INTRODUCTION: RETHINKING MECHANICAL AUTOMATA IN EARLY MODERN EUROPE

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This collection of essays addresses the questions of whether, and how, automata and artificial instruments were able to articulate key issues of their period, particularly ideas about social hierarchy, economics, and philosophy of technology. The purpose of this short introduction is not to exhaust the relevance of these ideas in early European history, nor indeed to engage with them extensively. It would be enough here to clarify some preliminary questions of methodology and definition that continue to obscure our comprehension of how pre-modern automata functioned as a nexus of both archival and information cultures. As repositories 'embodied' or constructed at a time of significant technological, intellectual, constitutional, and religious change, it is only logical that the automata carry distinctive material, social, legal, and political nuances.[1]

Moreover, if we open them up as the focus of historical investigation, they would reveal fresh insights in what some dubbed the *archival turn*, that is to say, a sustained upsurge of interest, since roughly a decade ago, in the routinized practices and political imperatives of record-keeping – including scribal forgeries – that converge into the twin issue of control and reflexivity.[2] As with custodial preservation, including the household, so it goes with early modern automata: they end up in what Elizabeth Yale calls a larger ecology of paperwork and print.[3] Their audience is constantly shifting. Documents await or stay frozen between memory and oblivion, on behalf of future users or co-creators of novel meaning, "in whose putative interests the record must be retained".[4] In essence, automatic artificiality is and remains a question of discipline, and it is not by chance, as Jessica Wolfe brilliantly suggested, if Renaissance ambassadors and courtiers were seen, at their performative peak, as successful machines.[5]

As a result of the themes I highlighted in the last paragraph, this introduction maintains that automata are enmeshed in the culture of early modern diplomacy, and that they are better understood as the refinement of an investment in media archeology.

It also provides an overview of three distinct points of discussion that have the potential to move beyond the consolidated scholarship on the mechanization of nature[6] and the instrumental asymmetries that Shapin and Schaffer have emphasized for the origin of experimental science.[7] A further comment I would offer, as well, is that instead of calling for a greater collaboration and a breaching across the disciplinary divide, for example between historians in the humanities and scholars working in STS and harder technological areas, mechanical automata would benefit

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from a careful commensuration of microhistorical tools with the 'macro' viewpoint typical of a Braudelian *longue durée*.

What follows is divided in four sections. The first two parts evaluate the epistemic relevance of early modern automata and their feasibility for synchronic analysis and for such proposed assembling of local and global dynamics; these sections, while trying to remain as brief as possible, also register some areas where automata are gaining a new attention (e.g. transalpine or French automaton-making and Mediterranean diplomacy). The third part is concerned with three opportunities that, if taken, should supply more precision and depth to the field, namely, spatial displacement, history of the senses, and technological re-enchantment seen in tandem with the aforementioned archival history that is asking to inscribe the site of preservation itself alongside our sources, effectively 'archiving' the archive.[8] The fourth part identifies a few salient themes that emerge from the papers collected in this special issue and raises some questions for future research.

1. Automata as a middle ground between global and microhistory

So far, the study of mechanical tools and automata, both fixed and moving, has traditionally privileged the case-study approach, exactly for the same reason why in our modern pragmatics of scientific rationality everything is 'embedded', contingent, and context-dependent.[9] As Jan de Vries recently wrote, speaking of zooming as a metaphor for changing the scale of historical enquiry, "[t]rue case studies… are controlled, detailed examinations of a particular phenomenon with care given to the context, so that it might be compared to other cases in which the context differs".[10] Based on this very ambivalent comparison, some studies fail to live up their billing; and the conceptual framework they depend on remains blurred.[11] In contrast, and despite their inherently eclectic variety of topics, automata may be best understood as attempting to reach a mid level between the long-term view and microhistory. Put differently, in the best of circumstances, automata are hybrid by design. Let me quickly expand on this point with some examples.

Regardless of its social and institutional background, any automaton is equipped to work not only *ex machina*, or artificially, but also and more specifically as a *deus ex machina*, or a theatrical device.[12] Individualized exhibitions of entertaining wonder have always accompanied and bolstered the historical life of these perplexing objects.[13] And at some juncture – namely, the Victorian Age – the inner theatricality of the automata took over and also acquired the distinction of a sympathy machine or imaginary prosthetic. Later still, the Industrial Revolution reflected on robots as a threat to human civilization and inaugurated a narrative whose encompassing teleology should be actively resisted.[14]

Before these two distinctive periods, however, the European life of automata was articulating around the dual kernel of mechanical engineering, together with its designs and painstaking materiality, and of sociability, which naturally fed into domestic as well as international markets.[15] In their ability to work as replicators of cultural, sentimental, and political body practices,[16] automata are quintessential expressions of curiosity and patronage within the context of what is often referred to

as the 'long eighteenth century'; by the same token, they also show the Enlightenment's affinity for thinking with, and of, machines and their metaphors.[17] Take these three examples, all well-studied: Wolfgang von Kempelen's chess-playing Turk (1784) and Jacques de Vaucanson's "digesting" duck (1739; ill. 1), plus a series of female automata created by Swiss craftsmaking families like the Jaquet-Droz and the Roentgen (e.g. the "Writing Boy" automaton). These specimens cannot be lumped in the same canvas without breaking or effacing an imperative need of contextualization. Paola Bertucci patiently reconstructs how Vaucanson's automata, the embodiment of useful knowledge and a distinctively artisanal conception, were placed at the heart of a state-subsidized debate on the deregulation of silk production.[18] The fact that the Bureau of Commerce ensured unrelenting support to Vaucanson, as she writes, demonstrates that their sanctioned observers were able to move beyond a deterministic notion of mechanical progress or success, and that they shared the social vision that was underlying the new manufacture of silk introduced by mechanizing human labor.

