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Patterning Recognition: Artificial Intelligence and the Problem of Perception in the Long Twentieth Century

by

Julia A. Irwin

A dissertation submitted in partial satisfaction of the

requirements for the degree of

Doctor of Philosophy

in

Film and Media

and the Designated Emphasis

in

New Media

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Associate Professor Jacob Gaboury, Co-Chair
Professor David W. Bates, Co-Chair
Class of 1939 Professor Anton Kaes
Professor Kristen Whissel

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Abstract

Patterning Recognition: Artificial Intelligence and the Problem of Perception
in the Long Twentieth Century

by

Julia A. Irwin

Doctor of Philosophy in Film & Media
Designated Emphasis in New Media

University of California, Berkeley

Associate Professor Jacob Gaboury and Professor David W. Bates, Co-Chairs

Patterning Recognition examines the concept of perception as it has co-evolved with the emergence and contemporary proliferation of artificial intelligence. I argue that "general intelligence," as it is described in debates regarding the implications of advancing AI, is fundamentally a perceptual issue. First, determining such thresholds in technological capabilities is contingent on our representational modes of evaluation, which are politically potent discursive objects. Second, the problem of how to approximate human perception in the computer has animated the history of artificial intelligence. And today's deep learning programs, though only loosely modeled after the human nervous system, acquire their learned complexity through exposure to data that represents a complex external world. Third, our AI-supported technologies entangle with human perception in increasingly indeterminate ways, for example in semi-autonomous military targeting systems and in instances of generative AI "art." Yet one of the fundamental limitations of artificial intelligence, as conceived by its designers today, is its incapacity to exhibit common sense. I disentangle this seeming paradox that perception is both phenomenal experience and technical program by tracing the intellectual debates and institutional programs that pursued the transformation from one into the other, and vice versa, and in doing so also revealed their elements that resist subsumption. I situate these conceptual refigurations within a political frame by analyzing how material uses of automation technologies have endeavored to make human and machine vision interchangeable, often in the name of expediency, in effect accelerating the speed of sight. I ask, under these conditions, how do we even recognize acts of (automated) recognition?

I address this question through a historical account that uncovers a uniting principle between twentieth-century ideas about organic perception, efforts to model it in a computer, and institutional programs to organize optical labor: an emphasis on vision's purposive quality. An Enlightenment penchant for *seeing to know* has lost favor to a neuroscience-informed *seeing to do*, effecting an enduring lack of clarity regarding the subject—or agent—of vision.

Patterning Recognition analyzes four key episodes through which the notion of perception as a machine-replaceable program of action both became conceivable and was frustrated. Part one, "Bodily Automaticity," examines the co-emergence of seemingly opposing concepts: human neural plasticity, scientific management, and industrial film in the 1910s, and theories of human affect and means-ends computer architectures in the 1960s. It reveals how the phenomena of the body that exist at the threshold of automaticity and perceptibility have also been framed as a limit case of computer automation. Part two, "Images and Interpretive Actors," examines efforts to translate image interpretation from a human to a computer activity, illuminating how James J. Gibson's "ground theory" of perception paradoxically informed both the U.S. government's development of AI-supported automatic targeting technology and empirical investigations into perception's role in the experience of novelty and collaborative world building.

For my parents,

Victoria and James

Contents

Acknowledgements……iii

Introduction……...1

Part One: Bodily Automaticity……16

Chapter 01
Couplings: Industrial Automation, Interactive Film, and Neural Organization……..17

Chapter 02
Conversions: Drives to Affects, the General Problem-Solver, and Metacommunication……..48

Part Two: Images and Interpretive Actors……78

Chapter 03
Objects: Nonhuman Targeting, Perceptrons, and Ecological Perception……..79

Chapter 04
Environments: Programmatic Reduction, Sensory Selection, and Recognizing Novelty……110

Conclusion……144

Bibliography……147

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—Introduction—

Patterning Recognition: Artificial Intelligence and the Problem of Perception in the Long Twentieth Century

Artificial intelligence in the twenty-first century presents a conceptual issue for the longstanding, predominant evaluative criterion in the field—the Turing test.[1] A legacy of Alan Turing's imitation game, introduced in 1950, this marker in its contemporary use measures whether the computer program can surpass human performance at a given task.[2] The objective among AI researchers today is to increase the degree of generality in artificial intelligence systems. For example, the centuries-old Chinese game Go has been a focal point for many in the field because, compared to chess, there are innumerable moves possible, and therefore winning requires novel gameplay. This is one way to distinguish an AI program from other, hard-coded algorithms: by the degree to which it can invent its own sequence of steps in achieving an objective, versus following an established, pre-coded way of solving a problem. Just as the game parameters are more open-ended, the skilled player's behavior in reaching its goals is, too, more unpredictable.[3] But despite Go's invitation for an exhibition of problem-solving along an indeterminate path, the game has a finite world of players and one clear objective—to beat the opponent.

Many of the contexts in which contemporary AI researchers imagine their technologies to participate are far more ambiguous with respect to objectives, however. Take, for example, an originary definition of "artificial general intelligence" (AGI), a term now part of our popular

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[1] See Alan Turing, "Computing Machinery and Intelligence," *Mind: A Quarterly Review of Psychology and Philosophy* 236 (October 1950): 433–460.

[2] The Turing test has been frequently referenced upon the release of OpenAI's ChatGPT and other large language model chatbots, as an evaluative measure that describes them as qualitatively of a different order than previous iterations of chatbots. See Celeste Biever, "ChatGPT broke the Turing test—the race is on for new ways to assess AI: Large language models mimic human chatter, but scientists disagree on their ability to reason," Nature 619 (July 25, 2023): 686–689, https://doi.org/10.1038/d41586-023-02361-7; "Study finds ChatGPT's latest bot behaves like humans, only better: The most recent version of ChatGPT passes a rigorous Turing test, diverging from average human behavior chiefly to be more cooperative," Stanford School of Humanities and Sciences, February 22, 2024, https://humsci.stanford.edu/feature/study-finds-chatgpts-latest-bot-behaves-humans-only-better; and Qiaozhu Mei et al., "A Turing test of whether AI chatbots are behaviorally similar to humans," Proceedings of the National Academy of Sciences (PNAS) 121, no. 9 (January 4, 2024), https://doi.org/10.1073/pnas.2313925121.

Alpha Go: https://deepmind.google/technologies/alphago/; https://deepmind.google/technologies/alphazero-and-muzero/

3 See, for example, Google DeepMind's AlphaGo, which is an AI program that in 2015 beat the then-world champion of Go: https://deepmind.google/technologies/alphago/. AlphaGo was trained on datasets containing millions of moves from actual games played by humans. DeepMind developed a subsequent program, AlphaZero, which learned through its own gameplay and information about the game's rules. DeepMind claims that "AlphaZero represents a crucial step towards creating more general systems": https://deepmind.google/technologies/alphazero-and-muzero/.

discourse. Proposed at a 1997 conference on the topic of nanotechnology and international security, its author describes AGI as "AI systems that … can be used to replace human brains … in tasks ranging from organizing and running a mine or a factory or piloting an airplane, analyzing intelligence data or planning a battle."[4] On one hand, we should note the conceit here that "intelligence" is confined to a brain, and that a brain and a machine are interchangeable entities. The focus on the brain as the unit to be replicated also indicates the author's orientation toward an ideal of abstract rationalization, toward processes immediately translatable to the logic gates, mathematical operations, and discrete input and output data required of any computer. On the other hand, implicit in the statement is a proposition that a brain is as a brain does—that this so-called intelligence is inseparable from the activities to which it is put to use. Further, the activities the definition references are *situated*; they involve perceiving and acting within complex and unpredictable environments, interacting with a number of social actors, and effecting change in politicized social contexts.

To evaluate an AI on its performance of these tasks, then, would require making a number of assumptions about how human beings undertake "running a mine," for example, when there are diverse ways to successfully do so and multiple perspectives on what counts as success. It would involve coming up with a systematized, singular paradigm for what mine management looks like. Such systematization in fact undermines the very project of generalization, on the AGI definition's own terms, as in the example of inventive Go gameplay. Even more urgent, though, is the very fact that these still-speculative AGIs are conceived as acting within environments with a great deal of social ambiguity and political stakes. In these situations, who or what is the arbiter of artificial general intelligence? If a research group were to achieve so-called AGI, how would we, collectively, recognize it as such?

This dissertation will argue that the way we represent the gap between human and machine "intelligence" is an organizing principle for the ways in which we make sense of, discuss, and shape our historical condition. Modulating the perceived gap between the two is often an effect of institutional activities that elicit technological innovation and capital accumulation, articulate and execute geopolitical strategy, and establish and maintain social conventions. It is also, at its foundation, of philosophical import: the very means upon which human beings have ex nihilo relied for establishing a shared sense of reality—perceptual experiences—are also a predominant subject for machinic replication today. Meanwhile, our interactions with these dynamic digital technologies palpably mold people's perceptual faculties.[5] A well established critique of artificial intelligence within the humanities has

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[4] Mark Gubrud, "Nanotechnology and International Security," presented at the Fifth Foresight Conference on Molecular Nanotechnology (November 5–7, 1997), https://web.archive.org/web/20110529215447/http://www.foresight.org/Conferences/MNT05/Papers/Gubrud/

[5] For discussions of this condition within the humanities and with particular focus on the phenomenological discordance between digital machine and human perception, see Shane Denson, *Discorrelated Images* (Durham, NC: Duke, 2020); Mark B.N. Hansen, *Feed Forward: On the Future of twenty-first-century media* (Chicago: U Chicago Press, 2015); and N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago: U Chicago Press, 2017. Examples of this discussion that take the form of ideology critique, see Wendy Chun, *Programmed Visions: Software and Memory* (Cambrdge, MA: MIT Press, 2011) and Alexander Galloway, *The Interface Effect* (Cambrdge, UK: Polity Press, 2012). The field of cognitive science also takes us this topic; see, for example: Nicolas Rothen et. al., "Coordinated neural, behavioral, and phenomenological changes in perceptual plasticity through overtraining of synesthetic associations," *Neuropsychologia* 111 (March 2016): 151–162; and Zoe Kourtzi et. al., "Recurrent Processing Drives Perceptual Plasticity," *Current Biology* 30, no. 21 (November 2020): 4177–4187. Finally the field of behavioral economics emphasizes behavioral plasticity; see, for example, Richard Thaler and Cass Sunstein, *Nudge: Improving Decisions about Health, Wealth, and Happiness* (New Haven. CT: Yale University Press, 2008).

