religion without referring to content, and hence implicitly to the degree of their correspondence with Christian ideas and forms. This shift does not mean

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<sup>1</sup> Josephson, 2012, 9.

<sup>2</sup> Josephson, 2012, 9; Evans, 2003.

<sup>3</sup> Josephson, 2012, 16-7.

that earlier definitions have disappeared. Oxford Dictionaries, for example, provides the casual inquirer with theocentric, hierocentric, and secularised definitions, the secularised definition being religion as a ‘pursuit or interest followed with great devotion’.<sup>4</sup> Where scholars have not explicitly problematised the concept of religion in non-Christian contexts, religion risks being understood and applied in an inconsistent manner.

Where scholars have problematised the concept of religion, their arguments fall into three categories: (i) those who see religion, superstition, the sacred, or in other words all non-scientifically provable beliefs to be an undifferentiated mass; (ii) those who see religion as an etic concept that needs to be modified, but which is otherwise useful; and (iii) those who consider religion irrelevant before the idea of religion was introduced into emic discourse. Scholars who perceive religion as an etic or emic concept in reference to East Asia in particular are further distinguished by whether they argue for treating a community’s religion as an undifferentiated whole, or the demarcation of communal beliefs into multiple religions.

This essay argues that the concept of religion is irrelevant to East Asia before the nineteenth century, when the concept began to make an impact on local discourse. “Religion” suggests a binary between the sacred and the profane, and the existence of distinct systems of belief and practice, neither of which seems to describe the East Asian context. Instead, five malleable categories are posited for the analysis of East Asian worldviews. These categories are: (i) philosophy as the ongoing discussion of thought; (ii) doctrine as the articulation of thought, that is the choosing amongst particular contested meanings to produce a version of philosophy that is ‘formulaic’ and ‘non-reflective’; (iii) the sacred as objects of respect and veneration; (iv) ritual as repetitive and excessive (in proportion to direct utility) behaviour; and (v) the *religious*, which in its adjectival form denotes the actors and institutions or aspects of institutions associated with the *performance* of ritual obligations.<sup>5</sup> This essay examines the role that place plays in the multiple worldviews extant in China and Japan before the nineteenth century: as a means of identifying different religious organisations or communities; as the site at which the combination of different doctrines and philosophies occurs; and as a sacred object or means to sacred objects.

### Place as Identity Marker

Place was a primary means by which different religious communities or organisations were identified. Doctrines were derived from multiple philosophical traditions on a non-exclusive basis, even though in China, more than Japan, one philosophical tradition tended to be dominant in the combinatory act.<sup>6</sup> As such, indicating the site at which doctrines were developed and disseminated, as opposed to locating them within a particular philosophical tradition or assigning them a new label *à la* Christianity, was a simpler means of distinguishing one from the other. In Japan, communities practising

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<sup>4</sup> *Oxford Dictionaries*, s.v. “religion,” accessed February 17, 2017, <https://en.oxforddictionaries.com/definition/religion>.

<sup>5</sup> Bentley, 1986, 144; Freedman, 2003, 126; Evans, 2003, 36 and 39; Feuchtwang, 1991, 32; Josephson, 2012, 9.

<sup>6</sup> Grapard, 1994, 7-10. The veneration of *kami* (神) and bodhisattvas in temple-shrine combinatory complexes.

particular types of Buddhism, such as Rinzai (臨在) or Shingon (真言), rarely referred to themselves by these labels. Place names and founder names were far more common. Even when the term *shintō* (神道) entered usage in the thirteenth century, it was attached to place or founder names, and as such, referred to combinative and locale-specific doctrines and not membership within an overarching system of belief, that is “religion”.<sup>7</sup>

In the same way that scholars have tended to identify religious communities in Japan by their sectarian affiliation first, the proliferation of academies in the Southern Song is generally seen in terms of the spread of Neo-Confucian thought. This assumption facilitates disregard for how these academies, then treated as sub-groups under the “-ism” of Neo-Confucianism, saw themselves in relation to each other.<sup>8</sup> The founders of these academies, rather than dedicating them to a particular philosophical tradition such as the *daoxue* (道学), which is the narrowest definition of Neo-Confucianism, selected their locations and legitimated their founding in reference to the relationship that these academies had with a particular scholar.<sup>9</sup> For example, whilst the Yuan scholar Cheng Jufu (程鉅夫) declared that the ‘Way is not attached to a place’, the reason he gives for the establishment of the Green Fields (*qingtian* 青田) academy at the Lu family shrine was that ‘it is from the traces that we know things, and by means of these things, we see the men, enabling scholars of later times to observe and emulate them, and express their feelings. Thus it is as though they are present in this place’.<sup>10</sup> Shrines and tombs were the loci at which ancestral worship occurred; the media between the living and the dead. As such, it was felt that these places were where the teachings of the masters were most easily understood.

