



Maker Culture Liminality and Open Source (Science) Hardware: instead of making anything great again, keep experimenting!

A liminaridade da cultura maker e o hardware de fonte (na ciência): em vez de fazer algo ser grande de novo, continue experimentando!

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RESUMO

A cultura maker, definida como um conjunto de experiências que agrupam ferramentas de hardware de código aberto (Weiss 2008; Mellis & Buechley 2011; Ames et al. 2014), de práticas faça-você-mesmo (Ratto & Boler 2014; Ames et al. 2014; Lindtner et al. 2016), promessas da fabricação digital, automática e distribuída (Gershenfeld et al. 2004; Ratto & Ree 2012), e equipamentos para a democratização da ciência (Pearce 2014; Pearce 2012), persiste como um objeto ambíguo de nossas recentes fantasias do design e da política. De um lado, há o surgimento de políticas e interesses governamentais nos EUA, China, Cingapura, Taiwan e Europa, sobre o tal “movimento maker”, levando diretamente ao atual chamado nacionalista do tipo “Faça (o país XYZ) Grande Novamente”. De outro lado, os projetos e atividades maker (experimentações com Arduino, construção de impressoras 3D, montagem de infraestruturas de laboratórios de biologia faça-você-mesmo), continuam restritos a um nicho exploratório e privado, mesmo quando são parte de redes informais e transnacionais (Vertesi et al. 2011; Kaiying & Lindtner 2016) que eu denomino “diplomacia geek” (Kera 2015). Sem afirmar claramente qualquer agenda local ou transnacional, os makers faça-você-mesmo negociam de maneira produtiva e

ABSTRACT

Maker culture defined as a set of Open Source Hardware (OSHW) tools (Weiss 2008; Mellis & Buechley 2011; Ames et al. 2014), DIY practices (Ratto & Boler 2014; Ames et al. 2014; Lindtner et al. 2016) and promises of digital, automated and distributed fabrication (Gershenfeld et al. 2004; Ratto & Ree 2012) or democratized science equipment (Pearce 2014; Pearce 2012) remains an ambiguous object of our recent political and design fantasies. On one side, there is a surge of government and policy interests in the so called "maker movements" in the U.S., China, Singapore, Taiwan, and EU leading directly to the present nationalist calls for "Making (XYZ nation) great again". On the other, maker projects and activities (Arduino tinkering, building 3D printers, setting up a DIYbio lab infrastructure) remain niche, exploratory and private, even when they are part of the informal, transnational networks (Vertesi et al. 2011; Kaiying & Lindtner 2016), which I call "geek diplomacy" (Kera 2015). Without clearly stating any local or transnational agenda, the DIY makers productively and creatively negotiate the various dichotomies between individualism and collectivism, local and global interests, nationalism and cosmopolitanism. They connect politics and design through "liminal," meaning individual and exploratory, experiences of prototyping and tinkering which differ greatly from

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criativa várias dicotomias entre o individualismo e o coletivismo, entre os interesses locais e globais, nacionalismo e cosmopolitismo. Eles conectam política e design através da liminaridade, em experiências individuais e exploratórias de prototipagem e tinkering, que diferem muito das formas de aquisição de conhecimentos, habilidades e prototipagem típicas dos contextos industriais e acadêmicos. Para explicar a liminaridade na cultura maker, eu expando o trabalho pioneiro de Gabriela Coleman sobre os paradoxos do movimento hacker (e do movimento de software aberto). As redes descentralizadas e transnacionais de makers e hackers são exemplos (tecnológicos) de comunidades e liminaridades (Turner, 1969), que negociam vários objetivos e agendas conflitantes por trás da fabricação, tecnologia e globalização. A cultura maker pode servir a agendas isolacionistas ou cosmopolitas ao mesmo tempo, e ainda abraçar a retórica do código aberto enquanto segue parcialmente patenteada, pirateada e híbrida. Ela mobiliza as esperanças do Sul Global de tecnologias de baixo custo, enquanto performatiza clichés do Vale do Silício e se utiliza do trabalho escravo e migrante na China, ou ainda de algum conflito africano sobre recursos minerais. Ao invés de empoderar alguma noção idealizada de sujeito, comunidade ou mesmo nação, ela demarca os limites e as condições do nosso entendimento sobre governança e sua relação com a produção, a fabricação e o design.

Palavras-chave: Cultura Maker; Hardware de Fonte Aberta; Política e Design; Sul Global.

the knowledge and skills acquisitions or prototyping common in the industrial or academic context. To explain this liminality in the maker culture, I extended Gabriella Coleman's (2012) pioneering work on the paradoxes of hacker (and open source software) movement. The decentralized and transnational networks of makers and hackers are examples of (technological) communitas and liminality (Turner 1969), which negotiate various conflicting goals and agenda behind making, technology and globalization. The maker culture can serve isolationist and cosmopolitan agendas at the same time, even embrace the open source rhetoric while remaining partially patented, pirated and hybrid. It mobilizes the Global South hopes of low cost technologies while performing the Silicon Valley clichés and using migrant slave labor in China, but also African conflict minerals. Rather than empowering some idealized notion of the subject, community or even nation, it demarcates the limits and conditions of our understanding of governance and its relation to production, making, and design.

Keywords: Maker Culture; Open Source Hardware; Politics and Design; Global South.

INTRODUCTION

In a recent post addressing the maker community, Pieter van Boheemen, the manager of the Open Wetlab at Waag Society in Netherland, appeals to the makers and geeks to explicitly address the ongoing "hijack" of the movement by the "alt-right" forces: "Has it occurred to you that the far right of the political spectrum often uses the same rhetoric as the Do It Yourself movement? The DIY movement that started as a positive, social, eco-friendly ideology seems to have (somehow) ended up with the same general narrative as nationalists." In this blog post, Pieter van Boheemen protests against the attack on solidarity and cooperation as the core

values of all democratic societies, but also of the DIY movement. The core DIY value of transparency and cooperation were hijacked by forces which misuse the DIY rhetoric to destruct any trust in the public institutions and processes: "(DIY was) a strategy for the public to claim a seat at the table of technological development discussions and make sure that the agendas and benefits of scientific progress result in equality. Now the DIY movement seems to have been hijacked by nationalistic, isolating agendas that are trying to achieve the exact opposite."