emphasized computational technology's antihuman and aperceptual qualities—its hardware is an inverse of fleshiness; its software a binary contrast to people's capacity and tendency to perceive and think with ambiguity.[6] And yet contemporary technical programs are charged less with closing the gap between human and AGI in ontological terms than with closing the *perceived* gap, a la Turing's imitation game. Thus this dissertation proposes that in order to address the contemporary topic of generality in machine ("intelligent") behavior, as a matter of humanistic and critical inquiry, we use as an analytic for artificial intelligence the problem of visual perception.[7]

By perception, I mean two independent domains: our institutional and cultural perceptions of what our technologies are doing—how we represent and evaluate them—as well as perception as an organismic phenomenon that these very AI programs are designed to replicate. The inherent entanglement of the two becomes apparent when we consider another, most urgent, evaluative project for determining the bounds of artificial intelligence. In 2013, the United Nations established a subcommittee made up of military, artificial intelligence, and legal experts to develop an international legal framework for lethal autonomous weapons systems (ironically called LAWS among this group; colloquially called AI arms).[8] In schematic terms, such systems contain a means for the machine to perceive, decide, and act. The group's foremost task was to write a definition of LAWS. Early on, the experts determined that they would need to invert the subject of the definition, along two conceptual axes. Emphasis would need to shift from the domain of the machine to that of the humans, and it would move from a focus on the technology as a fixed, spatially determined entity, to the temporally unfolding interaction between people and technical system and, within it, exceptional events. They asserted that "[a] categorical definition drawing on technical characteristics in an effort to separate LAWs from non-LAWS is unable to account for the already existing plethora of systems with autonomous/-automated functions."[9] The group instead created the evaluative criterion of "meaningful human control" to circumscribe the so-called autonomous technological functions and proposed the following leading principle: "a human simply pressing a 'fire' button in response to indications from a computer" is not sufficient meaningful control; "the use of force requires at least

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[6] See, for example, Adrian Mackenzie and Anna Munster, "Platform Seeing: Image Ensembles and Their Invisualities," *Theory, Culture & Society* 36, no. 5 (June 2019), https://doi-org.libproxy.berkeley.edu/10.1177/0263276419847508. See also works that discuss the materiality of information, such as: N. Katherine Hayles, *How We Became Posthuman* (Chicago, U Chicago Press, 1999), Tiziana Terranova, *Network Culture* (London: Pluto Press, 2004).

[7] For an analysis of the history of computing and artificial intelligence that focuses on other senses, especially auditory and haptics, see Mara Mills, "On Disability and Cybernetics: Helen Keller, Norbert Wiener, and the Hearing Glove," *Differences* 22, no. 2–3 (2011): 74–111 and Xiaochang Li, "The Measure of Meaning: Automatic Speech Recognition and the Human-Computer Imagination," in *Abstractions and Embodiments: New Histories of Computing and Society* (Baltimore, MD: Johns Hopkins University Press, 2022): 341–359.

[8] The group is called the International Panel on the Regulation of Autonomous Weapons, or iPRAW; ipraw.org. See also "Commentary on the GGE's Guiding Principles, September 2020, https://www.ssoar.info/ssoar/bitstream/handle/document/79319/ssoar-2020-international_panel_on_the_reg-Commentary_on_the_GGEs_Guiding.pdf?sequence=1&lnkname=ssoar-2020-international_panel_on_the_reg-Commentary_on_the_GGEs_Guiding.pdf, accessed July 20, 2024.

[9] "Hand Out for Workshop I—Concepts of Human Control," International Panel on the Regulation of Autonomous Weapons (iPRAW), October 27, 2020, 2.

situational understanding by the human operator/commander."[10] In making central a person's "situational understanding," the authors of the definition were framing interactional control as a matter of visual apprehension and comprehension, as a matter of perception.

But, in addition to the fact that "situational understanding" is a vague state to measure in any context, the commander and team's vision and cognition is shaped by the ways of seeing and information-processing of the computer. Its bounding boxes and other graphical features overlaying drone video footage, for example, remove objects from their contexts and direct the operatives' perceptual attention to look at this object and not that.[11] Further, the U.S. military is investing in programs for command and control environments that "augment cognition," loosely based on J.C.R. Licklider's 1960s computer-interface concept of the same name.[12] The military's AugCog program develops neurophysiological sensor systems that simultaneously measure body and eye position, attention and distraction, fatigue, and cognitive load at a given task, aimed at "the benefit of a real-time, closed-loop system that utilizes neurophysiological indicators of operator cognitive state to drive optimized human performance."[13] AugCog technologies have been tested in military-specific task environments, such as a "command and control station that requires management of a number of missiles, targets and shipboard launch platforms, and dynamic reassignment of missiles to targets as critical targets pop-up, missiles fail, and so forth. The prototype AugCog system … demonstrated an improvement in working memory throughput by at least 500% by using an intelligent sequencing mitigation strategy to strategically present related information about specific missile-target pairings when the [human operator's] working memory bottleneck was saturated."[14] In such a scenario, the commander's situational awareness is already mediated through a series of technologies that operate directly on the body and orchestrate its behavior. This AugCog description reveals how these institutional techniques blur the border between human and machine vision, and in doing so they evacuate the possibility for autonomy from both entities, effectively removing political responsibility from individual and institutional alike. "Situational awareness" in terms of neurological performance is hyper-charged, while in terms of consciousness and sociality it is invalidated. If meaningful human control is contingent upon situational awareness, but that awareness is to a great degree conditioned by the camera-computer system, the evaluative mechanism is annulled from within.

To address the problem of diffuseness between human and machine vision, *Patterning Recognition* proposes and develops a perhaps unexpected method. This project is not a history *of* artificial intelligence and its subfield, computer vision. It is indebted to those works, such as James Dobson's *The Birth of Computer Vision*, that have laid out this genealogy.[15] Instead it

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[10] Heather Roff and Richard Moyes, "Meaningful Human Control, Artificial Intelligence, and Autonomous Weapons," Briefing paper for delegate at the Convention on Certain Conventional Weapons (CCW) Meeting of Experts on LAWS, April 11, 2016; "Worksheet I…", iPRAW, 3.

[11] See, for example, Todd South, "New Army tech 'sees' through battlefield blind spots," *Army Times* (April 2021), https://www.armytimes.com/news/your-army/2021/04/14/new-army-tech-sees-through-battlefield-blind-spots/, accessed July 20, 2024.

[12] J.C.R. Licklider, "Man-Computer Symbiosis," *IEEE Annals of the History of Computing* 14, no. 1 (1992): p24.

[13] Kelly S. Hale et. al., "Augmenting Cognition in HCI: Twenty-First Century Adaptive System Science and Technology," in *Human Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition*, edited by Julie A. Jacko (Oxfordshire, UK: Taylor & Francis, 2012): 1343–1358.

[14] Hale, "Augmenting Cognition in HCI," 1351.

[15] James E. Dobson, *The Birth of Computer Vision* (Minneapolis, MN: U of Minnesota Press, 2023).

looks at the "meaningful human control" debate, and its non-military adjuncts such as those concerning generative artificial intelligence as a means of cultural production, as calling for a critical analysis of the very concept of perception. Rather than describe the machines that stand in for human eyes and brains on account of their technological determination exclusively, I look at what it means to do the work of perception today.[16] What has united ideas about organic perception, efforts to model it in the computer, and institutional programs to organize optical labor is an emphasis on vision's purposive quality. An Enlightenment penchant for *seeing to know* has lost favor for a neuroscience-informed *seeing to do*. This pursuit of perceptual expediency has effected an enduring lack of clarity regarding the subject of vision. *Patterning Recognition* explains the complexity of the problem of delineating human and machine control, or authorship, or even experience writ large.

Critical scholarship on digital technology tends to only tangentially address the issue of the ambiguity regarding who the subject of seeing and thinking is in this digital-media environment—and the political implications of this lack of clarity. Instead, it tends to analyze artificial intelligence techniques according to their ontological properties and participation in historically undergirded practices of imperialism and discrimination. Scholars articulate, with precision, the quality of "invisuality" in machinic programs that are otherwise intended to see the world in our stead. This enduring black-box quality of algorithms prompts scholars to invent new methods and repurpose existing ones that can both establish a familiarity with the machine by making its inner workings more transparent and also defamiliarize this very digital-media technology to counteract its otherwise absorbing effects on its users. Wendy Chun and Hito Steyerl, for example, argue for a hermeneutic practice that assumes a "garbage in, garbage out" approach to scrutinizing algorithms' opacity.[17] Historical methods are also called upon to expose a genealogy of ascending automation of vision and a contingent, growing impotence of human sensation and sense-making. These accounts tend to position machine vision apparatuses in a lineage of imaging technology, the original focal point of which is usually the photographic camera—the earliest mechanical, nonhuman eye. Computer vision programs that integrate into mechanistic decisioning systems like LAWs are conceived as "operational images."[18]

Introduced by the filmmaker and theorist Harun Farocki at the turn of this century in reference to the then nascent semi-autonomous weapons programs, operational images are both representations of a world and the automated programs that act upon the very subjects and objects of the world they depict. Farocki's avant-garde film trilogy *Eye/Machine* (2000–2003), in its montage of military footage from the Gulf War and industrial tests with military-grade robots and automated control-room technology, presents human beings as nothing more than the pressers of a 'fire' button, to use the UN terms, dwarfed by the expansive automatic targeting machine displays. As the operatives here appear to have no "meaningful control," operational

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[16] For an analysis of (the history of) AI based on the stance that AI is not replicating intelligence but rather labor and social relations, see Matteo Pasquinelli, *The Eye of the Master: A Social History of Artificial Intelligence* (London: Verso, 2023).

