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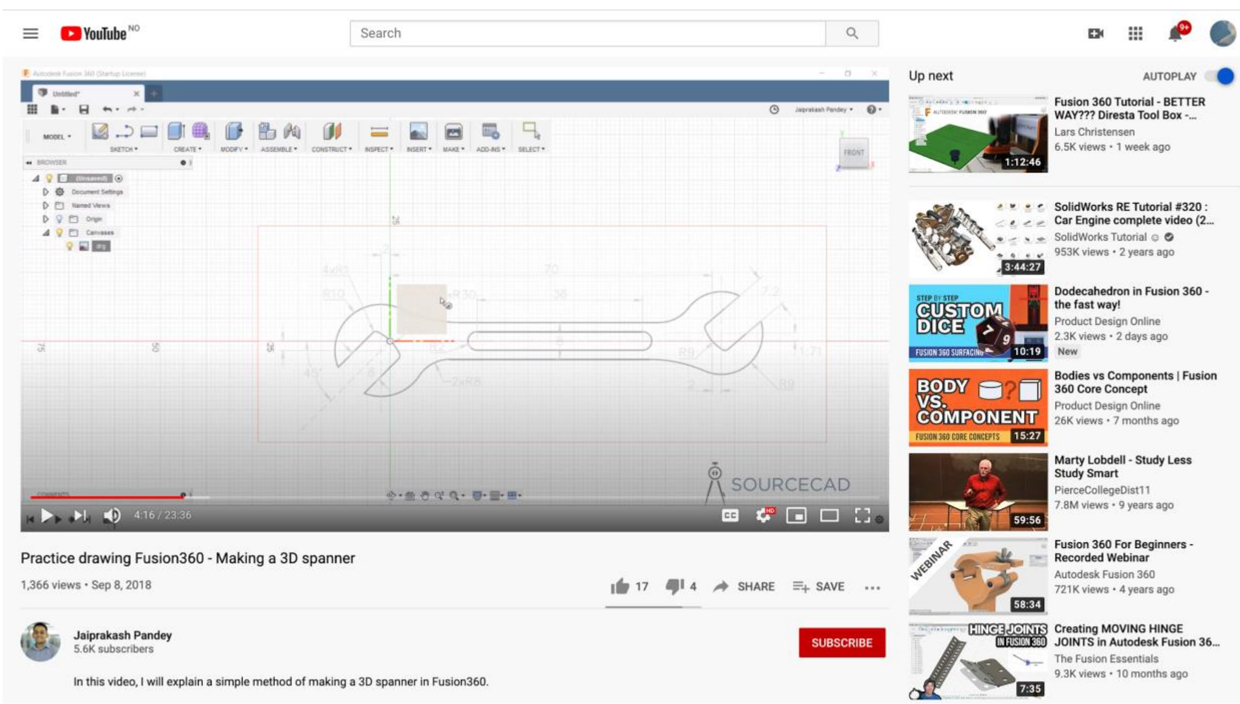
Snap to Grid

Abstraction, nonconscious cognition and cognitive assemblages in 3D modeling



A YouTube tutorial on how to 3D model a spanner

In this essay I will explore how N.Kathrine Hayles' concepts of nonconscious cognition and cognitive assemblages can be useful for analyzing 3D modeling software, a tool used in practices ranging from science and medical industries, to film, gaming, architecture, product development, maker culture and art. I will also use these concepts to reflect on the process of learning to work with 3D modeling tools, and at the informal YouTube channels on which such learning takes place.

Hayles introduces the concepts nonconscious cognition and cognitive assemblages in her book *Unthought: the power of the cognitive nonconscious*. In the prologue she explains how conceptualizing interactions between humans and technical systems can "enable us to understand more clearly the political, cultural, and ethical stakes of living in contemporary developed societies."[i] She describes *nonconscious cognition* as a kind of thinking without thinking, a capacity humans share with plants and technical systems, and defines *cognition* as "a process that interprets information within contexts that connect it with meaning"[ii]. She defines cognitive assemblages as "collectivities through which information, interpretations and meanings circulate"[iii] and gives examples of them such as traffic control systems, digital assistants and autonomous drones.