In this respect, Vaucanson's automata are so deeply rooted in microhistory that a historian has every right to 'dissect' their design and their *esprit* as a cross-cut of French Enlightenment. All the same, the "digesting" duck, not different than for the other pair, the "flute-" and "tambourine playing" androids, became a true sensation across Europe. Thus, macrohistory comes back into play. Indeed, Bertucci herself goes as far as to claim that once the duck's internal workings were made transparent an argument can be made about the epistemological inversion of the 'black boxing' (note her adoption of Latourian language) that up to that point distinguished proper machines from mere trickeries.[19]

From this other vantage point, then, the only historical scales that are suitable to mechanical automata are neither 'micro' or 'macro', but something that stays mid-range between the two. In the final end what links these disparate objects is simply cleverness. And I take the adjective clever here to represent the Greek idea, and narrative, of *metis*. In the Alexandrian tradition we know of two or three Hellenistic theoreticians like Hero, Pappus, and Archimedes who presented ingenious devices by simultaneously keeping in mind show-business on one side and military application on the other. As this work was translated or further expanded in the Renaissance,[20] these two considerations continued to exercise a significant attraction, giving birth to technical contrivances and to projects of architectural defense as well. To explain how practical and crowd-pleasing effects did progress side by side it is reasonable to recall the enduring appeal of surprise within the same Hellenistic culture. According to Reviel Netz, in fact, many mathematical pursuits of the period unfolded "with a degree of isolationism"[21] and it was primarily because of that if a new notion of proof or demonstration emerged: quite independent from and, to a degree, in competition with rhetorical *epideixis*.[22] Netz's bid for incontrovertibility is at its core a narrative that enables a triumph of the weak over the strong. By and large, this also reshuffles preconceptions about the 'small' and the 'big' and also reinforces Wolfe's analysis of humanism and machinery. A new intellectual game of Greek deductions had to be invented bit by bit – diagrams becoming indispensable to such an achievement[23] – for a scattered class of geometrical practitioners to enfranchise

their laboratory from the jurisdiction of logic, philosophy, and their dominant semiotics of specialization.

2. From the Alps to the Mediterranean

It is stunning to think about early modern automata as something you observe *de visu*, but is sustained by an explanatory paradigm and micro-techniques of transport. It took a great degree of make-believe and abstraction. Yet, I believe that this can be read as a display of cunning intelligence, a story full of Greek *metis*. And since the statutory requirements of certainty and credibility were equally at play, this "triumph of the weak" also became a template of social mobility for artisans. Arguably, this is how automaton making became a universal mechanical metaphor in early European history. There is an ongoing, considerable amount of interest in the intersection between natural philosophy and artisanal epistemology. Some of this is shaped into a 'post-Zilselian' sociology; and almost all of it reasserts the importance of embodiment in the disciplines of knowing.[24]

Within this vein, we read about famous philosophical trips to some lens-grinding shops. We learn about Leibniz's first-person (yet only partially successful) engagement with mining in the Harz region, and we receive an instructive lesson on Spinoza's keen interest in optical precision.[25] But it is especially with Descartes that we turn into what is mechanically produced in relation to the problem of working knowledge and expertise. "We are not *sufficiently accustomed* to thinking of machines," Descartes tells Burman, "and this has been the source of nearly all error in philosophy".[26] There is no space here to articulate how this fragment is emblematic of Cartesian mechanic replacement. To be sure, it approaches objects of knowledge with an emphasis on *habitus* and already, as it has been argued,[27] Descartes's *Météores*, printed in 1637, rested heavily on an artificial, rainbow-making fountain such as it could be seen in one seventeenth-century courtly garden.

Jean-François Gauvin showed very persuasively that in Descartes's mind artisans were more than "invisible technicians" vis-à-vis Boyle's gentlemanly "scientist", that he observed how they worked during his European tour, and that he tried to bring method into their discipline, albeit with a wavering conviction and different gestural solutions – all converging on the inculcation of *mathesis*.[28] Without responding in detail to Gauvin's fine essay and its central thesis, that early modern skill had to become synonymous with technical subordination to enter a new era, I would simply like to point out that we need not to be restricted to two options, such as they are set up by the end of the article: that is, either we assume that Descartes was fascinated by the clocks and automated figures he encountered in grottoes or royal parks of his time, or we assume that he perceptively sensed the rise of French absolutism and therefore attempted to supply to it new tools.[29] In my opinion, order and regularity belong by definition, and design, to the life of these objects. There is no necessity to see a disjunctive logic between two orders of magnitude: *habitus* and *scientia* give the impression of an unusual pair, but it is part of the 'timely' nature of an automaton to rehearse the proficiency needed to join the ranks of *honnêtes hommes*. Put

it shortly, automata occupy a middle ground between very small and very big; or, perhaps better, the small and the big are in synchrony with one another.[30]

By ascribing a cunning dimension to automata and by defending, in this sense, a long-term view of them as a science of wonders, however, I do not wish to claim that the production of these mechanical devices depended on the kind of unconstrained, "venatic methodology" which William Eamon once characterized as a combination of wit, quick judgement, and practical skill.[31] It was not to chase venatic clues or material signatures that Regiomontanus presented Maximilian I in Nuremberg with an iron eagle that could actually fly; or that another avian automaton, a peacock listed in the inventory of Rudolf II's Kunstkammer (1607-11) squawked and fanned real, charmingly Habsburg feathers.