[17] Clemens Apprich, Wendy Hui Kyong Chun, Florian Cramer, Hito Steyerl, *Pattern Discrimination* (Minneapolis, MN: U of Minnesota Press, 2019).

[18] Harun Farocki, *Eye/Machine I–III* (2001–2003). See also Harun Farocki, "Phantom Images," trans. Brian Poole, *Public*, no. 29 (2004), 13–22, https://public.journals.yorku.ca/index.php/public/article/view/30354; Volker Pantenburg, "Working Images: Harun Farocki and the Operational Image," in *Image Operations: Visual Media and Political Conflict*, ed. Jens Eder and Charlotte Klonk (Manchester, UK: Manchester University Press, 2017), 50–62; and Jussi Parikka, *Operational Images: From the Visual to the Invisual* (Minneapolis: University of Minnesota Press, 2023).

images are responsible for sensing objects and determining their significance as targets—they are the conductors of an institution's perception. Some have argued that operational images, because they do not need human eyes to do their work, imply the total excision of the human from the so-called loop.[19]

This thread of scholarship, then, frames its critical investigation according to the principles of "brain replacement" (or shall we say "brain/eye" replacement), that very condition germane to the AGI concept in the technical field. Meanwhile, it historically situates the notion of automated vision in a tradition of photography and cinema, rather than that of computing, neuroscience, and cognitive science—those research fields responsible for modeling vision in the machine. But I will show that the operational image—or, automated perception—became thinkable before computers were employed for this military labor. Even as they are the subject of a discourse of replacement, these systems have historically been developed on the basis of principles about the very workings of the human form—as a nervous system, as a rigid body in physical space, as an affective subject. They are both extra-perceptual translations of bits and approximations of human perception in both analytical and aesthetic terms. This paradoxical quality makes artificial intelligence and computer vision elusive as objects of humanistic study. This dissertation disentangles this conceptual knot by investigating how human visual experience became technical program, and vice versa, and examining how practices of visual representation enabled the transformations.

To address this seeming contradiction, I look at how the very concept of visual perception has historically been debated within the intellectual fields and institutional settings that sought to understand it by way of mechanistic models, develop analogues that could approximate it in a number of real-world activities, and meanwhile see it as a phenomenon that exposes the limits of computational simulation. Instead of analyzing artificial intelligence algorithms exclusively—and their precedents—as my primary subject, I look at perception as a contested, dynamic site for understanding both the boundaries and unboundedness of artificial intelligence as it entangles with theoretical discourse, social and political institutions, as well as individual aesthetic experience. Our perceptual faculties, modes of representation, and the critical distance they offer us to sense and make sense of our contemporary situation are especially urgent tools. And yet artificial intelligence and accelerating automation are altering what human perception is and does in both a phenomenological and a material sense.

The reason for the choice to focus on perception as a subject of AI automation, as opposed to the more oft referred to arenas of cognition and rationality, is based on my read of the field in its present, historically situated, iteration. Artificial intelligence textbooks feature the subject of computer vision as an independent chapter and describe it as a sub discipline within the broader domain of machine learning.[20] Also referred to as "the modern approach" to AI, machine learning is a method in which computer models acquire abilities to engage in "intelligent," situated activities through their exposure to data from the external world. I will argue, then, that machine learning writ large is based on perceptual principles, even if its modes of analyzing data are aperceptual from the perspective of human experience.

Exemplars of machine learning are artificial neural networks, and their 2010s manifestations are deep learning or multi-layered neural nets, which are loosely modeled on the

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[19] See Trevor Paglen, "Operational Images," *e-flex journal* 59 (November 2019), www.e-flux. com/journal/59/61130/operational-images. To see a counter to this argument, see, for example, Katherine Chandler, *Unmanning*.

[20] See Stuart Russell and Peter Norvig, "Chapter 25: Computer Vision," *Artificial Intelligence: A Modern Approach, Fourth Edition* (Hoboken, NJ: Pearson, 2021), 881–924.

workings of the human central nervous system. Neural networks have minimal originary structure, and that structure is quite literally molded based on its impressions of data. Though the concept of a neural net in the realm of computing co-emerged with the very conceptions of cybernetics and artificial intelligence in the 1940s and 1950s—notably with the invention of Frank Rosenblatt's perceptron model—machine learning was not popularized until the end of the twentieth-century and did not become the predominant method of AI until the 2010s.[21] For much of the field's history, attention went to predetermining and encoding into the AI systems in advance the processual structures of problem solving. They focused on the underlying principles of (pure) rationality. Already in 1956, Herbert Simon and Allen Newell had devised a program that solved over half the proofs from Alfred Whitehead's and Bertrand Russell's *Principia Mathematica*.[22] In the decades that followed, researchers developed schemes and parameters for "knowledge representation," building them into the "innate" mechanisms by which the computer agent could develop internal models of the world.

A more "bottom-up," sensory-based approach, and a return to focusing on the neural network, emerged in the 1980s and 1990s. The roboticist Rodney Brooks, inspired by philosophical ideas about "emergent behavior" in organisms and in particular people, was arguing for the centrality of immediate sense experience in all kinds of intelligent activities, including symbolic processing. Learning and the knowledge it produces is less a factor of highly developed, ossified symbolic representations in the mind-brain and more contingent on environmental interactions.[23] For those working in neural networks at this time, such as Geoffrey Hinton, internal representation was given more value than in Brooks' scheme, but in the neural net approach the mechanisms to build such symbolic models was based on perceptual principles: from its observations of the external world as represented in the training data, and with its parameters for perceiving, and then correcting, its own errors in making sense of and deciding about the input data. Both Brooks and Hinton were putting emphasis on the centrality of environmental impressions and agent behavior. Today the research community widely accepts a "rational-agent" approach to AI, threading the needle between these two predominating camps.[24] But in deep learning—that predominant method of the 2010s and 2020s—the degree of complexity of the internal models, and in their outputs, mirrors the breadth and complexity of the environmental situation, as made available by way of "sense" data. N. Katherine Hayles, invoking the theoretical biologist and philosopher Jakob von Uexküll, has referred to the deep learning dataset as the AI program's *umwelt*, akin to an organism's horizon of perceptual access to its world.[25] An implicit necessity of the historical shift within the field of artificial intelligence, accompanying the ascendance of machine learning in the twenty-first century, is a growing

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[21] See Frank Rosenblatt, *Principles of Neurodynamics: Perceptrons and the Theory of Brain Mechanisms* (Ithaca, NY: Cornell Aeronautical Laboratory, 1961). For the contemporary resurgence of neural networks (through deep learning), see the A.M. Turing Award profile of computer scientist Geoffrey Hinton: https://amturing.acm.org/award_winners/hinton_4791679.cfm, accessed July 20, 2024.

[22] See Allen Newell, Herbert Simon, and Cliff Shaw, "The Logic Theory Machine," *IRE Transactions on Information Theory* (September 1956). See also Pamela McCorduck, *Machines Who Think* (Natick, MA: A.K. Peters, 2004).

[23] Rodney Brooks, "Intelligence Without Representation," *Artificial Intelligence* 47, no. 1 (1991): 139–159.

[24] See Russell and Norvig, *Artificial Intelligence*, 37.

[25] N. Katherine Hayles, "Can Computers Create Meanings? A Cyber/Bio/Semiotic Perspective," *Critical Inquiry* 46 (Autumn 2019): 32–55.

sensitivity to the "task environment" and a conceit that increasingly complex AI behavior is contingent on its expansion.

With this schematic picture I present not an exhaustive, teleological historical account but instead intend to show that the problem of approximating perceptual experience accompanied the emergence of artificial intelligence and, even when the field was disavowing machine learning in favor of knowledge representation, it has been an enduring organizing principle of the field. *Patterning Recognition* is not centrally about computers identifying objects in images, though I do discuss such a practice. Instead, it frames perception as the contingent yet directed exchange between internal structures and processes, on one hand, and external environments on the other. My leading question, then, is what happens when the phenomenon of perception—one that undoubtedly has innumerable manifestations—is conceived and treated as an entity that can interchangeably be enacted by human beings and machines, when it is paradoxically isolatable and modular on one hand and on the other always already embedded in a world?

This question is something of an inversion of the inquiry undertaken by philosopher Hubert Dreyfus in his 1972 text *What Computers Can't Do: A Critique of Artificial Reason*.[26] Very much responding to the current in-vogue knowledge representation paradigms in artificial intelligence, Dreyfus issues a phenomenology-informed polemic, asserting that artificial intelligence researchers are operating under the assumption that "all knowledge and beliefs of an adult human being can be made explicit" by way of "formal representation" in a computer model.[27] This approach, Dreyfus explains, is driven by the ultra-rigid—all or nothing—properties of the computer just as it claims to simulate the "flexible" quality of the human mind. The text ultimately argues that a precedent for human intelligence is understanding, and people only acquire understanding through perceptual experience, or by being thoroughly situated in sensorially rich environments and having a great degree of "ambiguity tolerance" in perceiving and making sense of those surroundings.[28] Positioning these perceptual principles as tantamount and virtuous, Dreyfus does not rule out the possibility that machines could adequately exhibit them. To envision this, he cites Claude Shannon, a surprising reference given Shannon's role as an originator of Boolean-based information theory. Shannon had said: "'Efficient machines for such problems as pattern recognition … may require a different type of computer than any we have today. It is my feeling that this will be a computer whose natural operation is in terms of patterns, concepts, and vague similarities, rather than sequential operations on ten-digit numbers.'"[29] Dreyfus adds that in order for a machine to "behave with human intelligence," it would have to "have a body so that it could be at home in the world."[30]

The neural network approach to artificial intelligence was notably out of style at the time of Dreyfus's writing, and his critical remarks were primarily aimed at those knowledge-representation and cognitivist schemes that downplayed the influence of perception on the ways

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[26] Hubert Dreyfus, What Computers Can't Do: A Critique of Artificial Reason (New York: Harper & Row, 1972).