Applying Hayles' theories to the use of 3D modeling tools I will suggest that the abstraction process of digitizing a shape is a nonconscious cognitive process performed by 3D modeling software, and that this abstraction is a main attribute and primary reason for using 3D modeling tools. I will address how screens and user interfaces of 3D modeling tools constitute parts of the environment that their users are embedded in during their own nonconscious cognitive processes and connect this to what Hayles writes about hyper-attention and neurobiological changes in "the mindbodies of its users"[iv]. Moreover, I will contextualize these human and technical cognizers as actors in a larger cognitive assemblage constituted by 3D modeling technology, the people who use them, the platforms on which they circulate, and the industry built around it.

Finally, by telling the story of the computer graphics icon *The Utah Teapot,* I will draw lines between the abstraction occurring in the process of using 3D modeling tools and the standards and styles emerging in the software systems, communities that use them and what is made using them. I will argue that these standards are not only affecting these complex human-technical assemblages, but that they also make visible to us the situatedness of the actors within it.

I will write about this from my perspective as a sculptor using 3D modeling tools, and as a practice- based artistic researcher in visual art whose PhD project makes use of and reflects upon abstraction in 3D modeling technology.

Nonconscious cognition in 3D modeling

Defining cognition as "the interpretation of information within contexts that connect it with meaning" Hayles includes both technical systems, humans and other life forms in having this capacity.

Although technical cognition is often compared with the operations of consciousness (a view I do not share, as discussed below), the processes performed by human nonconscious cognition form a much closer analogue. Like human nonconscious cognition, technical cognition processes information faster than consciousness, discerns patterns and draws inferences and, for state-aware systems, processes inputs from subsystems that give information on the system's condition and functioning. Moreover, technical cognitions are designed specifically to keep human consciousness from being overwhelmed by massive informational streams so large, complex, and multifaceted that they could never be processed by human brains.v

In 3D modeling technology the most fundamental thing that the software does for us is to create a mathematical representation of a 3-dimensional object or shape. This abstraction process, the translation of an object or shape into x-y-z coordinates, I propose, is a nonconscious cognitive process performed by the software. It is an essential function, because it is what makes these forms readable by computers and convertible into other formats. That allows us to do things like digitally manipulate or animate the models, copy them, upload them to Thingiverse[vi] or send them as G-code to 3D printers or CNC machines. The digital fabrication machines can turn the 3D models into physical objects with high accuracy while using minimal manual labor and materials.