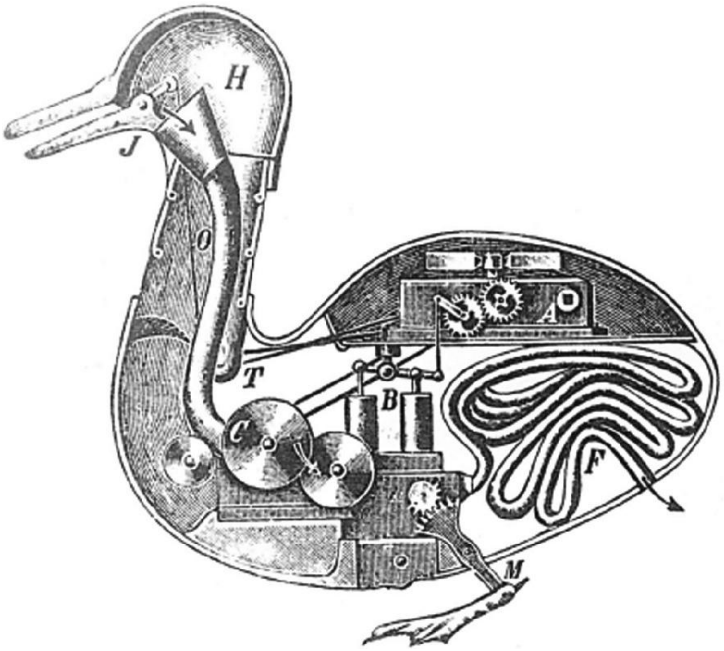

Fig. 1: Jacques da Vaucanson, Automaton of the "digesting" duck, 1739; public domain

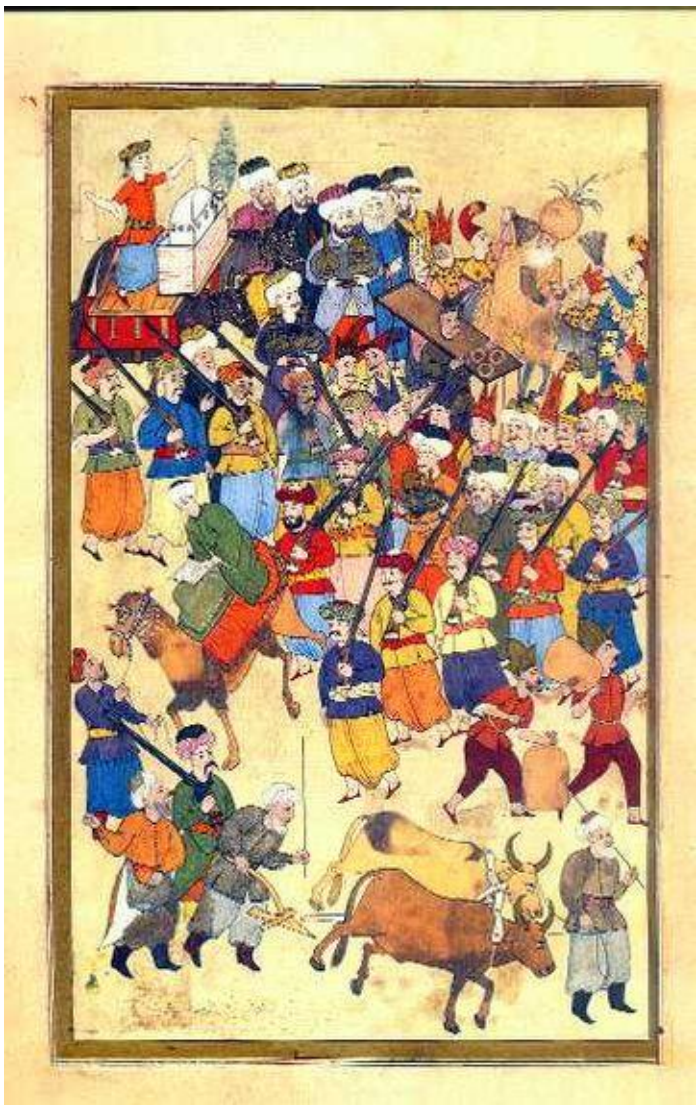

Fig. 2: Parade of the guilds in 1582, Topkapi Museum; public domain

Many historians, ranging from Horst Bredekamp to Alexander Marr, and Jessica Keating, have stressed that automata were the crowning point of a universal history that Kunstkammern embodied and further, that access to them was limited and restricted to a well-educated, courtly audience.[32] The similarities I have posited between the micro and macro scales are also operative in the comparative set of issues originating from the constructive ambivalence of intimacy and empire within the history of automata. A great example of this is the imperial circumcision festival of

1582, organized on behalf of the son of Sultan Murad III (r. 1574-1595) and celebrated in more than a dozen European accounts, both imperially commissioned and unofficial, visual and textual (ill. 2).[33]