Pieter van Boheemen not only explicitly defines the DIY movement as an "open collaboration and fair distribution of whatever knowledge or skills are obtained," but since 2015 he also runs the international open collaborative distributed biohackers training program "BioHack Academy,"¹ which in 2015 and 2016 connected the biohacking groups from US, Brazil, Japan, Iran and across Europe. His Open Wetlab efforts follow closely the transnational model of open biology activities as established by other biohacking groups involved in the open hardware and maker activities, such as Hackteria.org and its affiliates (Gaudi lab² and Biodesign³) or the anarchofeminists and transhackfeminists GynePunk collective connected to Pecheblenda biolab⁴ in Calafou, Spain, which focuses on gender issues, and other.

These transnational networks behind maker activities make little geopolitical sense. A typical Hackteria project involves participants from Zurich to Bangalore, Yogyakarta, Taipei and Ljubljana. The successful Safecast platform for radiation monitoring (Kera et al. 2013) is another example of open hardware efforts connecting hackers from Japan, U.S., Switzerland, Spain etc. Geeks, scientists, designers and citizen scientists involved in projects such as the BioHack Academy of Hackteria etc., simply exchange knowledge and knowhow in a sharp contrast to the "Make magazine" rhetoric defining the DIY culture as a mobilization of national and nationalist interests (Sivek 2011) or serving some neoliberal agenda as hoped by the policy makers (Davies 2017).

The nationalist turn in the DIY culture was most clearly voiced in the January 2017 Brookings Institute post, which offers five recommendations to Trump's administration on how to catalyze manufacturing in the U.S. (Muro & Hirshberg 2017). In this document, the maker movement is literally offered as a model of how to "Make America great again" completely ignoring the global and transnational agenda which was always part of the movement (Schlesinger et al. 2010; Moilanen 2012; Bardzell et al. 2014). Co-written by Peter Hirshberg, who was also a collaborator of Dale Dougherty, the founder of Make magazine and Maker Fairs, the document is trying to inspire the current administration to "embrace the Maker Movement as a deeply American source of decentralized creativity for rebuilding America's thinning manufacturing ecosystems." Maker movement is a "deep American source of creativity," which supports something called "localism" (isolationism in the old terminology)⁵, which is "both empowering and a quintessentially American must recognize the limits of federal power and find ways to encourage locally driven,

¹ BioHack Academy <http://biohackacademy.github.io/>

² GaudiLab official website: <http://www.gaudi.ch/>

³ Biodesign official website: <http://biodesign.cc/>

⁴ Pecheblenda official documentation: <https://pechblenda.hotglue.me/diwo>

⁵ The next presidential administration—Democrat or Republican—should build upon the localist momentum that President Obama has created. Democrats, often seen as the party of government, have a duty to support the most effective solutions to public problems. As such, they

cross-sector approaches. In <https://www.brookings.edu/blog/metropolitan-revolution/2016/02/26/the-new-localism-an-obama-legacy/>

story, one that de Tocqueville would immediately recognize, and that Donald Trump might even like." This "Trumpization" of the maker and DIY movements in the U.S., however, started before 2016 with initiatives such as "America Makes"⁶ in 2012, which was federally funded part by the Institute for Manufacturing USA, or with Obama's "Nation of Makers"⁷ programme and the "National Week of Making" events organized at the White House in 2014. While the nationalist rhetoric was always present in the Make magazine and Maker fair rhetoric (especially in Doherty's writing on the Make magazine blog), the "Nation of Makers" programme gave it a public recognition leading to its present meaning.

The "Nation of Makers" also followed closely other public initiatives inviting the makers to become part of nation building efforts, such as the "Mayors Maker Challenge,"⁸ which aims at restoring manufacturing in the U.S. city and supporting local production (Manufacturing Alliance of Communities)⁹. In 2015 the original rhetoric of supporting education and innovation through making escalated into an openly confrontational "anti-China" rhetoric. The maker movement suddenly was not only about local creativity and self-reliance, but became a weapon in the economic war with China supporting the "U.S. independence from Chinese goods". This title of the 2015 Washington Times article summarizes the shift while reporting on the work of the bipartisan "Congressional Maker Caucus", a group of 25 representatives, determined to educate colleagues about maker technology with the belief that it one day could help America declare independence from Chinese-made generic goods" (Shapiro 2015).

The step from supporting education and innovation to economic independence then logically leads to the present Brookings' calls to "Make America Great Again," in which a grassroots, independent and transnational movement was co-opted to serve openly nationalist and isolationist agenda. Such "localist" views of the maker and DIY movements, whose purpose is to "Make XYZ great (innovative, self-reliant) again" are also present in China, Taiwan, and Singapore, but they seem more nuanced and complex acknowledging the transnational networks behind innovation and not only maker culture (Lindtner 2014; Lindtner et al. 2016). The policy attempts to co-opt the grassroots movement of makers openly disregard the transnational and complex practices which are happening on the ground. The only official document which at least mentions the global "benefits" along the local importance of the movement is the official EU "Maker week"¹⁰: "I believe that makers will be able to make a positive contribution to our Society and to the European Economy, especially within the educational environment and by creating innovative Startups based on hardware products. I want to enhance this world of people who work locally but in a global network. I would like to combine our forces in order to organize a week of public events across Europe: a huge umbrella event under which local initiatives will flourish

⁶ America Makers website <https://www.americamakes.us/a>

⁷ Nation of Makers website <https://obamawhitehouse.archives.gov/nation-of-makers>

⁸ Mayors Maker Challenge letter: http://manufacturingalliance.us/wp-content/uploads/2016/06/Mayors_Challenge_Launch_Letter_.pdf

⁹ Manufacturing Alliance of Communities <http://manufacturingalliance.us/>

¹⁰ European Maker Week <http://europeanmakerweek.eu/about-us/>

as part of a European network." The document also states clearly the importance of collaboration and open hardware for the success of any DIY activities.