Moreover, particularly in the Yuan, “Neo-Confucian” academies were associated not primarily with study, but with the performance of rituals for the revered scholar. Tao An (陶安), the headmaster of the High Purity (*gaojie* 高節) academy stated that the institution was established at the tomb of Yan Guang in Yuyao (餘姚) ‘in order to sacrifice to him’.<sup>11</sup> The founder, or the scholar in whose name an academy was founded, and hence the particular way in which either or both interpreted the philosophical ideas of the time, was more important to the identity of an academy than its location within an overarching “-ism”. Walton emphasises that these academies became increasingly integrated into a landscape of what scholars identify as “religious” institutions such as Buddhism and Daoism. This integration occurred on the premise that what scholars conversely identify as not being religious, but “neo-Confucian” institutions, were previously inimical to their religious counterparts. On the contrary, conflict occurred not just between Buddhist and neo-Confucian institutions, and Daoist and neo-Confucian institutions, but also between Buddhist and Daoist institutions, bringing into question Walton’s distinguishing of Confucianism.<sup>12</sup> What should be emphasised instead is that in academies ‘the pedagogical ideal of ritual veneration of exemplars as a means of instilling values’ became increasingly

<sup>7</sup> Grapart, 1994, 4-5.

<sup>8</sup> Adler, 2014, 11-12.

<sup>9</sup> Adler, 2014, 4.

<sup>10</sup> Walton, 2014, 1241.

<sup>11</sup> Walton, 2014, 1260.

<sup>12</sup> Walton, 2014, 1268-9.

central to *instruction* in doctrine.<sup>13</sup> In this instance, religious behaviour, that is the performance of ritual obligations, did not involve interaction or exchange between the human and the non-human. The implied binary between the supernatural and the secular that the term “religion” often suggests does not exist here.

Nonetheless, East Asian worldviews should not, contrary to Stephan Feuchtwang’s argument for a single “Chinese religion”, be seen as monolithic undifferentiated wholes.<sup>14</sup> It is possible to discern different philosophical and doctrinal traditions, to which terms such as Confucianism, Buddhism, and Daoism, can be affixed. It is simply not useful then to label such traditions as “religion” or as purely secular systems of thought, or indeed, to see human actors as thinking and operating within systems. A comparison of China and Japan best illustrates the inadequacy of such a binary and systemic approach to doctrine and religious behaviour in highlighting the role that Chinese Daoist thought, which did not become institutionalised in Japan, nevertheless played in Japanese philosophy. For example, Watarai Yukitada’s *Ise nisho daijingū shinmei hisho* (伊勢二所大神宮神明秘書), written in 1285 as a compendium of up-to-date information on the Ise shrines, drew heavily on the cosmology found in the Daoist canonical text, the *Laozi* (老子).<sup>15</sup> However, Mark Teeuwen argues that Watarai and other Ise actors like him did not think of Laozi’s ideas as categorised under Daoism. Rather, in Watarai’s text and in other Zen Buddhist writings, terms from Laozi’s cosmology were used to describe Zen cosmology.<sup>16</sup> Daoism did not exist as a “religion” in Japan. However, the key elements in its philosophical discourse can be identified in the formation of various doctrines, whether or not these doctrines are recognised by scholars as primarily Daoist.

## Place as Sacred Space

Place was not just the preferred means of identifying religious communities that produced and taught diverse interpretations of the philosophical ideas available; it was also itself the object of ritual veneration, that is place could also be sacred. Sacred places could be three-dimensional or two-dimensional; natural or built; sacred because they were the pathway to a sacred place; or sacred in and of themselves. They did not have to be related to the supernatural. An example of this is cosmologically-ordered space.