For us to properly visualize the lavish display of Ottoman automata at the event it is necessary to reflect on four levels of experience: (i) everything was as carefully staged and rehearsed as to leave nothing to chance, to the effect that any 'absence' or 'presence' was made to be equally conspicuous; (ii) the set pieces themselves were, as in the case of a "moving" table with drinking trays, an expression of the guild system and coffeehouse culture (public male spaces);[34] (iii) given the inability to instigate their own locomotion, the automata relied on groups of assistants ceaselessly assigned to the representational schedule; (iv) a clear-cut distinction between a sense of ownership or indeed authorship on one side and a sense of consumption on the other was probably not available at this time. These combined observations suggest that it would be prudent to think of the 1582 festival as a hybrid "trading zone" made to resemble, but also to efface, the ceremonial architecture (i). Point (iv) further implies that plates or rubrics of man-made artificialia were always meant since the conception of the event to be itemized or travel beyond the Ottoman world, not unlike glass or exotic textiles;[35] as a consequence it is not so obvious that the automata showcased their lifelike quality or, for that matter, too, that they were engaged and uniquely tied to a specific climate in the courtly life which produced them[36] or to direct political messages to convey which of course exceeded the royal circumcision itself.

And while point (ii) seems to demarcate a certain degree of "non-knowledge" and lack of translatable socio-economic structures between the host and his guests,[37] point (iii) is remarkably clear in underlying that the vivification of the automata was attended by artisans and their proxies in a cyclic, multifaceted flurry of running and rewinding. It also clarifies that the agency of this major episode of Renaissance automaton-making is not dominated or preempted by someone in a position of power, as historians generally assume,[38] but rather by envoys and knowledge-brokers of various stripes.[39]

Religious, political, and technological facets mingled into a kaleidoscope in 1582, perhaps like the joyous entry of an early modern ruler into a city during a public festivity or an approved rite of passage. Without a doubt, the 'palimpsestic' features of this event were actively reinforced by rhythmic or sonic cues and by many other sensorial devices, including processional ones.[40] Where does all this leave us with regards to the automata? My contention here would be that, as polytemporal objects of study, automata function better at the mid-level: if we stand at twenty-five centimeters or at five meters from their historical context we may miss them anyway. Instead of speculating over their ability to harness power and mimetic technology, we should try to reinsert them in the stable yet oscillatory long term which is particularly visible in the Mediterranean case. Automata are neither a naive enactment of precise desires nor a signpost of 'Weberian' archetypes of gift-giving.[41] (Some of them in fact were never reciprocated because they were so hard to make in the first place.) Histories of automatic artificiality are bound to remain blurry and perspectival. But within these constraints it makes sense to see automata as the next section proposes

like "portable archeologies" and like treasures of immense possibilities for the history of knowledge and for students of information management.

3. Three unconventional directions: space, senses, enchantment

Michael John Gorman and Nick Wilding have studied the mechanical marvels of Athanasius Kircher in Rome, and those of his one-time German assistant, Kaspar Schott (1608-1666).[42] The superficial impression for the reader is that of an extravagant affair. But both Kircher and Schott availed themselves of numerous mathematical manuscripts kept in the *Collegio romano* and assembled by a famous German astronomer, Christoph Clavius, and his Austrian successor, Christoph Grienberger; in addition they also started to amass a large number of machines, which were later listed in a catalogue of Kircher's museum published by Giorgio de Sepibus in 1678.[43] This list comprises many automata: astronomical clocks and cogwork, hydraulic and magnetic-hydraulic conceptions, and a perplexing "water-vomiting" figure. Gorman and Wilding bestow careful attention to the sensual pleasures provided by Kircherian machines. They also comment at some length on the intellectual network displayed by this catoptric chest of automatic wonders:

> [f]or Kircher and Schott the manipulation of animals and automata was apparently a symbolic means of reinforcing, or trying to reinforce, the increasingly fragile political and philosophical status quo that aligned Vienna with Rome as the twin magnetic poles of a Catholic empire.[44]

There are many lessons to take away from this example. To begin with, the trajectory of Kircher's automata shows how these mechanical inventions were discarded by the main bedrock of natural philosophy, which by then was firmly entrenched in the experimental method, and continued their life chiefly as an exploration of the "secrets of nature" or an extravagant appendix.[45] It appears, moreover, that beyond signalling political brokerage automata allowed to display and even 'methodize' spatial displacement through artificial life.[46] As one reads in Schott's 1655 letters to Kircher, the Jesuits at Mainz were eager to receive Queen Christina of Sweden, who would later visit Kircher's museum in Rome.[47] More to the point, Mainz, Rome and Würzburg effectively functioned like the poles of a split laboratory, whose epistemic protocols were at least partially pivoted on automata.[48] Finally, the analysis of Kircher's automata clearly benefits from a consideration of these machines as an ensemble and within, not outside, the history of collecting.

Overall, these reflections constitute a first direction of research concerning early European automata and culminating in a notion of space (which I would prefer over the idea of territoriality).[49] Not only were these objects made up by puzzling parts, like wood inlays, brass or metal, but they were also charged with different goals, such as defense, entertainment, or time-keeping. One of these tasks was to mark the passage of space.