One of the reasons why the DIY transnational movement is becoming co-opted by the nationalist agenda is the lack of any official institutions protecting the interests of the "makers," which would also define their interests and politics. In this DIY practitioners and makers are similar to the open source and hacker communities described by Gabriella Coleman (2012) and their "elastic" and adaptable uses of rules and technologies to serve "divergent political and economic practices and imaginaries" (Ibid). Coleman brilliantly summarizes this on the example of "Debian's governance," which is a set of rules and procedure used by the developers of this free, Unix-like, operating system, to manage the whole projects. She describes it as a unique blend of the "democratic majoritarian rule, a guildlike meritocracy, and ad hoc deliberations," basically showing that there is always a tension between the more communitarian and liberal leanings in the open source community, which seems to strive in the paradoxes rather than attempting to resolve them. The open source communities of developers, practitioners and DIY makers combine political and design decision on a case to case basis leaving it for everyone to make a decision and experience the paradoxes directly. It is impossible to decide whether these acts of building your own equipment to conduct experiments or gather data "express the liberal traditions of free speech, the communitarian longing for community based on shared forms of life, or some romantic delusion of self-creation and radical autonomy?" (Kera 2013).

When reading Gabriella Coleman in 2015, I realized that her descriptions of the hacker practices remind me of the 17th and 18th century political philosophy reflections on whether a utopian state based on natural philosophy, science, or even atheism could exist. It seems that we are still asking the same types of questions in our reflections of the makers movements: can a community or even a state be based on open source, hacker and maker practices? How does such a Republic of makers and hackers operate or govern? Coleman's account of the open source movement shows that we can view these movements are provoking us to "imagine a state based on something other than religion, body politics, or other visions of perfect and natural unity (Thomas More, Francis Bacon, Tomas Campanella on natural philosophy, and later more radical materialist positions in Pierre Bayle, Denis Diderot or Baron d'Holbach)" (Kera 2013).

In this paper, I will develop the initial "Republic of codes (and makers)" insight and inspiration from Coleman and discuss the relation of politics to design and knowledge to governance in the present maker movement and DIY activities. I will use examples of open science hardware, but also projects from Shenzhen, which show most clearly the present dichotomies and paradoxes, such as the one of transnational and nationalist views of making. The public of makers and citizen scientists formed around prototyping with open source hardware seems to show a possibility of governance, which actively embraces paradoxes and liminality (Turner 1985). Rather than trying to achieve an ideal state, this tinkering with politics and design happens through socio-technical rituals in the hackerspaces and makerspaces, which enable the practitioners to experience firsthand the paradoxes behind various scenarios and thus liminality.

Spectators, makers, citizens and (DIY) air pumps

That tools produce their public and define politics is an insight, which we can demonstrate on the famous 18th century Joseph Wright's painting "An Experiment

on a Bird in the Air Pump". The painting shows how laboratory equipment not only provides data to scientists, but also engages the public in science (van Helden 1991; Baudot 2012). On the painting, a scientist (supposedly Robert Boyle) demonstrates a new instrument to a lay audience of women, children and well respected citizens who see a bird suffocating in the vacuum. This terrifying and visceral experience reveals the hidden forces in nature, but it also forms the public opinion of science through fear and awe. The vacuum pump serves science, but it also creates a certain type of public, which will be obedient to science and technology.

In sharp contrast to this image of the air pump and science, the present air pumps are part of everyday, mundane scene on pictures from various websites and social media supporting tinkering and DIY (Do-It-Yourself) and DIWO (Do-It-With-Others) practices. Services, such as Instructables,¹¹ support anyone with a 3D printer to print and immediately use an air pump in various contexts. The growing number of hobbyists, citizen scientists, hackers, makers, academics, and entrepreneurs use such platforms to share and democratize or "open" all laboratory instruments.

This democratization of instruments enables citizens to engage with science outside of the official laboratories, and to use them in a diversity of contexts. The OSH supports the freedom to explore, rethink and tinker with nature, politics, society, technology. It challenges both the epistemic (improving knowledge about nature) and normative (improving society) expectations from science. It brings together private experiments, creative explorations, and public aspirations of restoring an active citizenship and public sphere through (open and citizen) science, which are often at odds with each other. These paradoxical functions of the OSH form the liminality, which I claim enables the open hardware to remain open to individual experiences and experiments and resist the attempts of being misused for one particular agenda.

From civic and independent monitoring of water¹² and air quality¹³ to sound¹⁴ and VJing performances¹⁵, artistic and conceptual explorations¹⁶, but also entrepreneurial¹⁷ and educational uses¹⁸, open laboratory instruments extend their

¹¹ Instructables official website: <http://www.instructables.com/>

¹² Fixed sensor wiki documentation: http://wiki.biodesign.cc/wiki/Fixed_Sensor

¹³ Smart Citizen Science platform official website: <https://smartcitizen.me/>; List of Safecast radiation monitoring devices official website: <http://blog.safecast.org/devices/>

¹⁴ Git of CocoMake7 (A jugaad and low-cost educational platform for digital interactivity): <https://cocomake7.github.io/> using Attiny microcontroller developed by Hackteria for scientific experiments. Nalareksa sound installation using O₂ and CO₂ monitoring on the official website of Andreas Siagian, a member of Lifepatch citizen science network: <https://andreassagian.wordpress.com/category/installation/nalareksa/>

¹⁵ Youtube video documentation by Lifepatch of a VJing experiment with DIY microscopes: <https://www.youtube.com/watch?v=wE5oiwmpCA8>. It is using a PureData tool developed by Hackteria for VJing and DJing with microscopic images, official wiki: http://hackteria.org/wiki/Pd_microscope

¹⁶ Gel electrophoresis apparatus used for artistic explorations of food colors in the agar medium, official Hackteria wiki documentation: http://hackteria.org/wiki/Agar_is_the_Media; Artistic experiments with visualization and sonification of Daphnia zooplankton, official Hackteria wiki documentation: <http://hackteria.org/wiki/Daphniaology>

¹⁷ Quartz Crystal Microbalance official website: <http://openqcm.com/>; Open-source PCR Thermocycler official website: <http://openpcr.org/>.

¹⁸ The Amino One Desktop Biolab official website: <http://www.amino.bio/>; Open Source meteorological station wiki documentation:

functions far beyond academic or professional research. Instead of only wooing the public with challenging scientific hypotheses produced by experts, the low tech, digitally fabricated or repurposed tools support personal explorations, family activities and community-based projects. For example, the air pumps are parts of soda bottles and fish tanks, but also more serious, sustainable energy projects and experiments with algae biofuel reactors¹⁹. The DIY syringe pump even serves self-experimentation with microdosing of legal (Hurley 2016) and illegal substances²⁰ and playful uses of microfluidics²¹ in Hackteria's projects.