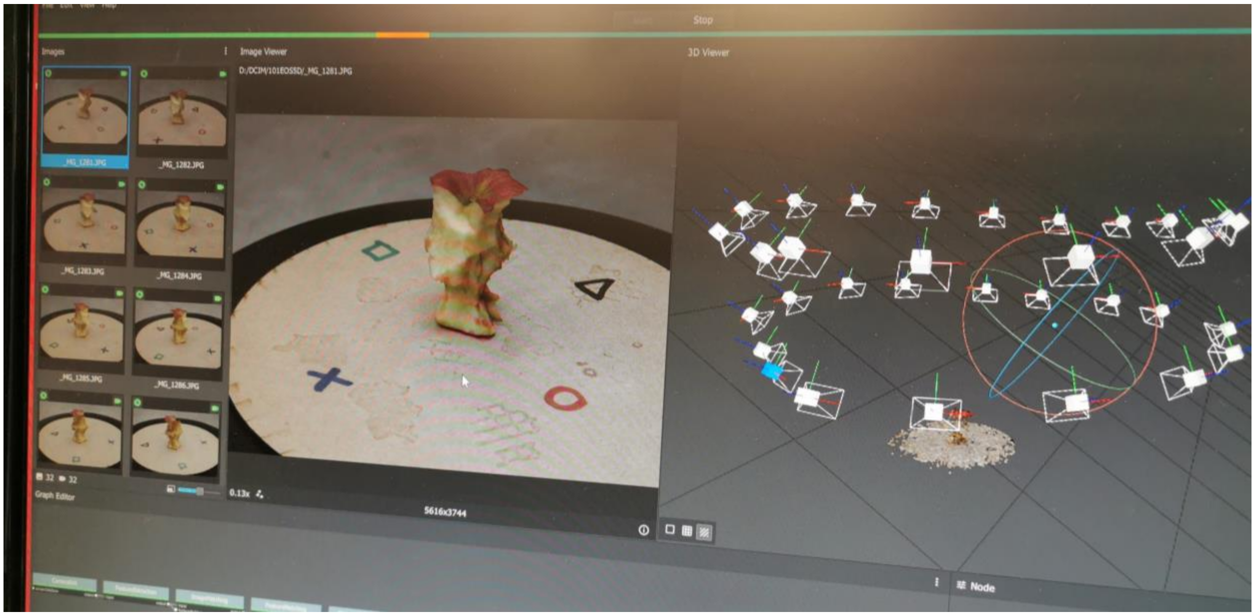


FIGURE 1- SCREENSHOT FROM PHOTOGRAMMETRY SOFTWARE MESHROOM

In what way technical co-cognizers assists me with making abstractions in 3D modeling, depends on what type of 3D modeling I am doing. I will use the examples of computer assisted drawing (CAD) and photogrammetry software to sketch out some of the main elements in this process.

When using CAD software hand gestures made with the mouse or keypad are registered as points in a coordinate system, which, if I enable it, will "snap to grid". This means that your drawing will lock onto a fixed coordinate system and that the lines and points are unable to move around until you delete this constraint[vii]. A gesture I have made with my hand has become a mathematical abstraction. Similarly, in the use of photogrammetry, a mathematical model is made from a physical object. Most of the object's material properties are lost on its way to the computer, such as smell, taste, temporality, surroundings, symbolic meaning and so forth. In the computer the object has taken on a new embodiment and a digital materiality, and is now expressed as a mesh of vertices, edges and surfaces.

Artist and researcher Rebecca Nadjowski describes translations between digital and non-digital materialities beautifully in a text on her artistic research project *Echo*, research involving photogrammetry scanning of plants in the botanical gardens of Melbourne: "Depth, texture, color and form of the plants along with the atmospheric conditions that affects the intensity of photons bouncing off of flora all become transformed. They move from a plane of environmental matter and force to a plane of digital materiality, where data is encoded and continually refigured and assembled as manipulatable, visual objects on a screen."[viii]

In the 3D modeling processes described above, we have externalized a human cognitive process to the technical noncoscious. It would take a really long time to measure and write down all the x-y-z coordinates of one of Nadiowski's flowers manually. That abstraction process is an example of something which can be done much more efficiently with the help from a co-cognizing camera/scanner and computer.

For humans, nonconscious cognition is based on input from our senses. Much of this information is not filtered onto consciousness, and it operates on a level below our different modes of awareness. As a sculptor I see this as a well-functioning description for my own engagement with tools, materials and spaces that make up a distributed cognitive system[ix] which allows an unplanned working process to happen. I am not consciously reflecting upon everything that goes on in my studio, but the environment I am in is affecting me and the work that I do. The screens, the mouse, keyboard and the 3D modeling software systems make up parts of this environment, and in the next paragraphs I will follow Hayles' in considering how working on screens might affect our thinking.

I have two screens with the software on my laptop and the YouTube tutorial on the second screen. On the YouTube screen I see the instructor and their recording, and I listen to their dense and technical explanations only relieved by short breaks of muzak, jingles and YouTube advertising. On the laptop I simultaneously navigate a user interface and face challenges such as finding menus in a version of the software that might be different from the one being demonstrated, finding tools in menu bars, changing user settings and remembering short cuts. I follow the instructor by copying what she makes as best as I can, and I constantly shift back to the YouTube screen to rewind and rewatch when it all goes too fast. This high-speed multitasking requires what Hayles calls *hyper attention*.[x] Hayles describes hyper attention as an ability to absorb information from many different places all at once without going into depth or focusing too long on one thing. Having this capability may be a necessary skill in a contemporary information-intensive society, or at least for a learner of 3D modeling. But as Hayles demonstrates, by referring to studies on neuroplasticity and epi-genetics[xi], it may come at the cost of our *deep attention*, the ability to concentrate on one single task over a longer period of time without losing focus. The simple neuroscientific explanation Hayles offers us is that when we do a thing often, we train neural connections in our brain to grow and strengthen based on this task, and by the same logic we "forget" the existing synapses that are not in use. This cognitive shift, which Hayles calls nothing less than a crisis in pedagogy for our colleges and universities, may be why I find it difficult to watch these tutorials through to the end, or to read a number of pages in a book without checking my phone.