It is not often remarked that one could apply to automaton-making Leon Battista Alberti's dictum that what makes a monument impressive is a stone that comes from abroad, and especially if it "has been conveyed along a difficult route".[50] In a tradition of studies that prefers to look at automata in isolation or one by one, and that emphasizes the effects at the expense of mechanisms and mobility, it might be quite useful to apply the notion of "portable archeology" which is a vector of aggregation and radiates cultural energy from the field of Mediterranean studies.[51] Aligned with this view is a second research strategy to which I already alluded before, in relations to the synesthetic and acoustic byproducts of Ottoman automata. It would be intelligent to use histories of the senses to study early modern automata because these devices blur the boundaries between subject and object and ultimately lead to fuzziness and performativity within their own cultural heritage.

The third and last reflection has to do with a controversial notion of technological enchantment applied to archival studies (as anticipated earlier in this introduction).[52] In addition to contributing to a more fruitful merging of 'microhistorical' and global trends I would like to reinstate automata as a leading feature of early modern information, not only because of the mechanics of mobility,[53] but also to see how external and Braudelian constraints such as rivalry, commerce, and postal service have shaped automatic life and to continue to build upon Voskuhl's insistence on *habitus* over simulation of live bodies, which means shifting the discourse toward affective bodily practices and their tissues of geopolitical concern. There is, of course, more to be said about the possibility of turning the 'cleverness' of these objects into a cognitive instrument for the history of media. In a recent study, the classical art historian Verity Platt analyzes a massive votive offering of the Orneatai at Delphi which is highly suggestive for the way in which the skills involved could transcend figuration and gender, but also the contractual limitations of the initial vow.[54]

Platt's technique of substituting the idea of clever device, or *sophisma*, with that of a cognitive artifact is quite useful for the history of automata, as well, and it translates in modern terms the inevitable asymmetries of power and status of her objects of study. Perhaps, the combination of enchantment and archival tools might turn the historian's attention to automaton-making as an organic unit: digging into buried deposits and vast assemblages like the ones listed for ambassadors, pashas and other such intermediaries. The complex negotiations and performative infrastructures of automata emerged largely in conjunction with acts of communication and preoccupations related to their storage.[55]

4. Engaging with the present papers

In the extreme variety of critical approaches, which this introduction could only touch upon, there is no need to read the papers collected here as a direct exemplification of the methods and directions I have just discussed. Nonetheless, Lily Filson's article on "Reformation England and the Performance of Wonder" has the distinctive advantage to focus on a 'transfer of technology' which is primarily related to the engineers who made the travel (in her case, experts from the Medici court in Florence). That is an aspect that is foregrounded in much of the literature I have cited

so far. Another interesting feature of Filson's work is the use of different media: literature, theatrical performance, plans or drawings. The proliferation of mechanical animation is inscribed in a heavy confessional debate. While these English automata repossessed some thaumaturgical power that was evacuated from crucifixes and living saints, Vera Keller's brief response paper, "Living Machines in the Early Stuart Court", further emphasizes two elements: the participatory nature of automata and their insertion into a higher environmental sphere. In this way, pneumatic technology achieves a privileged view of 'macrocosmic' features, as well as a point of access into the workings of selves and embodiment within a landscape.

With Miguel Palomo's paper "Christiaan Huygens's *Cosmotheoros*" (a text which was recently revalued, from a different a more narratological perspective, by Frédérique Aït-Touati's *Fictions of the Cosmos*) we move from technological know-how to a much more metaphorical understanding of the automaton, namely, seen here as a shorthand for a mechanical conception of the universe. Against this illustrious tradition, which was represented by Dijksterhuis, among others, Palomo insists that we need to balance off Huygens's mathematical and astronomical pursuits through the lenses of theology and anthropology. This idea takes us to Vittoria Feola's essay "Talismans as Machines", with which the reader explores something about the 'tools' used also by the aforementioned "observers of the cosmos"; many of them, as it turns out, are philological. Feola's paper is self-consciously predicated on a risky premise, that talismans could be seen as proper automata. That allows her first to enter into a seventeenth-century French debate on the study of nature, and second to present Jacques Gaffarel as, at once, a erudite, a libertine, and particularly as a competent Hebraist, recognized as such in his own milieu.

Simon Dumas Primbault's essay "An Ink-and-Paper Automaton" closes the circle and takes us back to the cognitive aspects of mechanization. Specifically, the paper takes a close view of the unpublished *De affectibus*, a manuscript written by Leibniz in Lower Saxony, and proposes to identify in the act of 'jotting thoughts' a link to computational metaphysics. Dumas Primbault's argument by design is larger than Leibniz. It considers paper technology and therefore the angle into early modern automata resonates with the introduction's focus on blind thinking and bureaucratic routines as shaping forces.

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References

[1] As an example of the cross-fertilization the subject demands, I myself wrote an entry at the intersection of Aristotelian theory and geopolitical ceremonial: Gulizia, S., "Automata", in *Encyclopedia of Renaissance Philosophy*, ed. M. Sgarbi (Cham: Springer, 2016), https://doi.org/10.1007/978-3-319-02848-4_900-1.

[2] See especially Stoler, A.L., *Along the Archival Grain. Epistemic Anxieties and Colonial Common Sense* (Princeton: Princeton University Press, 2009).

[3] Yale, E.R., *Sociable Knowledge: Natural History and the Nation in Early Modern Britain* (Philadelphia: University of Pennsylvania Press, 2016).

[4] I am citing from the introduction of Walsham, A., Peters, K., and Corens, L. (eds.), *Archives and Information in the Early Modern World* (London: British Academy, 2018), 16; see also Friedrich, M., *Die Geburt des Archivs: eine Wissensgeschichte* (Munich: Oldenbourg, 2013).