These plural, hybrid and often ambiguous (mis)uses of instruments show science as an everyday activity, which relates directly to the private, but also public (cultural, economic and political) lives and interests of the citizens. It ceases to be something well defined and given, which is only represented and communicated to the public by professional scientists, policy makers or science communicators, but becomes an experience of defining your place in the world and the vision of how the world should look like. The work on the DIY pumps in the biofuel and algae bioreactors²² as captured on Google search results shows citizens exploring sustainable scenarios of future food and energy production²³. The 3D printed air pumps show individuals protesting against the patent system, which is leaching on the open source designs, as expressed in a recent disclaimer²⁴. The miniaturized DIY syringe pump, which enables microfluidics techniques, also supported further Hackteria's research into electro wetting and its creative (mis)uses for art performances.

Whether as a hobby item, educational tool, new form of a protest or a probe into the future, the DIY air-pumps and other OSH examples experiment with the roles of instruments in science and public life. Designed and made by citizens themselves rather than designated professionals and industries shielded by ISO norms, these imprecise and uncalibrated tools support something between a science "cargo cult" and an attempt to democratize science by involving it with plural and diverse publics. How to describe this OSH transformation of Robert Boyle's air pump as a tool

https://pt.wikiversity.org/wiki/Pesquisa:Ferramentas_livres:Work_group_for_development_of_the_hype_robect_workbench for example the meteorological station <http://cta.if.ufrgs.br/projects/estacao-meteorologica-modular/wiki/Wiki>; Atomic Force Microscope official website: <https://openafm.com/>

¹⁹ Instructables documentation: <http://www.instructables.com/id/Solar-powered-algae-bioreactor/>

²⁰ Reddit group on microdosing self-experiments documentation: <https://www.reddit.com/r/microdosing/>

²¹ wetPONG website documentation: <http://wetpong.net/>

²² Instructable documentaioon: <http://www.instructables.com/id/How-To-Make-A-PVC-Water-Air-Vacuum-Pump/and> <http://www.instructables.com/id/diy-small-water-pump/>

²³ Search of bioreactors and hackerspace on Google.com gives roughly 3000 results of projects in various degrees of completion, such as this Instructables documentation: <http://www.instructables.com/id/Make-Biodiesel/>. There was even a competition on such bioreactors for space: <http://www.spacegambit.org/open-bioreactor/>.

²⁴ Thingiverse documentation: <http://www.thingiverse.com/thing:29623> "The design files for this thing (air-pump) have been removed as a protest against Stratasy after their decision to file a patent infringement lawsuit against Microboards Technology. Their decision is extremely destructive and also underlines that the patent system is obsolete as it no longer serves any purpose for the betterment of society. Its main role is as a blunt weapon used by incumbents to hamper innovation. I see absolutely no reason to continue indirectly supporting Stratasy by providing free content to Thingiverse."

with a privileged access to nature, but also political power, into this myriads of hobby items, citizen science projects, artistic and design experiments? I emphasize the liminality of building such equipment and experiencing the diversity, paradoxes and possibilities of connecting it with various public and private interests. Building such DIY equipment is more like a socio-technical ritual, in which the "initiated" has to experience all the ambiguity inherent in his community and time, rather than only replicating for the industry or the academia (or policy) consider as standard.

There is little evidence that these DIY, hands on and material engagements with instruments create any measurable impact on science and/or society even if they tackle some public issue, such as measurement of pollution or help us imagine alternative sources of energy. To describe further these paradoxes behind the DIY practices over OSH or other tools, I will reflect upon the present theories on the convergence between design and politics (Ratto 2011; Ratto and Ree 2012; Dantec and DiSalvo 2013), but also calls for object-oriented politics (Marres 2012; Marres and Lezaun 2011; Weibel 2005). I will show how these convergences lead to similar paradoxes (democratization x resignation on the political, transnational practices x nationalist agenda) and explain why the concept of liminality can help us understand the present dynamic between politics and design in the maker, citizen science and other DIY activities.

PROTOTYPES, LIMINALITY AND OSHW COMMUNITAS

The makers and tinkerers organized around open source hardware (OSHW) projects, such as the OSH, but also in the hackerspaces, makerspaces, hardware accelerators, Maker Fairs etc. form a heterogeneous and complex network with conflicting goals and agenda. There are transnational and localist tendencies, but also openly political and very private projects, which identify with the DIY culture. The maker activities democratize the design of the instruments while exploring various conflicting political, but also creative, artistic and unexpected uses as in the case of the DIY air pumps, which I describe as liminality (Turner 1969). While anthropologists use this concept to describe the ambiguous and transitory phases during rituals or other transformative, social and cultural changes and events, the concept can also capture the social and technical ambiguity behind and involved in the maker culture.

The maker prototypes are liminal objects, which gather a heterogeneous crowd with diverse political and design interests and agenda. They range from improvement of existing tools, where the politics concerns open source licenses supporting collaborative innovation²⁵, to more critical and activist attempts at building laboratory infrastructure in the Global South for open science²⁶ or responding to environmental crises with independent monitoring tools²⁷. Instead of limiting the technical and normative aspects behind such efforts to issues of autonomy of the subject or some ideal notion of a community (and numerous reiterations of the

²⁵ "OLINUXINO - Single Board Linux Computer" accessed December 12, 2014, <https://github.com/OLIMEX/OLINUXINO/>

²⁶ "Hackteria: Wiki collection of DIY Biology, Open Source Art Projects that use Biology, LifeSciences, Biotechnology," accessed December 12, 2014, <http://hackteria.org/wiki/>

²⁷ "Smart Citizen kit: Open source technology for citizens' political participation in smarter cities," accessed December 12, 2014, <https://www.smartcitizen.me/>

communitarian and libertarian discourses), I emphasize the liminal and liminoid (Turner 1985) properties of open hardware design.