[27] Hubert Dreyfus, What Computers Still Can't Do: A Critique of Artificial Reason (Cambridge, MA: MIT Press, 1992). In these quotes, Dreyfus is synthesizing his argument from the 1972 edition of the book.

[28] Hubert Dreyfus, What Computers Can't Do, 19.

[29] Hubert Dreyfus, What Computers Can't Do, 216.

[30] Hubert Dreyfus, What Computers Can't Do, 216.

of memory and problem solving.[31] Yet, today's machines are more at home in our world than they ever have been, in both theoretical and practical ways. They continue to be relay-based and numerical, contra Shannon's imagined ambiguous pattern-recognition engine, yet neural networks probe at fulfilling Dreyfus's prophesy, at least on their surface. Instead of being primarily concerned with logic problems, like many of the AI programs Dreyfus's book covers, the neural network acquires its capacity to make decisions through a process that approximates human perceptual experience. Not only does the neural net fundamentally assume environmental uncertainty, handling it through the use of probability theory, a model's initially indeterminate and open formal arrangement, which accumulates structure as a result of its incorporating data, appears to mimic the ambiguous and flexible qualities of the human brain and, some argue, mind.[32] Further, today's neural networks, and their embeddedness in robotic systems, could uncritically be argued to incorporate qualities of embodiment and its environmental sensitivity.

Dreyfus's argument has a contemporary analogue in media studies and philosophy of technology scholarship that similarly emphasizes a dialectic between the realms of embodied experience and mathematical rationality. This contemporary work makes the argument with more attention to the neural-network method, though. Orit Halpern, for example, gives a genealogical account of data as an aperceptual entity that nonetheless represents the very stuff of twenty-first-century perception. In Halpern's estimation, this came to be by way of the "transformation in the treatment of the senses as commodities, technologies, and infrastructures" brought on by the cyberneticists and their overlaps with operations research and designers originating the aesthetic practice of data representation.[33] Halpern's perspective is that, from the mid-twentieth century to today, the ambiguity tolerance Dreyfus speaks of has been overrun by a seeing-by-numbers type of vision and cognition. The stuff of computationally amenable perception, data both disavows human reason in praise of the calculable rationality *and* exhibits fundamentally irrational properties. Today's condition of "surplus data," Halpern and colleagues explain, is really "surplus derivation:" "The plausibility furnished by correlation abandons accuracy for a conspiratorial paranoia that finds every future in a past assembled from empirical patterns."[34]

Elsewhere Halpern has argued that this ascendance of data was accompanied, in the latter half of the twentieth century, by the emergence of neural network programs that, because they learned on population-level data and imagined cognitive activities at an environmental scale, not an individual one, that they "imagine[d] the *replacement* of human reason through distributed intelligence and the technology of the market."[35] If today we see the proliferation of conspiratorial thinking, Halpern argues, it is because these data-informed neural nets, and their

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[31] A primary target of Dreyfus's book is Marvin Minsky, who in 1968 authored, with Seymor Papert, a consequential critique of Frank Rosenblatt's Perceptron for its incapacity to thoroughly make conceptual generalizations from sensor-based input data. Marvin Minsky and Seymour Papert, Perceptrons (Cambridge, MA: MIT Press, 2017 [1969]).

[32] Underlying many of the currents in artificial general intelligence research is the neuroscience "digital brain" movement. See "The coming decade of digital brain research: A vision for neuroscience at the intersection of technology and computing," in *Imagine Neuroscience* 2 (2024), 1–35. For a critique of conceptions of a "digital brain," see David W. Bates, *An Artificial History of Natural Intelligence: Thinking with Machines from Descartes to the Digital Age* (Chicago: U Chicago Press, 2024).

[33] Orit Halpern, *Beautiful Data* (Durham, NC: Duke, 2014), 17.

[34] Orit Halpern, Patrick Jagoda, Jeffrey West Kirkwood, and Lief Weatherby, "Surplus Data: An Introduction," *Critical Inquiry* 48, no. 2 (Winter 2022): 197–210.

[35] Orit Halpern, "The Future Will Not Be Calculated: Neural Nets, Neoliberalism, and Reactionary Politics," *Critical Inquiry* 48, no. 2 (Winter 2022): 334–359, 335, my emphasis.

corollaries in neoliberal, speculative markets, have undermined the very ground of human thinking and naturalized its automated analogue in the "intelligent" but necessarily opaque machine. The underlying assumption of this line of discourse, exemplified here by Halpern but shared by many, is the fact that these insidious human-thinking displacement systems involve so many layers of abstraction from a perceptible world and from human ways of sense-making and social, discursive organization. The implicit conceit, then, is that what is needed is a critical practice that makes transparent the otherwise opaque and aperceptual qualities of the machine and its data-based composition, with the ultimate goal of allowing human beings to restore a sense of "accuracy," which presumably is achieved *through* perceptual experience.

Despite writing a half century apart and from different theoretical vantage points, Dreyfus and Halpern are similarly critiquing "artificial reason" by contrasting it with embodied (non-datafied) sensing. Yet there is a notable paradox in the positive aspects of their arguments, and not only with respect to the ontology of the machine but to the ontology of human perception. Dreyfus centers the "vague similarities" and "ambiguity tolerance" as the very seat of human (perceptual) understanding and therefore reason. Human thinking is fundamentally indeterminate. Halpern's position contradicts that of Dreyfus, and for her the abstraction and probabilistically driven "flexibility" of the thinking machine is what makes it antihuman, inaccessible, and undermining of perceptual truths. *Patterning Recognition* takes this tension as a productive point of departure for understanding the roots of a "meaningful human control" debate and its social and aesthetic corollaries.

It seems to me that artificial intelligence technology exposes a problem that isn't necessarily *about* the technology.[36] The phenomenon of empirical understanding is both the means by which human beings reach a place of shared reality, and therefore the ground from which democratic institutions can emerge and be maintained. On the other hand, the mutability and contingent aspects also understood to be the conditioning elements of human perceptual experience suggest that that ground never existed. While the modern era has been periodized as that era when, in institutional settings, subjective accounts have been subordinated to the "objective" recordings of the mechanistic machine, today both artificial intelligence technical research and social science research emphasize the centrality of perceptual and cognitive plasticity in the machine *and* the human being alike.[37] This implicit effort to sync up the nervous circuits of both the body and the neural net-driven mechanism is a primary issue to which *Patterning Recognition* will put attention. My approach recognizes the conceptual distance between formal, artificial models of the brain-mind and the organismic and social ones they are designed to replicate while also emphasizing the contemporary discursive concepts and practices that explicitly and implicitly collapse the distinction. From a humanistic perspective, then, my inquiry looks at the very conditions that make possible and foreclose the individual and social phenomenon of establishing perceptual, and therefore critical, distance.

This problem of the intermingling of human and machine plasticity is being taken up within the field of artificial intelligence itself, and among those technical and social science researchers intervening in the "meaningful human control" debate and the broader emerging

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[36] This line of thought originates in Martin Heidegger, "The Question Concerning Technology" in *Martin Heidegger: Basic Writing*, edited by David Farrell Krell (New York: Harper Collins, 1993 [1954]): 307–342.

[37] Regarding "objectivity" and the displacement of subjective perception to an objective machine based on measurement, see Daston and Galison, *Objectivity* (New York: Zone, 2010) and Jonathan Crary, *Techniques of the Observer: On Vision and Modernity in the Nineteenth Century* (Cambrdige, MA: MIT Press, 1990).

discipline of AI safety, also referred to as "Human-Compatible AI."[38] For this group, and in particular for one of its leading voices the computer scientist Stuart Russell, a conceptual knot is at the heart of making AI that acts with transparency and in the interest of collectively held human values. While a game like Go has a clearly stated objective, and a deep learning program can invent its indeterminate path to this determinate end of "winning," in the vast majority of real-world, social settings, the objectives of humans aren't clearly defined for any of many reasons: because they aren't explicitly stated, because they perhaps elude formal explication altogether, or because in a variety of activities people don't make their objectives a matter of their own conscious awareness. How, then, to ensure the machines being designed today align with human values, or preferences?[39]

Russell proposes a paradigm that takes the uncertainty of human goals as a given. Given the technical name "inverse reinforcement learning," Russell's solution is a model that observes human behavior as it unfolds and in doing so it "learns what the human … *wants*, in the form of trajectory constraints that it can achieve."[40] By making the observation of incremental human behavior a primary feature of the AI's behavior, we can avoid the likelihood that artificial *general* intelligence programs will invent antisocial means of achieving goals that potentially impose calamity on our institutions and ways of life. Instead, "machines designed in this way will defer to humans: they will ask permission; they will act cautiously when guidance is unclear; and they will allow themselves to be shut off."[41] These systems will align with human values (e.g., solve the value-alignment problem) by making good on their mechanistic version of the quality of *plasticity*. Whether embedded as an operating principle in a machine-learning algorithm or a social institution, the value-alignment paradigm of inverse reinforcement is to be evaluated according to the criterion of "provably beneficial." However, Russell recognizes that such a benchmark would require "having roughly coherent and … stable preferences about the future," but "the consequences of *plasticity* in human preferences … present a serious philosophical challenge to the very idea of provably beneficial AI."[42] *Patterning Recognition* takes up this philosophical problem, which I argue is also a historical and political problem.