Historians of cosmologically-ordered space rarely attempt to categorise it under one of the major religions in East Asia, even though scholars such as Mark Teeuwen do speak of cosmologies related to specific religions.<sup>17</sup> Instead, the syncretic way in which religious institutions or religious architecture are often included in cosmologically-based constructions of space emphasises that cosmology was neither solely a science as we understand science, nor a religion. Cosmology was a theory of how the universe worked, as Josephson demonstrates in his study of National Learning (*kokugaku* 国学) scholars in the mid-nineteenth century. *Kokugaku* scholars saw European scientific principles as having

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<sup>13</sup> Walton, 2014, 1265.

<sup>14</sup> Feuchtwang, 1991.

<sup>15</sup> Teeuwen, 2015, 107-8.

<sup>16</sup> Teeuwen, 2015, 117.

<sup>17</sup> Lewis, 2006; Meyer, 1991; Wheatley, 1971; Stavros, 2014; Teeuwen, 2015, 104.

their origins in the workings of native, Shintō deities. Western science and the ancient Japanese texts had to be combined in order to truly understand the universe.<sup>18</sup> The scientific and the religious were not antithetical entities.

Cosmologically-ordered space further illustrates the absence of a binary between the secular and the supernatural. For example, the Bright Hall (*mingtang* 明堂) in Han texts was built so as to imitate the structure of the cosmos, that is in a grid form with rooms corresponding to the months of the year. The emperor would then change every aspect of his life and government in accordance with the ‘monthly ordinances’.<sup>19</sup> Similarly, the royal palace and Buddhist temples in Heian-kyō were meant to imitate the ritual state shrines of the Tang capital, what is now referred to as *shinden-zukuri* (寝殿造り).

The close relationship between the sovereign and the divine, particularly the political benefits that such a relationship offered to the sovereign, means that the deliberate resemblance of royal residences to sites where ritual obligations were performed is not in itself surprising. Michael Stavros, for instance, interprets the Heian nobility’s adoption of the *shinden-zukuri* as a means of demonstrating their membership in the state hierarchy by copying state forms. These spaces were then adapted from their ideal forms so as to accommodate their dual roles as ritual and residential space. For example, the *shinden-zukuri* consisted of ‘a conglomeration of as many as fifteen discrete structures arranged symmetrically along a north-south axis’, with the central *shinden*, acting as the master’s main residential quarters (in other words, it imitated the grid pattern of Heian-kyō and Chinese-style capitals, and as such, was, as they were, microcosms of the cosmological order).<sup>20</sup> These structures did not in general have fixed interior walls, and thus did not have discrete rooms. However, it became the practice to partition interior space temporarily using folding screens, curtains, and bamboo shades. From the twelfth century onwards, this practice applied even to central *shinden*, the central and most significant part of the ritual space.<sup>21</sup> Cosmologically-ordered places were simultaneously sacred, in that they were objects to be venerated by ritual, and residential quarters with non-ritual functions. More importantly, their sacralisation was not grounded in man’s interactions with a separate realm of the “sacred”, but in what their builders and residents took to be the principles that underlay this one.

## Conclusion

The concept of religion is irrelevant to East Asia prior to the introduction of the term itself into emic discourse in the mid- or late-nineteenth century. This is because religion, even when the term’s definition is revised to encompass non-Christian traditions of belief, and even when it is recognised that religion is an etic as opposed to an emic concept, retains two fundamental assumptions: there is a binary relationship between the secular and the supernatural, and beliefs and practices form integrated systems. The role of place in East Asian worldviews as a marker of religious communities and as an object of ritual veneration

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<sup>18</sup> Josephson, 2012, 109-17.

<sup>19</sup> Lewis, 2006, 260-1.

<sup>20</sup> Stavros, 2014, 25.

<sup>21</sup> Stavros, 2014, 40-1.

demonstrates that differentiating between philosophical discourses or performances of ritual obligations as concerning either solely the secular or the supernatural, is not relevant to the East Asian context in the emic sense, nor useful in the etic sense. The role of place as a site where the combination of different philosophical and doctrinal traditions occurs at the ideational and practical level shows that East Asian worldviews should not be treated as an undifferentiated whole, but as possessing multiple sources that can be identified as Daoist, Buddhist, and so on. At the same time, place as such a site also shows that to assume that Daoism and Buddhism are systems of belief and practice is limiting. Religion is irrelevant to East Asia, but the elements that constitute scholarly discourse on religion, such as the religious and the sacred, when carefully defined, are not.

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# ENDNOTE

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