OSHW as a messy, complex, and ambiguous object of our recent political and design fantasies, demarcates the limits and conditions of governance rather than directly empowering some idealized subject or a community. OSHW's geography, design and politics are in a permanent transition and transformation creating paradoxical and uncanny networks (OSHW *communitas*) difficult to describe, let alone judge. OSHW embraces the open source rhetoric while remaining partially patented, pirated and hybrid. It mobilizes the Global South hopes and performs Silicon Valley clichés while being produced by migrant slave labor in China using African conflict minerals.

Even the most iconic of the open hardware projects, such as the "TV-B-Gone Kit"²⁸ for switching off annoying LCD screens in public spaces or the "Tweet-a-Watt"²⁹ for monitoring electricity consumption, which test public space interventions and ideas of regulating consumption, remain inherently playful and exploratory. The open hardware projects are never ambitious solutions to some large scale social, political, and economic problems, such as the Cisco's or Intel's smart cities visions embedded in corporate sensors (Caragliu et al. 2011). They cannot be reduced to props either, which only enhance public participation, discussion and deliberation through design as is often the case with mockups and prototypes in Critical Design (Dunne & Raby 2013; Dunne 2008; Wilkie & Ward 2009) and Science Communication (Kirby 2009; Simon 2010; Wilkie 2010).

The OSHW prototypes just like the OSH science instruments are functional in some perpetual beta state, but they rarely if ever share the exaggerated rhetoric of "exploits" from Critical Engineering (Oliver et al. n.d.) or interest in a contested and "adversarial" design (DiSalvo 2012), which emancipate and educate the masses about technological infrastructure through the work of enlightened designers, artists, engineers or hackers. They are close to the mundane objects of Critical Making (Ratto 2011; DiSalvo 2014) with their emphasis on collaborative and participatory work, which makes them scalable and global, but their rhetoric remains elusive. They remain liminal in terms of their purpose, but also economic and material conditions of their creation, and they often lack the type of "critical reflection", which mobilizes the critical makers into empowered DIY citizens (Ratto & Boler 2014).

The recent views on prototypes as tools for forming a new public through design open an important issue of how to discuss the convergence of social, political and design efforts in the case of open hardware. While some criticize the recent vogue of connecting politics with design as a "solutionism" (Morozov, 2014), a revamped and softened version of the old technocratic rule (Feenberg 1994; Habermas 1989), I disagree with this reversal assessing technology as a simulated and imperfect form of social action. The problem with the present accounts of political prototyping and design as a form of social action as well as with their criticism are the simplified notions of both technology and politics. The liminal nature of the legal, geopolitical, but also geological networks and relations operating behind every electronic component are rarely mentioned, and most just emphasize how design and technologies serve (or fail to serve) some preconceived notions of liberal democracy, communitarism or other political inclinations of the authors.

²⁸ "TV-B-Gone Kit," accessed December 12, 2014, <http://www.ladyada.net/make/tvbgone/>

²⁹ "Tweet-a-Watt kit," accessed December 12, 2014, <http://www.ladyada.net/make/tweetawatt/>

The messy technical, legal, social, and political aspects of OSHW behind these expectations and fantasies remain ignored or potentially reduced to something even more abstruse in actor-network theory. To avoid this, I propose the concept of liminality used originally to describe pre-modern societies, where the division between "technology" and "social structure" or practice remains complex. This allows me to reflect on how engagements with OSHW problematize our views of technology, patents, innovation, but more importantly also our concepts of social action, politics, and governance. More than other technologies, OSHW with its insistence on community based, peer innovation and improvements, exposes the genealogical roots of our idea of politics and governance, which are modeled after the activities of the "free" aristocratic citizens of Athens excluding any engagements with material labor and production (Salkever 1992; Rosen 2005). I do not however attempt to revamp any Marxist notions of the division of labor, structure or production (Carver 1991; Fuchs & Dyer-Witheford 2012), which reinforce just another version of the ideal subject and community. The notions supporting historical materialism are based on the right (teleological) insight into a classless society, which defines what it means to act rightfully and support this supposedly necessary historical state (classless society). It is exactly this logic between insight and action, theory and practice, which I want to question, and emphasize the liminality in OSHW projects, which problematize the relation between politics and technology as issues of insight versus action. While Marx and Engel's critique of consciousness and idealism (Marx & Engels 1998) comes close to my critique of the division of powers between knowing (having and insight) and making (action), their ontology and psychology (of needs) remains close to Plato's tripartite theory of the soul, which served as a base of all western ideas of governance defined as a division of powers (Smith 1999). Instead of this tripartite notion of the soul (and governance), which is hierarchical and static, based on an ontology of forms and teleological insights into perfection, Turner's ethnographic studies of liminality in the preindustrial, indigenous cultures (Turner 1969) offer a better model for studying the present DIY engagements and explaining the relation between design and politics.

Socio-Technical rites over 3D printing

The connection of politics and design in project, such as the air-pump, are similar to the rites of passage, which emphasize transitions between different, often conflicting states in both the subject and the community, technology and politics. The open hardware design and politics as rites of passage involve various political and material forces and actors without imposing any teleological goals. They will never create the ideal global polis governing peacefully the trade in minerals for the ideal consumer-producer and maker, but they keep revealing new layers and challenges behind our technological and political involvements and ideals.

The thesis is that the OSHW prototypes with all their ambiguous and indeterminate attributes of conflict based, but liberatory, semi-patented and almost pirated, but still open source technologies, "ritualize social and cultural transitions" (Turner 1969: 95) in the present. They are the ultimate object of our present, which summarizes and performs the transitions and ambiguities of our technology and politics. For some members of the OSHW community, the transitions are transformative, but for most they just preserve the old hierarchies and power relations after a period of turmoil.

Rather than looking for an ideal convergence of politics and design resolving all ambiguities, the OSHW prototypes test our fantasies and excesses of both politics and design. For example, the famous MakerBot30 controversy (Molitch-Hou 2014; Dickel et al. 2014) shows such transition and unfolding of the OSHW *communitas* behind the 3D printing efforts. The 3D printing *communitas* is not the perfect society of digital fabrication, in which anyone can download and print objects and materials they need, but a paradoxical transition from expiring patent to open source and then new patents, where some members become more radicalized open source advocates while others support the patent system.