A modern conception of human plasticity was perhaps first elaborated by the philosopher and psychologist William James, in the late nineteenth century, who articulated it as a combination of neurological conditions, phenomena of the mind, and social organization. Informed by the brain science of the day, James explained that plasticity in the human central nervous system is "the possession of structure weak enough to yield to an influence, but strong

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[38] See the UC Berkeley Center for Human-Compatible Artificial Intelligence, https://humancompatible.ai, accessed July 20, 2024. See also the Stanford Institute for Human-Centered Artificial Intelligence, https://hai.stanford.edu, accessed July 20, 2024.

[39] See Stuart Russell, *Human-Compatible*, 177. Russell says, "The real complications arise … because humans are not perfectly rational: imperfection comes between human preferences and human choices, and the machine must take into account those imperfections if it is to interpret human choices as evidence of human preferences…. 'Putting in values' is, of course, exactly the mistake I am saying we should avoid, because getting values (or preferences) exactly right is so difficult and getting them wrong is potentially catastrophic. I am proposing instead that machines learn to predict better, for each person, which life that person would prefer, all the while being aware that the predictions are highly uncertain and incomplete," 177–78.

[40] Russell, *Human-Compatible*, 190.

[41] Russell, *Human-Compatible*, 243.

[42] Russell, *Human-Compatible* 188.

enough to not yield all at once."[43] Out of this malleability arises a phenomenon that co-constitutes the quality of plasticity but nonetheless is necessitated by it—habits of thought and action. This conception of the human perceptual system and behavioral repertoire as both impressionable and prone to ossification is present in much critical theoretical thought on the human condition in modernity and postmodernity, notably with Theodore Adorno's and Max Horkheimer's notion of the "culture industry." Within this view, mass media that hides the ideological underpinnings of its representations imposes images and behavioral programs by way of palatable, aestheticized objects to be consumed. Bernard Stiegler alerts us to its twenty-first-century version—an "automatic society"—in which just as machines constantly shift their very ontological status constantly, there is a phenomenological ossification as these networked objects operate at a subperceptual, libidinal level.[44] Put differently, Stiegler describes this condition as the "proletarianization of sensibility."[45]

We might think of this perceptual condition in slightly different terms, such as that of the cyborg. What Donna Haraway had in mind when she explicated the revolutionary potential of a cyborg concept and mode of being, in her notable manifesto, was that the creative, thoughtful integration and implantation of human and machine components could set us on a different path than that of the culture industry.[46] And while there is plenty of work today that heeds Haraway's call and takes up the practice of critical human-machine amalgam-making, particularly in the arts, when we look at emerging technologies that are manifestations of a cyborg way of life a different picture emerges. We might consider, for example, Elon Musk's Neuralink technology, and other brain-computer interfaces that imagine directly connecting the human cortex with computers in order to bypass the use of the body in their interactions with virtual and potentially physical environments.[47]

This collapse of the gap between computer circuits and organic synapses has destabilizing potential when considered in a historical-philosophical context, for reasons other than AGI being inherently antisocial and dangerous a la science-fiction narrative tropes. We might take as an example an alternative to the Neuralink implant technology—the period when those living in the Zinjanthropian era begin chipping flint. As mid-twentieth-century prehistorian André Leroi-Gourhan determined, these tools evolved in parallel with the development of the human brain's cortex.[48] Stiegler takes up Leroi-Gourhan's assertion in a philosophical-historical register, arguing that even though historical origins are aporetic, this originary technical object *made* the human as much as the human made the technical object, and this pattern has repeated in various historical eras.[49] I read into this historically situated philosophical framework a key

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[43] William James, *Principles of Psychology, Volume I* (New York: Dover Publications, 1950 [1890]), 105.

44 Bernard Stiegler, Automatic Society: Volume I: The Future of Work, translated by Daniel Ross (Cambridge, UK: Polity Press, 2017).

45 Bernard Stiegler, "The Proletarianization of Sensibility," boundary 2 44, no. 1 (2017): 5–18.

46 Donna Haraway, "A Cyborg Manifesto," A Cyborg Manifesto: Science, Technology, and Socialist-Feminism in the Late Twentieth Century (Minneapolis, MN: U of Minnesota Press, 2016 [1985]): 5–68.

47 See Neuralink's website: https://neuralink.com. See also Miguel Nicolelis and Nicolelis Lab, 20 Years of Brain-Machine Interface Research, 2 volumes (Durham, NC: Duke University Medical Center, 2020).

48 See André Leroi-Gourhan, Gesture and Speech, translated by Anna Bostock Berger (Cambridge, MA: MIT Press, 1993 [1964]).

49 See "Who? What? The Invention of the Human," in Bernard Stiegler, Technics and Time, Volume I, translated by Richard Beardsworth and George Collins (Palo Alto, CA: Stanford University Press, 1998 [1994]): 134–179.

point—the tool *became* a tool because it was *recognized* by its maker as a tool. The two are at once mirrors of one another and notably distinct entities, neither of which can be subsumed into the other. The gap between them is what makes self-reflexivity possible, and therefore what makes autonomy and meaningful collective change (contra habituation and ossification) possible. And to the extent the construct presents too essentialist and too unified a picture of "the human," we might find in Donna Haraway's figure of the cyborg a call for this kind of mirroring by way of dissonance, and dissonance by way of mirroring, between biological being and "lively" machine.[50] Haraway embraces the inherent incompleteness of the human being—a quality that in fact puts pressure on the Western conception of the "individual." This partiality Haraway elaborates is both exposed by this AI-informed historical moment and is the source of possibility for new, even intimate, couplings with our relay-based partners. Such a possibility is animated by "autonomous" human beings appropriating the machine in the service of self-fashioning and an exhibition of productive difference, enabling the attainment of social cohesion amid discordance. Indeed, Haraway offers this positive program in light of what she sees as the dangers of a false collapse and unity of the biological-machine amalgam.

As much as the modern era can be conceived as a period defined by the overtaking of the human senses and reason alike by way of "enframing" automatic technical systems, *Patterning Recognition* focuses on four episodes in this history in which that very tendency encountered friction, in both the development of concepts and their translation into material practices.[51] The dissertation examines the conceptual emergence of pattern recognition in the long twentieth century. It asks how theoretical concepts relating computer and brain/mind, and camera and eye, affect and are affected by material forms of social organization, cultural expression, and political decision-making. Part one, "Bodily Automaticity," traces the evolution of perceptual concepts, industrial and computer automation techniques, and the address of biological beings as automatable. Chapter one examines the co-emergence of the theory of the neural network, as propounded by William James, and that of scientific management, and how industrial psychologist Lillian Gilbreth triangulated the two through industrial film exhibition programs for training the muscle memory of industrial workers. Chapter two offers an alternative origin story for affect theory, which is often attributed to Silvan Tomkins, both identifying the aspects of this theory that draw on information-technology principles while also highlighting how historical actors central in these debates, Walter Reitman and Gregory Bateson, attended to the unruly aspects of human affects—drives and exceptional metacommunicative states such as belly

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50 Donna Haraway, "A Cyborg Manifesto," 11. Haraway says: "Late twentieth-century machines have made thoroughly ambiguous the difference between natural and artificial, mind and body, self-developing and externally designed, and many other distinctions that used to apply to organisms and machines. Our machines are disturbingly lively, and we ourselves frighteningly inert."

51 The concept of enframing (translated from the German "Gestell") was introduced by Martin Heidegger in "The Question Concerning Technology." Gestell is a periodizing feature of modern technology—its systematicity. While the tool had traditionally had a singular function, a technical system renders the surrounding world itself functional. Technics qua system conceives of nature as exclusively energy supply, and endorses an domination and exploitation of it as such. There is an implicit paradox at the heart of this concept, that Heidegger did not recognize but that Stiegler would several decades later articulate: On one hand, it is through complex behemoth technical systems that human beings obtain a thorough command over nature. On the other hand, Gestell is so all-encompassing and self-perpetuating (enframing) that it supplants human reason with nonhuman, calculative reason, such that the human cannot think itself or nature outside the logic of technical systematicity. See also Gilbert Simondon's periodization of the modern era with respect to the self-organizing qualities of the nineteenth-century steam engine in *On the Mode of Existence of Technical Objects*, trans. By Cecile Malaspina and John Rogove (Minneapolis, MN: University of Minnesota Press, 2017 [1958]).

laughter—and their simultaneous qualities of incomputability and automaticity at the threshold of perceptibility.

Part two of *Patterning Recognition*, "Images and Interpretive Actors" examines efforts to translate image interpretation from a human to a computer endeavor, revealing pattern recognition's elevation of *seeing to do* over an Enlightenment penchant for *seeing to know*. Chapter three draws out the tension between James Gibson's "ground theory" of perception and its appropriation in the CIA's first use of neural network programs to machine-automate aerial photo analysis and accelerate target recognition. This historical account looks at the dialectic between a decontextualized, object-based way of seeing and an ecological mode of perception that chapter four examines from an alternative, near opposite perspective. Here, I focus on how cognitive psychologist Ulric Neisser, co-creator of a prominent computer architecture for pattern recognition, identified in human perception the tendency not to simply distinguish foreground from background, signal from noise, as computers must do (even those deep-learning programs today) and as had been assumed to be a feature of biological and subjective perception. A defining feature of human vision for Neisser—and a consequential notion for contending with contemporary "meaningful human control" discourses and the limits of so-called autonomous technologies—is the tendency for human beings to *see through noise* and in doing so to retain the possibility of accessing environmental abundance, ambiguity, contradiction, and complexity.