[5] Wolfe, J., *Humanism, Machinery, and Renaissance Literature* (Cambridge: Cambridge University Press, 2004).

[6] Roux, S., and Garber, D. (eds.), *The Mechanization of Natural Philosophy* (Boston: Springer, 2012).

[7] Shapin, S., and Schaffer, S., *Leviathan and the Air-Pump: Hobbes, Boyle, and the Experimental Life* (Princeton: Princeton University Press, 1989).

[8] An extreme, but certainly not eccentric, case is the quasi-liturgical handling of Protestant handwritten records and scribal artefacts; Rublack, U., "Grapho-Relics: Lutheranism and the Materialization of the Word", in *Relics and Remains*, *Past & Present* Supplement 7, ed. A. Walsham, (Oxford: Oxford University Press, 2010), 144-166, proposed to think of them as 'enchanted matter' with peculiar preservation strategies.

[9] Deictic surveying and something resembling a form of collective accountability of the experimental observation is what the adjective "scientific" today means, according to the insightful remarks of Latour, B., "The Netz-Works of Greek Deduction", *Social Studies of Science* 38 (2008): 441-459. While Latour here is commenting, rather perceptively, on the coalescing vogue of "epistemic" images, a classic example of the context-dependent style is Findlen, P., "Controlling the Experiment: Rhetoric, Court Patronage, and the Experimental Method of Francesco Redi", *History of Science* 31 (1993): 35-64; among the many other examples one could bring out here, recently Avxentevskaya, M., "The Spiritual Optics of Narrative: John Wilkins's Popularization of Copernicanism", *Journal of Literature and Science* 8 (2015): 1-16, also derives lunar discovery to argumentative and rhetorical practices. Conversely, a classic study of the typology I would identify with the microhistorical method is Gaulke, K., "Perfect in Every Sense: Scientific Iconography on an Equation Clock by Jost Bürgi and the Self-Understanding of the Astronomers at the Kassel Court in the Late 1580s", *Nuncius* 30 (2015): 37-74.

[10] De Vries, J., "Playing with Scales: the global and the micro, the macro and the nano", in *Global History and Microhistory*, *Past & Present* Supplement 14, ed. J.-P. A. Ghobrial (Oxford: Oxford University Press, 2019), 23-36, at p. 30. In his advocacy of a judicious aggregation of microhistory and global trends, De Vries is building on the previous and useful distinction between microhistory as a 'test' and as a 'bottom up' technique by Trivellato, F., "Is There a Future for Italian Microhistory in the Age of Global History?", *California Italian Studies* 2 (2011): 10.

[11] Occasionally, the opposite occurs: as in the case of the spectacular, if over-ambitious, framing of Fleming, J.D., *The Mirror of Information in Early Modern England: John Wilkins and the Universal Character* (Cham: Palgrave MacMillan, 2017), which shuttles from a patient work of historicization to a sweeping account of communicative abridgement, up to our digital and noise-free dreams.

[12] I am orchestrating these two elements, mechanical engineering and performance, in my upcoming essay on the role of analogy in Kepler's thought: Gulizia, S., "Truth and Testimony in the Seventeenth Century: A Keplerian-Artisanal View", *British Journal for the History of Mathematics* (forthcoming).
[13] See at least Cambiano, G., "Automaton", *Studi storici* 35 (1994): 613-633, Bynum, C., "Wonder", *The American Historical Review* 102 (1997): 1-27, and Tkaczyk, V., *Himmels-Falten: zur Theatralität des Fliegens in der Frühen Neuzeit* (Paderborn: Wilhelm Fink, 2011).
[14] As correctly indicated by Kang, M., *Sublime Dreams of Living Machines: The Automaton in the European Imagination* (Cambridge, MA: Harvard University Press, 2011).
[15] For curiosity and travel, see Bertucci, P., *Viaggio nel paese delle meraviglie. Scienza e curiosità nell'Italia del Settecento* (Turin: Bollati Boringhieri, 2007) and "Enlightened Secrets: Silk, Industrial Espionage, and Intelligent Travel in 18th-Century France", *Technology and Culture* 54 (2013): 820-852; for the epistemology of craft, Bertucci, P., *Artisanal Enlightenment: Science and the Mechanical Arts in Old Regime France* (New Haven: Yale University Press, 2017).
[16] It should be emphasized that this view is insisted upon by Voskuhl, A., *Androids in the Enlightenment: Mechanics, Artisans, and Cultures of the Self* (Chicago: Chicago University Press, 2013), who argues against the idea of seeing them as simulations of live bodies defended by Riskin, J., "Eighteenth-Century Wetware", *Representations* 83 (2003): 97-125; see also, more recently, Riskin's book *The Restless Clock. A history of the centuries-long argument over what makes living things tick* (Chicago: University of Chicago, 2016). Voskuhl's point is important but often neglected by other historians.
[17] Schaffer, S., "Enlightened Automata", in *The Sciences in Enlightened Europe*, ed. W. Clark, J. Golinski, and S. Schaffer (Chicago: Chicago University Press, 1999), 126-165.
[18] Bertucci, P., (2017), 193-205.
[19] Bertucci, P., (2017), 204.
[20] Marr, A., "Understanding Automata in the Late Renaissance", *Journal de la Renaissance* 2 (2004): 205-222. See also Jaeger, M., *Archimedes and the Roman Imagination* (Ann Arbor: University of Michigan Press, 2008).
[21] Netz, R., *The Shaping of Deduction in Greek Mathematics: A Study in Cognitive History* (Cambridge: Cambridge University Press, 2003), p. 310.
[22] Netz, R., (2003), 293. See also Tybjerg, K., "Wonder-making and Philosophical Wonder in Hero of Alexandria", *Studies in History and Philosophy of Science* 34 (2003): 443-466, and Berryman, S., "Ancient Automata and Mechanical Explanation", *Phronesis* 48 (2004): 344-369.
[23] Lüthy, C., and Smets, A., "Words, Lines, Diagrams, Images: Towards a History of Scientific Imagery", *Early Science and Medicine* 14 (2009): 398-439.
[24] On Zilsel, see at least the retrospective of Krohn, W., and Raven, D., "The 'Zilsel Thesis' in the Context of Edgar Zilsel's Research Programme", *Social Studies of Science* 30 (2000): 925-933; with regards to bodily practices, the seminal study of Smith, P., *The Body of the Artisan. Art and Experience in the Scientific Revolution* (Chicago: Chicago University Press, 2004) has found by now legions of followers, with the risk of having become, unwillingly, the "new" orthodoxy of seventeenth-century philosophy.
[25] I have chosen the following essays simply on grounds of personal preference: Wakefield, A., "Leibniz and the Wind Machines", *Osiris* 25 (2010): 171-188; Vermij, R., "Instruments and the Making of a Philosopher: Spinoza's Career in Optics", *Intellectual History Review* 22 (2013): 70-94.
[26] Cottingham, J. (ed.), *Descartes' conversation with Burman* (Oxford: Oxford University Press, 1976), 44 (emphasis mine).