YouTube tutorials as human-technical assemblages

When moving the perspective from individual actors over to the systemic effects of human-machine interaction, Hayles uses the term *cognitive assemblage*. In the following paragraphs I will examine the informal YouTube channels where teaching, learning and many people's first encounters with 3D modeling software takes place, as one of these complex human-technical assemblages.

Hayles describes a cognitive assemblage as "an arrangement of systems, subsystems, and individual actors through which information flows, effecting transformations through the interpretive activities of cognizers operating upon the flows. A cognitive assemblage operates at multiple levels and sites, transforming and mutating as conditions and contexts change."[xii] And moreover, "Hybrid by nature, they raise questions about how agency is distributed among cognizers, how and in what ways actors contribute to systemic dynamics, and consequently how responsibilities - technical, social, legal, ethical - should be apportioned."[xiii]

In a YouTube channel both human and technical actors are involved, such as the people who make YouTube tutorials, the 3D modeling program they use, the people who follow and comment on their tutorials, the laptops they work on, the user data collected when they work, the people and industry who develop the software systems, the designs and the knowledge that is being transmitted and the platforms on which the knowledge is shared. The assemblage is flexible and adaptable, it involves nonconscious cognitive processes performed by humans and technical systems as well as conscious thinking. It is based on material processes and it has concrete material outputs, such as a digitally fabricated thing or discarded plastic support materials from the 3D printer.

When learning to work with the 3D modeling software Fusion 360 I watched a lot of tutorials on YouTube, and I became curious about the people who make them, the unexpected things that they pick as exercise objects to demonstrate the software, the strange elevator music playing in the background and the active participation by their followers in the chat sections. It was especially the repeating occurrences that struck me, for example how the exercise object was often a practical, functional object, such as a wrench, a cup holder or knife, and how the instructor usually was white, male, and European or American. This cognitive assemblage had some standards within it, and I wanted to find out if they could have anything to do with the abstractions they are built with. That was one of the motivations behind the work *Holder* (2020), an artwork I made consisting of interactive sculptures and YouTube tutorials.

In the making of this work, I contacted three different YouTubers and asked them to create instruction videos where they demonstrate how to 3D model and fabricate sculpture designs I have made. In addition to commissioning these videos, I conducted short interviews with them to find out more about why they started making YouTube instructionals, what exampe objects they use and who watches their videos. One of the YouTubers, Sirisha Shashikanth, is a mechanical engineer from Hyderabad, India who runs the YouTube channel DesignSangam. After becoming a mother in 2007, Shashikanth needed to work from home to combine work and childcare. After working with making an online directory of kindergartens in India for some time, she started making online tutorials on 3D modeling. In that way she found a way to combine home office with her profession as a mechanical engineer, and she pursued a career as an online 3D modeling teacher. Shashikanth has been a speaker at several AutoDesk India events, and she is a role model for women aspiring to learn 3D modeling and work in the technology sector. Although the inequality of *who has access* - to a computer or the internet - reflects global economic and social inequalities, Shashikanth is an example of someone who contributes to breaking with stereotypes and diversifying cognitive assemblages in 3D modeling technology.

When I asked Shashikanth what kind of objects she used to demonstrate the software, she answered "real life components like pen stands, photo frames, keychains and what not."[xiv] This corresponds with the answer from Kevin Kennedy, who said that "Most of my beginner tutorials focus on "every day" or common household objects. I've found this to be beneficial as a greater number of students have a visual perception of the object. Things like screwdrivers, legos, etc… objects that are used globally."[xv] This fits with my own impression of what the standard exercise object is, as I modeled many digital wrenches while learning 3D modeling. To me these seemingly random objects at hand tell a story about the environment of the YouTube instructors, and in the following section I will look at how a similar "object at hand" once became one of the most iconic standard objects of 3D modeling.

Figure 2-screenshot from "how to make a utah teapot" (2016)

The Utah Teapot - a standard 3D model

The following anecdote from the early days of 3D modeling also served as a starting point for my artwork *How To Make a Utah Teapot* (2015), a 13 minute long video showing ceramic artist Anne Lise Karlsen wheel-throwing a ceramic copy of this computer graphics icon. The project began while learning the 3D modeling software 3DStudioMax, and being puzzled about a teapot sitting next to cubes, cylinders and spheres, as one of the "standard primitives"[xvi] from which to build compound shapes.