The limits in 3D printing open hardware innovation and governance bring many different responses, both in terms of design and politics, creating something of parallel and plural futures of 3D printing (Pettis 2014). The individuals and communities involved in the MakerBot controversy as an example of such OSHW *communitas* experience a type of "limbo of statuslessness" (Turner 1969:97) with all the "high and low, homogeneity and differentiation, equality and inequality" (Ibid) of present politics and technology. They are in transition between the regulated, patented and structured form of innovation and society, and the wildly creative, collaborative, open and free design and politics of the original OSHW efforts. With OSHW we are experiencing the prototypes as such liminal entities, which are "neither here nor there; they are betwixt and between the positions assigned and arrayed by law, custom, convention, and ceremonial" (Turner 1969: 95). It is a type of "oscillation" rather than a dialectic, which the global *communitas* of tinkerers performs over OSHW, remaining open about the future.

It is always tempting to read Marx's Eleventh Thesis on Feuerbach (Marx & Engels 1998) (The philosophers have only interpreted the world, in various ways; the point is to change it) as the ultimate makers' manifesto of politics merging with design for some better society. It is also easy to apply the famous passages from "The German Ideology" to the sentiments voiced by many and free, critical makers and DIY citizens, who also claim to reflect while producing and making: "...in communist society, where nobody has one exclusive sphere of activity but each can become accomplished in any branch he wishes, society regulates the general production and thus makes it possible for me to do one thing today and another tomorrow, to hunt in the morning, fish in the afternoon, rear cattle in the evening, criticize after dinner, just as I have a mind, without ever becoming hunter, fisherman, herdsman or critic." (Marx and Engels 1998: 53)

The problem is that these passages (and many present reflections of maker culture) contain an idealized (or demonized and alienated) notions of a community and its subjects, which guide the practices and the actual engagements with materiality and ontology. In my view, the (OSHW) practices are not emancipatory, they do not serve an idealized notion of politics nor technology, they are simply liminal, enabling transitions and experiments between existing and new configurations of power, resources, subjectivities, fears and fantasies. Most importantly, they allow us to view more critically both technology and politics and to understand their limits and genealogy.

The examples, which I plan to discuss, offer such liminal forms of convergence of design and (global) politics. They show the ambiguity of the emerging *communitas*, which I will provocatively call the Republic of Tinkerers. Instead of searching for

³⁰ "MakerBot," accessed December 12, 2014, <http://www.makerbot.com/>

another ideal politics based on design, making or praxis, or for the right place and use of design and technology in politics, I will use the present activities around open hardware and its liminal objects, sites and institutions, to question why making and tinkering were always excluded from politics. Instead of the rhetoric of change as a path to universality and freedom, voiced in the famous passages from Marx and Engels (Marx & Engels 1998), but also in the present literature on the convergence of design and politics (Ratto 2011; Ratto & Ree 2012; Dantec & DiSalvo 2013; Marres & Lezaun 2011), I will explore governance as a liminal, open ended, plural and in the best case, just experimental process with a complicated relation to materiality.

Republic of Makers (Demiurgoi) in Shenzhen

What type of citizens and public do the liminal object (OSHW) and its complex relations between playful and serious engagements, open source and patents, but also complex geopolitical networks, form? Is this tinkering public (OSHW *communitas*) reflective of its practices or recursive in terms of following a certain ideal (Kelty 2008) or imagined community (Anderson 1991) as in the case of open source software efforts? Is this recursivity a form of political deliberation, which is moving from purely discursive practices into material and design efforts (Ratto 2011) and ontological experiments (Marres 2013; Mol 1999)? Against the ideas of a recursive and reflective public following and defining some ideal society through design, I am using the concept of liminal public (OSHW *communitas*) probing the limits of governance. The OSHW *communitas* around testing prototypes explores liminality and transition and embraces the paradoxes rather than defining any ideal community of empowered subjects. In this sense, it is close to the paradoxes of geek politics identified and described convincingly by Gabriella Coleman as syncretic and productive in her ethnographic study of the communities of geeks and hackers around open software (Coleman 2013).

To discuss this liminal public of makers, we can use the most important site of present OSHW practices, which is Shenzhen in China, the manufacturing capital of the world, where many of the open hardware projects in recent years congregate as noticed in the recent studies of innovation in China (Lindtner 2014; Lindtner and Li 2012; Jeffery 2011). Shenzhen summarizes well the ambiguities and liminality beyond the convergence of politics and design, the paradoxes of making and tinkering. It questions the ideals of a public and individual empowerment through DIY making, which drive the theories of convergence and emancipation behind the convergence of politics and design.

Shenzhen hosts the transnational open hardware accelerators, which define the future of innovation, but also the semi-legal copycat, shanzhai production of mobile phones and other products, while still remaining the central production site of the official (patented) electronics industry. The mysterious equilibrium between the of liberated hardware, such as OSHW and shanzhai, and the very regulated Apple, Samsung etc. products, simply activates the inherent paradoxes of the special economic zone catering the needs of both developed and developing worlds (Longyi and Lihua 2009; Liu 2010). It is a place where the problematic migrant factories use even more problematic minerals from Kongo and other conflict zones to interact with the promissory local and global high tech startup scenes, Silicon valley, MIT research labs, but also the network of hackerspaces and makerspaces.

Shenzhen as an open hardware *communitas* is a place to experience the liminal aspects of tinkering, making, and material iterations and the paradoxes behind the pirated, patented and open source technologies and industries. Most importantly,

this Republic of Tinkerers is an opportunity to question the embedded views of governance based on the denigration of makers (demiurgoi) as political actors in Plato's Republic (Plato n.d.). The default view of governance means to perform the right insight into the ideal society by serving the enlightened guardians and philosophers, which are in charge of defining these insights and visions of the ideal society. The denigration of makers who prefer to make and test before defining the insight, informs all western concept of politics and its devaluation of all material engagements, such as production or minerals.

China or Congo and other places involved in the material production of electronics and the trade with minerals will never meet the democratic standards of Plato's republic for the simple reason that they exclude the demiurgoi. They will never become responsible geopolitical actors in the governance of the minerals nor models of sustainable growth, and the only attempts for conflict free and transparent trade with Congo remain US based³¹. The concept of good governance somehow automatically serves the interest of western corporations, such as Intel, and regulations, which basically structure and control the market with electronics to serve the west as the ideal community. This community based on the right (democratic) insight outsources and excludes making and messy engagements with minerals or other materials as work for slaves, makers and simply actors without the right insight.