[27] Werrett, S., "Wonders never cease: Descartes's *Météores* and the rainbow fountain", *The British journal for the history of science* 34 (2001): 129-147.
[28] Gauvin, J.-F., "Artisans, Machines, and Descartes's *Organon*", *History of Science* 44 (2006): 187-216.
[29] Gauvin, J.-F., (2006): 203.
[30] I agree with the criticism of Mukerji, C., *Impossible Engineering: Technology and Territoriality on the Canal du Midi* (Princeton: Princeton University Press, 2009) offered by Broman, T., "Working Knowledge: Technical Practices, Social Identities, and Expertise in Early Modern Europe", *Historical Studies in the Natural Sciences* 44 (2014): 80-89, especially at p. 88. Mukerji says that the Canal du Midi was a *big* project; but the 'overwhelming' and the 'dwarfing' are assumptions that could have been easily superimposed onto professional credentials, for example those of German automaton-makers in Kassel or Prague. All projects of any serious consequence therefore could be considered "impossible" simply because one can never be sure if the people employed knew what they were doing. Similarly, I would say, automata do not ensure stewardship towards the state or a "system of impersonal rule".
[31] Eamon, W., *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture* (Princeton: Princeton University Press, 1994).
[32] Here I am using as the main reference of these debates in the history of art the latest book by Keating, J., *Animating Empire: Automata, the Holy Roman Empire, and the Early Modern World* (University Park: The Pennsylvania State University Press, 2018): and, specifically, I am paraphrasing a quote from p. 15, and implicitly questioning if the "gulf" that separates the synchronic life of automata is as steep and unsurmountable as she put it (p. 7), and likewise that the only intelligibility of these instruments lies in the courtly culture where they were produced.
[33] See at least Terzioglu, D., "The Imperial Circumcision Festival of 1582: An Interpretation", *Muqarnas* 12 (1995): 84-100.
[34] See Sajdi, D., *Ottoman Tulips, Ottoman Coffee: Leisure and Lifestyle in the Eighteenth Century* (London: Bloomsbury Academic, 2014), and Hattox, R.S., *Coffee and Coffeehouses. The Origins of a Social Beverage in the Medieval Near East* (Seattle: University of Washington Press, 1985).
[35] Hanss, S., "Material encounters: Knotting Cultures in Early Modern Peru and Spain", *The Historical Journal* 62 (2019): 583-615.
[36] As I explained earlier, this is a foundational obsession of those who apply microhistory to automata and end up with heavily-contextualized readings of them. At one extreme the tendency is to consider automata as the peak of historical embodiment, a physical manifestation of the "demonic", or of other organic theories, such as the Paracelsian fusion of art and nature; another tendency is to cleanse automata of all cultural construction and favor the view that they collapsed the distance between the viewer and the object. Either way, perhaps because automata are taken to be self-conscious, the result is that they make sense only if embedded at the heights of a confessional crisis, a political threshold, or a communicative anxiety. See the essays collected by Hyman, W.B., *The Automaton in English Renaissance Literature* (Farnham: Ashgate, 2011) for these trends, and for more on distance as an 'ecological assembling' see Easterby-Smith, S., "Recalcitrant Seeds: Material Culture and the Global History of Science", in Ghobrial, J.-P. A., (2019), 215-242.
[37] The reasonable caution advocated by Brendecke, A., *Imperio e información, funciones del saber en el dominio colonial español* (Madrid-Frankfurt: Iberoamericana, 2012), and Zwierlein, C., *Imperial Unknowns: The French and British in the Mediterranean, 1650-1750* (Cambridge: Cambridge University Press, 2017) applies here as well.
[38] To make only one example: Keating, J., (2018), 2.