In the 1970s Sandra Newell bought a Melitta teapot in Salt Lake City which her husband Martin Newell, one of the pioneers in 3D modeling, brought to the lab and digitized at the Utah university.[xvii] He drew the teapot on graph paper and wrote down its x, y and z coordinates before making it available to download for free. This ready-made abstraction was especially welcomed by the people working in this emerging field of computer graphics who otherwise had to manually register the x-y-z coordinates of the objects they worked with. As 3D modeling technology advanced it also became apparent that the teapot had many attributes making it perfect for testing how the 3D modeling software works, such as a combination of convex and concave surfaces allowing the user to see how light bounces off the object in a virtual scene. Through its widespread usage in computer graphics the Utah teapot gained its status as a cyber-cultural icon, and it still remains in the standard shapes libraries of many 3D modeling software programs today. According to digital historian Jacob Gaboury the Utah Teapot "offers a lens through which we can better understand how computer graphics articulates and standardizes the object world."[xviii] In an interview about his forthcoming book *Image Objects*[xix], in which the teapot figures as one of five objects from the early history of computer graphics, Gaboury says that "While every year graphics seems to inch closer and closer to a kind of simulated realism, many of the algorithms and equations that structure computer graphics remain – like the teapot – unchanged over the fifty year history of the discipline."[xx]

I asked ceramicist Anne Lise Karlsen to make a porcelain version of the Utah Teapot based on an image, and I filmed her focused and skilled movements transforming a lump of clay into a teapot. It became taller and slenderer than the Utah Teapot, and to my surprise it looked much more like the original Melitta teapot which the Utah Teapot was based on. A couple of years after making the video, I came to learn that this was no coincidence. During a demonstration of their research in the 70s Newell and his associates presented how one could alter one of the digits in the dataset describing the teapot. They reduced the teapot's height by ¼ of the original height and decided that they liked this new look better. Thus, their aesthetic preference also became a decisive factor for one of the standard objects in computer graphics.

Following the thinking put forward by feminist STS scholar Donna Haraway in her seminal essay "Situated Knowledges"[xxi], the Utah Teapot is interesting because it demonstrates the non-neutrality of the tools and the people who develop them. Furthermore, it indicates that these human-technical assemblages are not deterministic, but situated in a geographical, temporal and cultural context. The other thing that the story of the Utah Teapot shows us is the significance of abstraction, and of externalizing this task to the technical nonconscious. In the next and final chapter I will reflect on connections between the process of abstraction and the creation of standards.

Abstraction and standards in 3D modeling

The etymological roots of abstraction is the latin "abstrahere", which means to draw away. Our ability to extract something from something else, to simplify complex phenomena into abstract concepts, is, according to Hayles, an essential component in all theorizing[xxii] and a capacity of higher consciousness[xxiii]. She describes it as a requirement for things such as creating language, which again is a precondition for making compound tools with continuously increasing complexity.[xxiv] When a 3D scanner registers point cloud data from an object, only information about its shape is saved. Most of the object's initial attributes are not accounted for when the scanning software turns the point cloud into mathematical abstractions. The abstractions that can be read by different types of software, manipulated in shape and size, and flow through different material embodiments. The 3D model can make it seem like the mathematical abstractions can take on any kind of materiality, that the information is indifferent to its material embodiment. The view of materiality and information as separate entities is a view that Hayles in her book How We Became Posthuman traces back to the cybernetics movement, and what she calls an ancient game of downplaying the importance of embodiment and material instantiation and privileging the abstract as the real. [xxv]