With each episode, my approach attends to the contradictions within these theoretical debates and initiatives to implement them in material ways. Concepts like perceptual plasticity, for example, point toward both that which is indeterminate and overdetermined, and my analysis makes central this multi-vocal quality of automated perception. My methodological conceit in this project aligns with that of Stefanos Geroulanos and Leif Weatherby, who "propose to break with the tendency to treat cybernetics only as a subject of critique, and instead throw light on its history in such ways as to cast cybernetics as a theoretical resource in the present."[52] And, I take a similar position to that of Ronald Kline, who has historicized twentieth-century cybernetics by evidencing the profound *disunity* among the ideas of historical actors in this field.[53] The interpenetration of computer technology and operations research in the twentieth century helped to establish conditions for thoroughly integrated systems whose ascendance in sophistication of "human replacement" capabilities and proliferation in institutions effected a technological seamlessness and operated outside the bounds of perceptibility. Kline's scholarship illuminates the decidedly non-teleological aspects of cyberneticists' ideas that otherwise appear to have been instantiating in self-regulating information machines the very simulation of processes of entropy, negative entropy, and a teleological construct of historical time and technological progress. Following Kline, I use a historiographic method in order to highlight the conceptual concerns of historical actors that didn't univocally cohere in the popularized, overarching narrative and that make that narrative's seams perceptible and intellectually productive for the present.

Patterning Recognition takes the stand that there is no singular "perception" to be recovered; rather, it probes at the very conditions, which are nonetheless technically conditioned, from which perceptual activity and possibilities emerge. Some of the most potent ideas I have identified for taking on such a project emerge from within the field of cybernetics, artificial

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[52] Stefanos Geroulanos and Leif Weatherby, "Cybernetics and the human sciences," in *History of the Human Sciences* 33, no. 1 (2020), 3–11, 6.

[53] Ronald Kline, "How disunity matters to the history of cybernetics in the human sciences in the United States, 1940–1980," *History of the Human Sciences* 33 no. 1 (May 2020): 12–35. See also, Ronald Kline, *The Cybernetics Moment: Or Why We Call Our Age the Information Age* (Baltimore, MD: Johns Hopkins University Press, 2015).

intelligence, and cognitive psychology—those disciplines contending with the very possibility—and, importantly, limits—of mechanical and electronic models of human perception. For example, in the mid-twentieth century Gregory Bateson developed the notion of metacommunication in human behavior, drawing attention to the ways in which people, in interpersonal situations, co-construct the very *channel* of communication simultaneously with their expressing the *contents* of communication.[54] That channel, or set of parameters, is as much a matter of perceptual understanding as it is of symbolic exchange. Ulric Neisser argued for his colleagues in computer science to recognize a paradoxical condition of human perception that eludes computational replication: On one hand, the very parameters for recognizing patterns in embodied perception are often not available to people in explicit terms, either by way of empirical study of experience or through mechanical or digital representations of the eye and brain. On the other hand, a quality of human beings is a capacity to (learn to) "'turn round upon their own "schemata" and to construct them afresh.'"[55] As Eleanor Gibson discovered, the means of perception in humans are largely a matter not of innate rules but of learning through experience.[56] And on this note and implicitly in response to Neisser's and Eleanor Gibson's claims, James J. Gibson would develop the notion that, through their experiences connecting them to rich ecological (social and natural) systems, people can learn *to recognize recognition as such*.[57]

These rich theoretical interventions offer frameworks for thinking about how people can develop ways of consciously apprehending their means of perceiving, whether those be the habituations acquired individually or as part of social institutions (and their ideological frameworks), and rewriting those very perceptual rules. In drawing out the multifaceted quality of perception, *Patterning Recognition* exposes both the surprising affordances of automation in the sensing, organic body and the limitations of automation technology in simply replicating perceptual acts that mediate access between an agent and a complex environment.

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[54] See Gregory Bateson, "A Theory of Play and Fantasy," in *Steps to an Ecology of Mind* (Chicago: U of Chicago Press, 2000 [1955]): 177–193.

[55] Ulric Neisser, *Cognitive Psychology* (Englewood Cliffs, NJ: Prentice Hall, 1967), 293.

[56] See Eleanor Gibson, *The Principles of Perceptual Learning and Development* (New York: Appleton-Century-Crofts, 1969).

[57] See James J. Gibson, *The Ecological Approach to Visual Perception* (Hillsdale, NJ: Lawrence Erlbaum Associates, 1986 [1979]).

Part One

Bodily Automaticity

—Chapter 01—

Couplings: Industrial Automation, Interactive Film, and Neural Organization

In his popular 1950 book *The Human Use of Human Beings: Cybernetics and Society*, the computer scientist and philosopher Norbert Wiener proposes the concept of an "automatic factory."[58] This speculative plant would build on those self-regulating mechanisms whose inventions prompted the industrial revolution, such as the steam engine and then the electrical motor and vacuum tube and eventually, in Wiener's historical moment, computing technology. According to Wiener's teleology, "The notion of programming in the factory had already become familiar through the work of [Frederick Winslow] Taylor and the Gilbreths [(Frank and Lillian)] … and was ready to be transferred to the machine. This offered considerable difficulty of detail, but no great difficulty of principle. I was thus convinced as far back as 1940 that the automatic factory was on the horizon."[59] The automatic factory would mark the possible excision of the human being from factory operations. And yet, Wiener bases his very notion of industrial automaticity on a metaphor of an organism:

> The computing machine represents the center of the automatic factory, but it will never be the whole factory…. The all-over system will correspond to the complete animal with sense organs, effectors, and proprioceptors, and not, as in the ultra-rapid computing machine, to an isolated brain, dependent for its experiences [sensing] and for its effectiveness [motor activity] on our intervention.[60]

Seamless functioning is thus reliant on the machinic replacement of human visual, aural, and tactile sensing; motor activity; and the computer's "judgements at a low level."[61]

Wiener's automatic factory description both cites Taylor, the originator of scientific management, but also inverts his core principle. In Taylor's 1911 text explicating his strategy for factory organization, he introduces the dictum, "In the past the man has been first; in the future the system must be first."[62] Systematization, in Taylor's conception of it, was informed by the ways of machine parts and their mechanisms, as the human body's unwieldy quality was thought to be the very problem scientific management was to overcome. Wiener's invocation of the body

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[58] Norbert Wiener, *Human Use of Human Beings: Cybernetics and Society* (London: Free Association Press, 1950), 150.

[59] Wiener, *Human Use of Human Beings*, 150.

[60] Wiener, *Human Use of Human Beings*, 157.

[61] Wiener, Human Use of Human Beings, 159.

[62] Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper and Brothers, 1913), 7.

as a reference point for ultimate automation is no surprise given his extensive study of the human nervous system as reference point for self-organizing computers, and the field cybernetics more broadly. But on the theme of an automatic manufactory, his citing Frank and Lillian Gilbreth is particularly apt. In 1917, industrial psychologist Lillian Gilbreth had introduced the notion of "the human factor," which was an experimental attempt to reconcile a profound problem emerging in the early twentieth century: increasingly, the scale and speed of industrial technology was incompatible with those of the human form.[63] Though supporting the industrialist pursuit of efficiency, Lillian Gilbreth thought it necessary to organize a workforce by addressing workers' bodies as nervous systems—calibrating them individually to align with efficient workflows and coordinating them into efficiently coupled networks. She originated the notion that factories, to be both efficient and sustaining, should be like organisms.

The neurologically informed theory of the human factor presages Wiener's speculative displacement of the person from the factory. Yet it also is an originary conception of an *interface* between oppositional machine and worker, among coordinated workers, and across an individual's own proprioceptive sensations. Lillian Gilbreth, with her husband Frank, would put theory into practice, through a suite of industrial laborer training programs that used the then-nascent film technology to materialize an encounter between human figure and industrial environment that could forge their harmonious, ergonomic compatibility.

Lillian Gilbreth occupied a peculiar position within her industrialist milieu. Contemporaries recognized her and Frank Gilbreth for developing motion study, which merged moving-image techniques with the principles of scientific management. Film scholars have since historicized the two of them as standard-bearers of the industrial film genre.[64] Like her peers in industry, Lillian was a proponent of factory automation. Anson Rabinbach's term *productivism* best captures the ethos underlying the Gilbreths' approach to scientific management.[65] Productivism collapsed the material specificity of the human body and machine to treat both as interchangeable sites for the conversion of energy. Paradoxically, because efficiency was the prized criterion for determining value, the particular qualities that furthered or inhibited productive power were of utmost concern. Many scientific management experts, including Frank, treated the human worker according to the logic of the machine, or what critics have characterized as the total rationalization of labor and leisure.[66] Within this framework, the concept of the human factor appears merely as a way to engineer worker comfort in otherwise inhospitable manufacturing settings. However, as I will show, Lillian Gilbreth shrewdly stressed what others disavowed—that factories relied extensively on the smooth functioning and productive capacity of each body on staff. Accounting for individuals' physiological and psychic proclivities could directly increase industrial yield. Lillian Gilbreth did not simply nudge her

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63 This term first appears in the 1917 conference proceedings of the National Conference of the Western Efficiency Society in a paper Lillian Gilbreth wrote titled "Measurement of the Human Factor in Industry."

64 See Scott Curtis, "Images of Efficiency: The Films of Frank B. Gilbreth," in Films That Work: Industrial Film and the Productivity of Media, ed. Vinzenz Hediger and Patrick Vonderau (Amsterdam: Amsterdam University Press, 2009), 85–99.

65 Anson Rabinbach, The Human Motor (New York: Basic Books, 1990), 3. Rabinbach's study focuses on European thought and scientific culture. I have found that productivism aptly describes the set of conscious and unconscious values and activities of the Gilbreth milieu in the United States during this same period.

66 Contemporary critics of industrialization, such as those of the Frankfurt School, were commenting on "the social costs of modernity conceived as the increasing colonization … of social relations by abstract and quantitative relationships." Rabinbach, The Human Motor, 85.

contemporaries into more morally sound territory but established a new way to address worker-subjects, the echoes of which are acutely present across today's digital-media environment.