The ignorance about the conditions of production and the costs of mining minerals behind the liberatory and corporate hardware is just the most recent form of the original exclusion of demiurgoi in Plato's Republic (Plato n.d.). The blueprint of all our ideals of governance is this separation of powers and various forms of trias politica (Hendrickson 1997; Stewart n.d.), which simply degraded and opposed making and production. Good governance defines itself as a contemplative, cognitive and discursive achievement (Habermas 1989) based on the right insight into the true nature of our soul and society available only to certain actors. The separation of powers between the groups that make the decisions and the excluded one that executes them is still the preferred model of governance, which on the global level translates into a division between the developed North whose innovation and political culture is slowly adopted or transferred to the Global South. The material engagements with OSHW, which perform political agency in places such as Shenzhen, parts of Indonesia, and other non-western places enable us to identify and question these exclusions and separation of powers.

Republic of Garages: Solar Pocket Factory

The unique geopolitics of the OSHW *communitas* around Shenzhen and the liminality of open hardware prototypes transitioning between various ideologies and interests, is well illustrated by one of the first important project, which originated there, of a micro-solar factory. The Solar Pocket Factory³² was a joined effort of MIT graduates from Haddock Invention³³, a company based in Hong Kong but operating in Shenzhen and part of a complex network of affiliates, such as Mantis Shrimp

³¹ US Public Private Alliance for Responsible Minerals Trade (PPA), Electronics Industry Citizenship Coalition (EICC), Conflict-Free Sourcing Initiative (CFSI) in the "GeSI search," accessed December 12, 2014, <http://gesi.org/search/?recent=2417>

³² "Solar Pocket Factory," accessed December 12, <http://solarpocketfactory.com/>

³³ "Haddock Invention," accessed December 12, <http://www.haddockinvention.com/>

Invention³⁴ from Manila and other SMEs from Asia, EU and South America. This self-described "network of workshops and garages" combined the hacker ethos and the new models of crowdfunding with elements of traditional business practices, such as the multinational, networked structure of their affiliates, and even patents. This strange hybrid of an organization almost mocked the corporate pan-global structures. It was trying to produce disruptive, low-tech prototypes, which provide solutions to both developed and developing countries in terms of energy efficiency (small solar panels for mobile phones), critical for the developing countries.

The network of garages was started by the MIT graduates, Alex Hornstein and Shawn Frayne, in cooperation with local teams of tinkerers in developing countries to support the design of future clean confluent technologies (Frayne n.d.), such as the low tech solar panels and wind turbines. Their green energy prototypes power wireless sensor nodes for environmental monitoring, but also mobile phones etc., which improve the situation in many places with missing energy infrastructure. They describe their technological and social goals as iterative process and complex networks around prototypes: "I'm developing this network because I believe paradigm-shifting, disruptive, confluent (insert punditry here) technologies, emerge from a different innovation machine than has traditionally been the engine of progress in the past. These new inventions are not churned out [by] the 'invention factories' that Edison created in 1876, where hundreds of engineers worked twenty hour days on the same punch clock under one roof. Nowadays, the biggest problems aren't near the wealthiest markets, and creativity is too spread out across borders" (Hornstein n.d.).

These cells in what they hope will become "a global invention organism — the Ocean Invention Network" (LeCompte n.d.) are small teams of four to five people from both sides of the wealth divide, which are testing new models of manufacturing, R&D and business. They embody a "liminal" model, where graduates from MIT go to Shenzhen and involve developing countries in building prototypes together and not only manufacturing there.

The company was based in Hong Kong legally, but work and target markets were defined as Thailand, Philippines, because these less regulated spaces prove more supportive of innovation and experiments between patented and open sourced, liminal technologies. Shenzhen presents an ideal site for experiencing the liminality behind such prototypes, which Shawn Frayne and Alex Hornstein call confluent technologies and described as "technological magic that happens when challenges faced in developing countries meet the challenges faced in wealthy countries" (Hornstein n.d.; Frayne n.d.). Mobile payments, which are heavily used in places, such as the Philippines or Kenya, were all originally developed for places with missing infrastructure and then actually adopted by the so called "developed nations" in a reverse manner. The innovation in developing countries is liminal because of scarcity of resources, but also different geopolitical networks, which are pushing the innovators to develop more resilient and original solutions: "Whenever new products are developed to serve new customers at radically different price points, something wonderful that happens – a rupture breaches the status quo, where incremental innovation produced by incumbent industry giants is wiped away by a leap forward... These confluent technologies were developed to solve some challenge in emerging markets, under the pressure of cost constraints very different from the constraints in

³⁴ "Mantis Shrimp Invention," accessed December 12, <http://manilamantis.com/>

Silicon Valley. Emerging markets are the breeding ground for new innovations that will topple industries, not despite their constraints but because of them. For the first time, the lack of electricity, scarcity of clean water, and the great need for medical diagnostics in the small village of La Borgne, Haiti, can force into existence new solutions that have the power to overturn multi-billion dollar empires across the economic divide in rich cities like Tokyo and San Francisco. That is what the Ocean Invention Network is all about – teasing out great inventions from the confluence, and making some trouble along the way." (Frayne n.d.)

The liminal prototypes in this case act almost as dream-works, which involve various unconnected (and sometimes conflicting) desires and publics formed around them in various stages of their design, creation, and distribution. The open hardware processes seem closer to the unconscious and even biological phenomena of crosspollination and symbiosis rather than to well-defined economics of launching a product or doing an IPO and the whole politics of licensing and patenting or policy of diffusing innovation to the Global South. These projects may not resolve our present resource-based conflicts, but they offer more visibility to the material bases of production and its role in economy and politics. The independent, ad hoc and mobile R&D centers, the garages in Delhi, Shenzhen and Manila, together with fablabs, hackerspaces and similar institutions around the world work on liminal prototypes, such as the non-turbine wind generators (Hong Kong/Hawaii)³⁵ or underwater drones (Octo23 in Paris)³⁶ etc. to define the new innovation networks.

Liminality and Prototypes: Will they make XYZ great again?