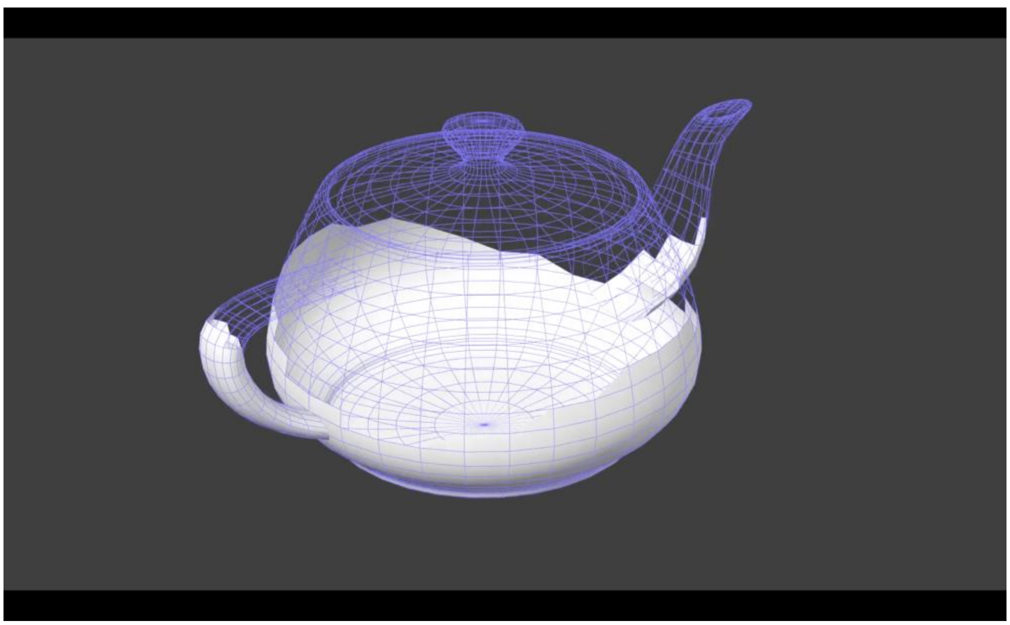


FIGURE 3- SCREENSHOT FROM "HOW TO MAKE A UTAH TEAPOT" (2016)

One of the attributes making The Utah Teapot useful for programmers was that it was a simple shape that could be described using relatively few coordinate points, producing a small file requiring little computational power. In some cases, standard objects are created specifically to challenge and improve the technology, as indicated from the rapidly increasing polygon count on the wikipedia page "standard 3D test models"[xxvi].

One of the objects on this list, the Benchy boat, is made with attributes that require the 3D printer to be calibrated correctly in order to get a successful print, and thus it can be used to adjust and find the best settings for your printer. 3D Studio Max, the software where I initially discovered the Utah Teapot, has for a long time been a market leading computer graphics software. One of its other standard primitives which seemed strange to me to consider a standard object, was the "ringwave". This is a disk with a parametric flower/star shape in the middle, made to animate explosions in the universe.[xxvii] The software systems themselves become "industry standards" and the companies are naturally competing to get in that seat. Recently the Swedish company Quixel, creator of the world's largest repository of 3D scans, was bought by the owner of the gaming engine Unreal Engine (UE). Quixel is founded on the aspiration of "speeding up how creators build digital environments, by giving them access to a vast and ever-expanding library of 3D building blocks, and easy-to-use tools to greatly simplify the creative process".[xxviii] Quixel is releasing new assets (3D models) on their website to downloadable for free *if* you are working in UE. These assets take about 6 days of professional, manual labor to create, making the download-for-free option a preferred one for game developers. Currently many of the beach rocks in virtual worlds originate in Tenerife, because that is where Quixel went to 3D scan maritime nature. Most likely one can soon download beach rocks that have been scanned all over the world, but this homogeneity in a rapidly developing technology reveals that these virtual worlds are built by zeros and ones. To round off this section on abstraction and standards in 3D modeling I will return once more Hayles'and How We Became Posthuman.

Abstraction is of course an essential component in all theorizing, for no theory can account for the infinite multiplicity of our interactions with the real. But when we make moves that erase the world's multiplicity, we risk losing sight of the variegated leaves, fractal branchings, and particular bark textures that make up the forest.[xxix]