Gilbreth's 1914 book *The Psychology of Management: The Function of the Mind in Determining, Teaching, and Installing Methods of Least Waste* and related writings draw on the nascent field of psychology.[67] In these publications, she positions media exhibition as a site for establishing relations between still and moving images, factory systems design, and human sensory experience. In this chapter I analyze these works as a means to interpret the overarching Gilbreth project. Frank has largely garnered the credit for the duo's motion-study films and inventions, because Lillian, as a woman and a mother of twelve, was rarely present on the factory floor, where media was directly put to use.[68] Having undertaken extensive study in philosophy and pedagogy and obtaining a doctorate in psychology from Brown University, Lillian was the theoretician, not the practitioner, of the couple. Her medial position afforded some analytical distance that allowed her to bridge disciplines in original ways. Writing Lillian Gilbreth into the historical record requires accounting for her simultaneous exteriority and proximity to the industrial spaces she sought to transform. The conceptual foundations she developed nonetheless provided the rationale for the Gilbreths' entire operation and are what warrant its continued relevance.[69]

The contemporary field of human-computer interaction (HCI) cites Lillian Gilbreth as its originary figure. HCI is responsible for the research, design, and development of computer hardware and software interfaces and the interactions by which people access, manipulate, and experience digital information. A familiar example of an HCI invention is the set of gestures for interacting with smartphones. For example, Apple Inc holds a 2007 patent for the interactive finger motions that sync with the iPhone's touchscreen and operating system—single tap, double tap, pinch-to-zoom.[70] These "digital" motions are historically situated, corporate-defined programs of action for users to embody.[71] Reading them through Lillian Gilbreth's human-factors concept that undergirds such design practices illuminates how they are not only externally facing computer interface commands but also interior neurological activities. Another example

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67 Lillian Gilbreth, Psychology of Management: The Functions of the Mind in Determining, Teaching, and Installing Methods of Least Waste (New York: Sturgis and Walton, 1914). Lillian Gilbreth studied psychology at UC Berkeley, Columbia, and eventually Brown, from which she obtained a PhD in 1916. This text was originally written as a PhD dissertation but was instead published for a readership of businesspeople. Frank and Lillian's subsequent writings liberally cite this text, evidencing that it became a touchstone for the overarching Gilbreth initiative..

68 For more on Lillian's family life, see Jane Lancaster, Making Time: Lillian Moller Gilbreth—A Life Beyond "Cheaper by the Dozen" (Lebanon, NH: Northeastern University Press, 2004).

69 The contemporary field of human-computer interaction (HCI) cites Lillian Gilbreth as an originator of its foundational principles (many of which are outlined in this article). HCI is responsible for the research, design, and development of computer hardware and software interfaces. A familiar example of an HCI invention is the set of gestures for interacting with a smartphone. See Jonathan Grudin, "A Moving Target: The Evolution of Human-Computer Interaction," in Human Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, 3rd ed. (Baton Rouge, FL: Taylor and Francis, 2023). Lillian Gilbreth's concepts also contributed to a genealogy of cybernetics, a field concerned with computing and information science formalized by Norbert Wiener in the 1940s and 1950s. Wiener cites the Gilbreths in The Human Use of Human Beings (1950; repr., London: Free Association Books, 1989), and his design for an "automatic factory" follows the paradigms explicitly established by Lillian Gilbreth.

70 Christie, Westerman, and Apple Inc, Detecting Gestures on Multi-Touch Sensitive Devices, US patent, issued April 12, 2011.

71 For a theorization of contemporary touchscreen media, see Jianqing Chen, "Touchscreen Media: The Touch and User-Spectators in Twenty-First Century China," Ph.D. dissertation.

demonstrates how this hyper-individualized, flexible aspect of digital technology addresses the nervous system at an institutional scale: In 2018, Amazon Technologies Inc was granted a patent for a wristband that tracks warehouse employees' precise movements and, when a motion is deemed inefficient, vibrates to coax the worker along a different path. The haptic feedback serves both an educative function and a means for furnishing the company with real-time work-rate data for worker evaluation.[72] Amazon's wearable device, and the physically situated, human activities into which it is to be embedded, indicate that in contemporary times—even amid the proliferation of artificial intelligence systems—"automatic factory" means something different than what Wiener envisioned almost a century ago. As a legacy of both early twentieth century scientific management and neuroscience-informed psychology, today it is just as important as then that "automatic" also refers to human beings interfacing with technology.

Lillian Gilbreth developed such a working definition of bodily automaticity. Her theory hinged on one paradoxical feature of the human being, as it was identified by the neuroscience and psychology of her day—bodies have the capacity to be arranged and rearranged in innumerable ways. This plasticity implies a degree of agency on the part of the workforce, but Gilbreth instead aimed to harness it to impose new work habits and, ultimately, to accelerate labor. Gilbreth conceived of workers as active learners who could conduct complex flows of energy through the dynamic factory, yet they needed to adhere to a strict set of standard, repeatable labor methods. Film and photography were apt analytical instruments, because they reorganize time and space and could therefore be used to reorganize people.

Lillian Gilbreth devised a set of motion picture exhibition practices that directly addressed the spectator's body—and features of bodily difference. The program coordinated between depicting laborers performing work-sequence motions onscreen, generating appeal and will among spectators, and occasioning their embodied mimesis. She thus positioned film as an interactive medium. Motion study was conceived not only as a means for depicting work but, through scrutinizing sensory-motor training, as a way to program, or install, specific embodied acts. Gilbreth argues that film screenings could calibrate one's sensory organs, articulate one's thoughts from without, and order one's limbs to engage with workshop implements according to a rigidly specified sequence. Gilbreth's rubric for gestural and behavioral comportment conveys a political approach to factory organization. Film and photography, framed as *interactive media*, emerged as modes of exchange that paradoxically promoted the liberal ideals of freedom and choice while imposing homogenized and predictable behavior.

FROM WORKER-AS-MACHINE TO FACTORY-AS-ORGANISM

Lillian Gilbreth's writings introduce a novel framework for instrumentalizing the principles of academic psychology for industry (see fig. 1). *Psychology of Management* triangulates the period's predominant voices in these two fields—William James and Frederick Winslow Taylor, respectively—with the exhibitory possibilities of visual media.[73] She aimed to unite factories and

[72] Cohn and Amazon Technologies Inc, Ultrasonic bracelet and receiver for detecting position in 2D plane, US patent, issued January 30, 2018.

[73] Lillian Gilbreth's contemporary, industrial psychologist Hugo Münsterberg (who was also a follower and colleague of James), also published on the use of psychology in industry (in 1913), and about film's relation to the mind (in 1916). Unlike Münsterberg, who treated the factory and cinema as two distinct realms, Lillian Gilbreth champions film and photography specifically for their capacity to effect industrial efficiency. See Hugo Münsterberg, *Psychology and*

laborers by refashioning both to form a new, optimally functioning whole. Scientific management as invented by Taylor had transformed labor practices by separating work method from work product and removing the responsibility for determining how a job could be completed from the person who was to perform it.[74] Traditionally, workers were evaluated on a final outcome but could freely determine their route to get there. Taylorism systematized the route; it discretized processes into their most basic and repeatable functions so that employees could develop expertise in one narrow feature of the job. Lillian was committed to scientific management's emphasis on abstraction and procedure as a means for obtaining efficiency. *Psychology of Management* in fact implicitly reanimates Taylor's proposition that the system be prioritized over the human being.[75] Yet, Taylor's mechanical form of functionalization would, Lillian argued, "turn men into machines."[76]



Figure 1: Lillian Gilbreth, ca. 1913 (Courtesy of Purdue University Archives and Special Collections, Purdue University Libraries)

Compelled to devise a more human-centered system, Lillian Gilbreth used Jamesian psychology, which she married to Taylorism by way of the concept of functionalization. Among psychologists, a function describes "'a psychologically simple process,' [comparative in] its elementariness to a muscular contraction as an element of a step in walking."[77] Those functions specifically of interest to psychologists involve "'states of consciousness,'" such as sensing, reasoning, imagining, or direct physical engagement with one's environment.[78] As singular, material processes experienced by the nervous system, functions are composed of dynamic, purposive, sequences analogous to factory work sequences, Lillian observed. This notion of purposiveness comes from William James's early conceptualization of pragmatism: "Thought in movement has thus for its only possible motive the attainment of thought at rest [also called beliefs] …. Beliefs, in short, are really rules for action; and the whole function of thinking is but

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Industrial Efficiency (Boston: Houghton Mifflin Company, 1913) and *The Photoplay: A Psychological Study* (New York: D. Appleton and Company, 1916). See also Dudley Andrew, *The Major Film Theories* (New York: Oxford University Press, 1976), chap. 1; and Giuliana Bruno, "Film, Aesthetics, Science: Hugo Münsterberg's Laboratory of Moving Images," *Grey Room* 36 (Summer 2009): 88–113.

[74] See Frederick Winslow Taylor, *The Principles of Scientific Management* (New York: Harper and Brothers Publishers, 1913).

[75] Frederick Winslow Taylor, *The Principles of Scientific Management*, 7.

[76] Lillian Gilbreth, *Psychology of Management*, 37.

[77] Gilbreth, 53, citing James Sully, *The Teacher's Handbook of Psychology* (New York: D. Appleton and company, 1910), 1.

[78] Gilbreth, 22, citing William James, *Psychology: Briefer Course* (New York: H. Holt, 1909), 1.

one step in the production of habits in action."[79] Sensing, thinking, and acting are elementary functions, at once modular and temporally connected. Together, they mediate the exchange between a subject's interior and exterior worlds. Thinking exists at the threshold of plasticity and habituation—it is unstable until it becomes fixed, at which time it directs decisive motor acts.

James's pragmatism was premised both on the philosophical ideas of his colleague Charles Sanders Pierce, but also on nineteenth-century brain science. While he did not subsume the activity of the mind to the physical properties of the nervous system, James identified analogous principles in the two. In his two-volume magnum opus, *The Principles of Psychology* (1890), James describes the paradoxical condition of organic neural organization: "We may construct [a nervous system] which will react infallibly and certainly, but it will then be capable of reacting to very few changes in the environment" and will do so in a repetitive manner. "We may, on the other hand, construct a nervous system potentially adapted to respond to an infinite variety of minute features in the situation; but … how indeterminate and unforeseeable [its] performances [will be]…. This very vagueness constitutes [its] advantage."[80] James's understanding of neural habit it peculiar, because embedded in habit's definition is its co-constitution by its very opposite. It both indicates the mechanical functioning of the brain yet is closely linked to the sophistication of the human mind. According to James, "*the phenomena of habit in living beings are due to the plasticity of the organic materials of which their bodies are composed*," plasticity being "the possession of structure weak enough to yield to an influence, but strong enough to not yield all at once."[81] In other words, habit is a direct factor of the human brain's lack of innate organization, and also for its potential to acquire structure through sense experience.