In all these discussions about the new public of makers and hackers, the prototypes merge with political deliberation to support some form of an ideal political vision, to which I want to oppose our emphasis on liminality and paradoxes. The OSHW prototypes are a symptom of a crisis of our ideas of governance rather than a well functioning model of future policy based on design. The merging of material exploration in prototypes with the discursive and reflective politics in recent literature on making and open source movements (Ratto & Ree 2012; Ratto et al. 2014; Kelty 2008; Paulos n.d.; Coleman 2013) often leads to two opposite conclusions.

While Coleman (2013) emphasizes the paradoxes behind the political engagements with software, Paulos embraces the creation of "an entirely new form of citizen volunteerism, community involvement and participation" through environmental monitoring, which can "effect real political change" (2014), which summarizes most of the writing on the issue. Do these prototypes serve the open (uncertain and maybe even problematic) future or does their recursivity support some ideal of politics? While Kelty's technologically savvy public connects the moral imagination with the technical infrastructure by recursively working and improving both (2008), our view of the Republic of Tinkerers shares Coleman's (2013) observations that this convergence of politics and design is exploring the liminal states between libertarian and communitarian ideals.

The iterative design processes in Kelty are always subjugated to the demands of the moral imagination of the ideal community, which uses the "activities of making, maintaining, and modifying software and networks, as well as the more conventional

³⁵ "Windcell," accessed December 12, <http://www.haddockinvention.com/projects/clean-energy/windcell174>

³⁶ "Octo23," accessed December 12, <http://www.octo23.com/about/>

discourse... to argue about technology, but also through it... They express ideas, but they also express infrastructures through which ideals can be expressed (and circulated) in new ways” (2008: 3). The crucial point for Kelty is that the connection between technology and society or the “operating systems and social systems” (2008: 6) is about the imaginary potential of the public sphere as an ideal community: "In fact, if the public sphere exists as more than just a theory, then it has no other basis than just such a shared imagination of order, an imagination which provides a guide against which to make judgments and a map for changing or achieving that order. Without such a shared imagination, a public sphere is otherwise nothing more than a cacophony of voices and information, nothing more than a stream of data, structured and formatted by and for machines, whether paper or electronic." (2008: 11)

The recursive here is basically synonymous with the shared, imagined community, a concept appropriated from Charles Taylor (2004) who describes the present crises of liberalism. Kelty is trying to apply Taylor's shared ideal of the moral and social order and social imaginary to technology. The hackers perform the social imaginary over the technologies, but how can they resolve scarcity of resources and slave labor? Kelty's and Taylor's positions in our opinion recall Plato's Republic connection of politics with the right insight of the enlightened philosophers or groups, which simply do not need to care about the material conditions. The insight of the contemplative reason (or the moral imagination) drives the technologies, practices and actions. While I can agree that autonomy and a certain transcendence of the public sphere (the imaginary) may be necessary for strong normative ideals in any community, the liminal, experimental, open-future politics is closer to what I can observe in the OSHW engagements in Shenzhen and the Global South.

Can we have politics, which is not based on insights and moral imagination as the forces driving any actions? The OSHW engagements seem to show a possibility of such politics, in which actions and material engagements in marginal places lead to creative geopolitical experiments and more resilient, but also inclusive politics. This politics is not yet fully realized, but it inspires us to question the genealogy of our concept of governance. Justice in Plato's Republic (Book IV.6—IV.19) (Plato n.d.) is achieved only through the right use of our faculty of contemplative and theoretical reason, which needs to be employed by the right class of citizens, rather than as something experimental, collaborative and uncertain, open for testing by different citizens or negotiations between different actors. The western idea of governance insists on this separation of powers and expertise, because only the right insight can enable the right action. But what happens in a crisis with many stakeholders, risks and uncertainties related to the use of various technologies, where no one can achieve the right insight, and all actions have uncertain results and effects? Is such separation of powers a useful policy for society, which needs to distribute the effects, opportunities, but also the risks and effects of every new technology and invention?

The present OSHW prototypes, which involve testing and improving design solutions while self-regulating and changing politics, seem to offer such alternative. The Republic of Tinkerers is closer to Plato's city of pigs with its spontaneous justice based on the interaction between various actors, who produce what is needed, rather than the feverish and luxurious city prone to excesses described in Books II and III. Philosopher Kings and their Kallipolis, which Plato envisions as ruled by the ideal of the contemplative life, seem to be losing their grip on our political imagination in favor of another hero from Plato's dialogues, the demiurg (Plato n.d.). The artisan and the craftsman from the dialogue Timaeus create a new universe from

chora, by managing the chaos and experiencing liminality and transition. He has the capacity to create the beautiful and functional well-ordered cosmos while balancing his vision with the material conditions. Rather than defining competencies first and acting later, the demiurg creates a natural (ontological) and political unity through the material work, while the Kallipolis remains a utopia of the perfect insight and control of the perfect humans, which is more like a world ruled by some big data policies, which supposedly give us an insight into the truth.

SUMMARY

With our discussion of OSHW prototyping I tried to question the idea of governance as a separation of powers of thinking and making, which informs the present claims about the convergence between politics and design and the various ideas of a new public. The OSHW prototypes show a different model of policy, which emphasizes engagements with new (often marginal and excluded) actors and which explores liminality rather than any ideals. The OSHW prototypes define regulation as an experiment and iteration rather than supervision, recursivity and insight. This *communitas* built on such experience of liminality of a Republic of makers is more than a group of consumers (prosumers) or some demographic category (geeks) defined by the tools they use or want to improve. They are global stakeholders mitigating the risks and benefits of every particular technology, which they try to open by actively improving it and reflecting upon its effects. They are citizens-makers trying to define normative goals behind DIY, open source technologies, such as the importance of open science in the Global South or sustainable communities based on independent environmental monitoring and energy infrastructure against the nationalistic agenda. In this sense, they exemplify the previous notions of the public, which combines design and politics (communicative, recursive, imaginary public), but they add to this an experimental aspect, where risk and uncertainty are also shared. The future in the Republic of makers is liminal, plural and conditional, where the risks and benefits are tested and experimented with rather than assessed in advance, and there are always new challenges, because even justice becomes an iterative and experimental process.

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