[39] See Beihammer, A., Parani, M., and Schabel, C. (eds.), *Diplomatics in the Eastern Mediterranean 1000-1500: Aspects of Cross-Cultural Communication* (Leiden-Boston: Brill, 2008), and Rothman, N., *Brokering Empire: Trans-Imperial Subjects between Venice and Istanbul* (Ithaca: Cornell University Press, 2014).

[40] For a post-Habermasian view of urban space in their interactive awareness with early modern print and information, see Rospocher, M., *Beyond the Public Sphere: Opinions, Publics, Spaces in Early Modern Europe* (London: Duncker & Humblot, 2012); the importance of thinking with sound and acoustic research has been stressed by various authors, and most recently by Sterne, J., *The Audible Past: Cultural Origins of Sound Reproduction* (Durham: Duke University Press, 2003), Butler, S., and Nooter, S. (eds.), *Sound and the Ancient Senses* (London: Routledge, 2018), and Birdsall, C., and Tkaczyk, V., "Listening to the Archive: Sound Data in the Humanities and Sciences", *Technology and Culture* 60 (2019): 1-13.

[41] The literature on the topic is extensive; here I privilege a long-term approach: see Cutler, A., "Gifts and Gift Exchange as Aspects of the Byzantine, Arab, and Related Economies", *Dumbarton Oaks Papers* 55 (2001): 247-278, Behrens-Abouseif, D., *Practising Diplomacy in the Mamluk Sultanate: Gifts and Material Culture in the Medieval Islamic World* (London: I.B. Tauris, 2014), and Nechaeva, E., *Embassies - Negotiations - Gifts. Systems of East Roman Diplomacy in Late Antiquity* (Stuttgart: Franz Steiner Verlag, 2014).

[42] Gorman, J., and Wilding, N. (eds.), *La "Technica curiosa" di Kaspar Schott* (Rome: Edizioni dell'Elefante, 2000).

[43] See Asmussen, T., *Scientia Kircheriana: Die Fabrikation von Wissen bei Athanasius Kircher* (Affalterbach: Dydimos Verlag, 2016).

[44] Gorman J. and Wilding, N., (2000), 264.

[45] See Laird, W.R., *The Unfinished Mechanics of Giuseppe Moletti* (Toronto: University of Toronto Press, 2000), 7-28. By saying this, I do not mean to suggest that Kircher was anachronistic or that automata should be dismissed as an esoteric and erudite chapter. Far from it: it is more than reasonable to assume that mechanical contrivances were part of a programme which the Society of Jesus saw as fitting across a fragmented and warring Europe and which they carefully kept separate from the mainstream language of experimentalism. See on this Waddell, M.A., "The World, As It Might Be: Iconography and Probabilism in the *Mundus subterraneus* of Athanasius Kircher", *Centaurus* 48 (2006): 3-22.

[46] On the spatial dimension of automata see Truitt, E.R., *Medieval Robots: Mechanism, Magic, Nature, and Art* (Philadelphia: University of Pennsylvania Press, 2016), who also develops an interesting narrative of foreignness.

[47] Garstein, O., *Rome and the Counter-Reformation in Scandinavia. The Age of Gustavus Adolphus and Queen Christina of Sweden, 1622-1656* (Leiden-Boston: Brill, 1992).

[48] Distributed cognition in early modern laboratories needs to be studied more. Here I specifically have in mind the work of Hans-Jörg Rheinberger, of whom see at least *Toward a History of Epistemic Things: Synthesizing Proteins in the Test Tube* (Stanford: Stanford University Press, 1997), and "Experimental Systems - Graphematic Spaces", in Lenoir, T. (ed.), *Inscribing Science: Scientific Texts and the Materiality of Communication* (Stanford: Stanford University Press, 1998), 285-303.

[49] See note 31.

[50] Alberti, L.B., *On the Art of Building in Ten Books*, trans. J. Rykwert (Cambridge-London: MIT Press, 1989), 25. In terms taken from post-processual archeology, this means that we start by recognizing the properties rather than the materiality that makes the automata: see Ingold, T., "Materials against Materiality", *Archaeological Dialogues* 14 (2007): 1-16.

[51] See especially Necipoğlu, G. "Connectivity, Mobility, and Mediterranean Portable Archaeology", in *Dalmatia and the Mediterranean*, ed. A. Payne, (Leiden-Boston: Brill, 2013), 313-381, and Iafrate, A., *The Wandering Throne of Salomon: Objects and Tales of Kingship in the Medieval Mediterranean* (Leiden-Boston: Brill, 2015).

[52] See the discussion of Gell, A., "The Technology of Enchantment and the Enchantment of Technology", in *The Art of Anthropology* (London: Berg, 1999), 159-186, and Young, M.T., "Enchanting Automata: Wilkins and the Wonder of Workmanship", *Intellectual History Review* 27 (2017): 453-471.

[53] Nelles, P. "*Cosas y cartas*: Scribal Production and Material Pathways in Jesuit Global Communication", *Journal of Jesuit Studies* 2 (2015): 421-450.

[54] Platt, V., "Clever Devices and Cognitive Artifacts: Votive Giving in the Ancient World", in *Agents of Faith: Votive Objects in Time and Place*, ed. A. Payne, (New Haven: Yale University Press, 2019), 141-157.

[55] Cevolini, A. (ed.), *Forgetting Machines: Knowledge Management Evolution in Early Modern Europe* (Leiden - Boston: Brill, 2016).