Conclusion

In this text I have applied N. Kathrine Hayles' concepts nonconscious cognition and cognitive assemblages in a reflection around 3D modeling tools, the process of learning how to work with these and the informal platforms on which such learning takes place. I have suggested that the main function of 3D modeling software, the translation of an object or shape into a mathematical abstraction, is an operation we have externalized from human consciousness to the technological nonconscious. Based on Hayles' writing on neuroscience, I have proposed that when people are working with 3D modeling tools, engaged in nonconscious cognitive processes and absorbing information from an environment consisting of screens and user interfaces, this is rewiring our brains and creating lasting neurobiological changes. Moving the focus to the systemic and collective effects of human-3Dmodeling interaction by approaching it as a cognitive assemblage, I have looked at the YouTube channels that share how-to videos on 3D modeling and also at standards that emerge on these platforms and in these tools. By telling the story of the Utah Teapot I have speculated on the connections between the process of abstraction in 3D modeling software and the creation of standards. Whether these are wrenches, teapots, explosions in the universe or seaweed from Tenerife, these standards are interesting because they show the situatedness of the human-technical assemblages in which they are produced. More than that, they show how these standards are constantly influencing what is being made using these tools, the people who use them and the ones consuming its products, and ultimately how we look at the cognitive assemblages in which we take part.

Notes and references

[i] N.Kathrine Hayles. (2017). *Unthought: the power of the cognitive nonconscious*. Chicago and London. The University of Chicago Press. Prologue.

[ii] Hayles. Unthought, p 22.

[iii] N. Kathrine Hayles (personal communication, September 26, 2020) responding to followup question after *Technologies are Us* seminar.

[iv] Hayles. *Unthought*, p119

[v] Hayles. *Unthought*, p 11

[vi] Thingiverse is an online platform where people can upload and download 3D models for free and for purchase.

[vii] A constraint is a function you can place on a sketch element that keeps it in a fixed relation to other elements in the sketch.

[viii] Rebecca Nadjowski, Indeterminate, eco-media 2020 online conference hosted by Screen & Sound Cultures and the Critical Intimacies Reading Group at RMIT University, Australia. Accessed zoom recording via Youtube 1.Sept 2020 https://www.youtube.com/watch?v=-O_sMjD8l9I&t=4654s

[ix] Applying the term Distributed Cognitive System as used by Hayles in *Unthought,* p2.

[x] N. Kathrine Hayles. (2012). *How We Think*. Chicago and London. The University of Chicago Press, p 98-100

[xi] Hayles. *How We Think*, p 100

[xii] Hayles. *Unthought,* p118

[xiii] Hayles. *Unthought*, p119

[xiv] The interview with Sirisha Allamneni Shashikath can be found on https://www.unmakingabstractions.com/ua-txt

[xv] The interview with Kevin Kennedy can be found on https://www.unmakingabstractions.com/ua-txt

[xvi] Standard Primitives is the name of the basic building blocks in 3DStudioMax.

[xvii] Read about the story of the Utah Teapot at http://www.primarymaterials.org/blog/jacob-gaboury Primary Materials, 3.11.2020 or https://3dmodelinganimation.weebly.com/the-utah-teapot.html

[xviii]"Interview with Jacob Gaboury," Primary Materials (2017), eds. T. Asmussen, M. Buning, R. Kett, and J. Remond, www.primarymaterials.org. http://www.primarymaterials.org/blog/jacob-gaboury accessed 3.11.2020

[xix] Jacob Gaboury. (2021). *Image Objects: An Archaeology of Computer Graphics*. MIT Press.

[xx] Primary Materials blog, 3.11.2020

[xxi] Donna Haraway, "Situated Knowledges, The Science Question in Feminism and The Privilege of Partial Perspective" Published in *Simians, Cyborgs and Women,* 1991, Free Association Books, Great Britain.

[xxii] N.Kathrine Hayles. (1999). *How we became posthuman: virtual bodies in cybernetics, literature and informatics.* Chicago and London. The University of Chicago Press, p 12.

[xxiii] Hayles, Unthought, prologue p2

[xxiv] Hayles, *How We Think*, p 89-90

[xxv] Hayles, How We Became Poshtuman, p 13

[xxvi] On Wikipedia site "standard 3D test models" you find an overview of 3D models used to test functionality of 3D modeling software, scanners, printers and more. Polygons are triangles that the model is built up from, and as the technology and computational power has advanced over the years this number has increased drastically.

[xxvii] Autodesk Knowledge Network, https://knowledge.autodesk.com/support/3ds-max/learn-explore/caas/CloudHelp/cloudhelp/2016/ENU/3DSMax/files/GUID-8BAF8C36-9102-4A37-BEB2-472F1452E6C7-htm.html

[xxviii] Quoted from the "about" section on the company website https://quixel.com/about. Accessed 03.10.2020.

[xxix] Hayles. *How we became posthuman,* p 12.