In James's analysis of nineteenth-century brain science, he updates a model developed by German-Austrian neuropsychiatrist Theodor Hermann Meynert.[82] The empirical and theoretical aim of Meynert's work centered on explaining psychological functions based on the physical structure of the nervous system.[83] Using the example of a young child touching her finger to a candle flame and, through the experience of pain, learning to avoid such a repeated experience, James describes the Meynert scheme in terms not too dissimilar to those of Wiener: "Nerve-currents run in through sense-organs, and whilst provoking reflex acts in the lower centres, they arouse ideas in the hemispheres, which either permit the reflexes in question, check them, or substitute others for them."[84] Within this view, peripheral nervous system elements controlling sensory-motor activity are activated automatically, and the central nervous system gets jolted

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[79] William James, "Philosophical Conceptions and Practical Results," *University of California Chronicle* 1, no. 4 (September 1898): 290–91. This quotation is from James's first treatise on pragmatist philosophy, in which he cites ideas previously articulated by his colleague, Charles Sanders Peirce. James presented this lecture at UC Berkeley, and the undergraduate Lillian Moller (later Gilbreth) was almost certainly in the audience. See George A. Miller, introduction to *The Principles of Psychology* by William James (Cambridge, MA: Harvard University Press, 1981), xvi; Lancaster, *Making Time*, 52; and Charles S. Peirce, "The Fixation of Belief," in *Philosophical Writings of Peirce*, ed. Justus Buchler (New York: Dover Publications, 1955), 5–22.

[80] William James, *Principles of Psychology, Volume I*, 140.

[81] James, *Principles of Psychology vI* 105.

[82] Meynert was a teacher of Sigmund Freud, who worked in his lab in Vienna in the 1880s.

[83] Otto M. Marx, "Nineteenth-Century Medical Psychology: Theoretical Problems in the Work of Griesinger, Meynert, and Wernicke," in *ISIS*, 61, no. 3 (Autumn, 1970), pp. 355–370, 362. See also Theodore Meynert, *Psychiatrie, Klinik der Erkankungen des Vorderhirns* (Wiens: Braumüller, 1884).

[84] *Principles vI*, 24.

into producing a new neural pathway that connotes some *meaning* that a flame produces bodily pain when touched and that contributes to future behavior inhibiting such movement of the forearm and finger. After proceeding through empirical examples of patients with aphasia, however, James concludes that "the lower centres are more spontaneous" and less machine-like and "the hemispheres are more automatic … than the Meynert scheme allows."[85] There is a certain determinacy to the child/candle flame example, in that the sensory experience gives way to a binary and fixed set of simple concepts (e.g., a flame has a quality of heat), and it also fixes the child's future behavior to a certain course of action (here understood in the negative, inhibiting touching the flame).

It should also be noted that the finger-to-flame is a particularly punctuated moment in a subject's experience of time, accompanied by a spontaneous interruption of nervous activity. But not all experiences will elicit such conscious intervention, nor will all thinking involve a rewriting of one's anticipatory behavior ad infinitum. It takes a certain kind of (pre)cognitive function that can facilitate such an interaction, a non-focal style of attention, which happens to persistently operate just out of the focal point of consciousness yet nonetheless shapes it. Two things factor significantly in making such a material alteration of ideational processes possible. First is the notion of plenitude, that quality that necessitates habit in the human, and the second is fringe consciousness. The senses, the brain and mind, and the effector organs all have the capacity to do *more than* any single moment allows them to do. Thus, "consciousness is at all times *a selecting agency.*" [86] Habits of thought and bodily activities are but repetitions of selections once made.

Lillian Gilbreth wagered that, in the vein of James, if "thought at rest" and "rules for action," could be decoupled from the individual and exteriorized, they could form a basis for worker training that would produce human-centered yet automatic factory operations.[87] Both James's pragmatism and Taylor's functional system disarticulate means from ends, planning from doing. The ways bodies are represented on screen in the Gilbreth film collection makes these conceptual principles visible and material.

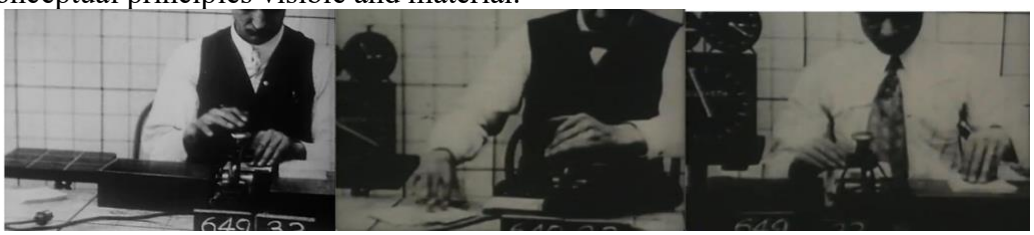


Figure 2: Stills from three short motion-study films, each demonstrating a method for stamping memos. From left to right, the methods get progressively more efficient by distributing the work across different limbs. (Courtesy of Purdue University Archives)

[85] *Principle vI*, 72. It is this chapter ("Functions of the Brain") in which James begins to develop his theory of emotions (which would eventually get canonized as the James-Lange theory of emotions), which is beyond the scope of this essay. Nonetheless, the emotions, like fringe consciousness, operate as something of a go-between between automatic and conscious activity. On page 76, James states that feelings are "native tendencies" that contribute in the production of reflex behavior. They are also complex, nonconscious, selectors of sensory and proprioceptive information for conscious attention in the mind. Fringe consciousness, as I am reading it, is an effect of the activity of the emotions, in part.

[86] *Principles vI*, 139.

[87] It should be noted that James's own intellectual commitments, especially those by the early twentieth century, swerved in the opposite direction and examined those aspects of human experience that exceeded machine automation. See David William Bates, "Unstable Brains and Ordered Societies," in *Distributed Perception: Resonances and Axiologies*, ed. Natasha Lushetich and Iain Campbell (London: Routledge, 2022), 117–29.

Many Gilbreth films demonstrate precise performances of such action programs, embodying Lillian's industrialist reading of James (see fig. 2). In *Psychology of Management*, she asserts that "the best worker to observe [on film] is he who is so skilled that he can perform a cycle of prescribed standard motions automatically, without mental concentration."[88] One set of moving-image sequences features a worker who demonstrates methods for stamping dates on memos. In the most optimized version, the left hand feeds the memo to the stamp, the foot (which is out of the frame) presses a pump that forces the stamp down, and the right hand pulls the memo out. Each limb is an independent entity, engaging with discrete materials in a whirling yet procedural dance with technology. This so-called exemplary standard is a vigorous, hyperbolic display of able-bodied labor. By design, the individual figure acts as a container for peripheral neural activity rather than a site for consciousness. Like her counterparts in industry, Lillian Gilbreth championed a reorganization of the human form that had desubjectifying effects. However, she was doing so not according to the logic of a rationalized machine, but on the human body's own terms. Indeed, *Psychology of Management* affirms the Taylorist premise that workers "should be accustomed to being measured, physically and psychologically" yet focuses on the embodied means by which they can recognize themselves as subjects of measurement.[89] Further, the "great advantage of micro-motion study," Lillian argues, is not only that it "demands cooperation" of the filmed individual but also that "its results are open to study by all."[90] The value of film exhibition, then, depended on its ability to shape workers' perceptions of their own bodies, psyches, and social standing.

This reference to an audience of factory spectators suggests the second objective of *Psychology of Management*: deciphering how to intricately coordinate large, diverse groups of laborers to improve productivity. The text (re)maps psychology (which focuses on the corporeally bound individual) onto an institutional body (see fig.3). Just as the memo-stamping movie demonstrates the routing of hand gestures across the work surface and horizon line of the film frame, "the workers themselves are routed [through the factory] by means of the … route chart…. These programmes are no dead, static things. They are alive, pulsing, moving, progressing with the progress of the work."[91] The film and graphical chart alike call attention not to the subjects and objects involved in work but rather to motion as a phenomenon abstracted from scale and matter. A body is a transferrable concept; its functions are not essentially related to the entity performing them, and that coupling can be rewritten. Gilbreth's text performs an analytical move that, I argue, replaces the metaphor of human as machine with an inverted scheme—factory as organism.

Psychology of Management conceives of workers not as cogs in a mechanical system but as organs whose reliable performance of a single function, and integration with other organs, is instrumental to the sustained existence of the whole. Accordingly, duties are classified in organic terms as sensing, thinking, or acting. This human-factor approach was by no means a radical departure from Taylor, however, from whom the text draws its insistence on the distinction between manager and worker. Lillian Gilbreth cast the body in hierarchical terms: factory

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[88] Lillian Gilbreth, *Psychology of Management*, 103.

[89] Gilbreth, 105.

[90] Gilbreth, 103.

[91] Gilbreth, 194–95

managers would be "eye workers" and engage in distanced, analytical observation.[92] Those responsible for the manual labor, alternatively, were to develop "a fineness of touch" and become "fingerwise."[93] Film and photography were, too, endowed with a dual role along sensorial lines. On one hand, filmstrips and long-exposure photographs enabled managers to meticulously study workers in action and determine methods of least waste. On the other, moving images offered a visually appealing template of gestural motion that groups of worker-spectators could directly imitate. Replace sentence with: Lillian called this "installing methods of least waste."[94] Ultimately, the Lillian Gilbreth method sought to develop and nurture a kinesthetic sense.

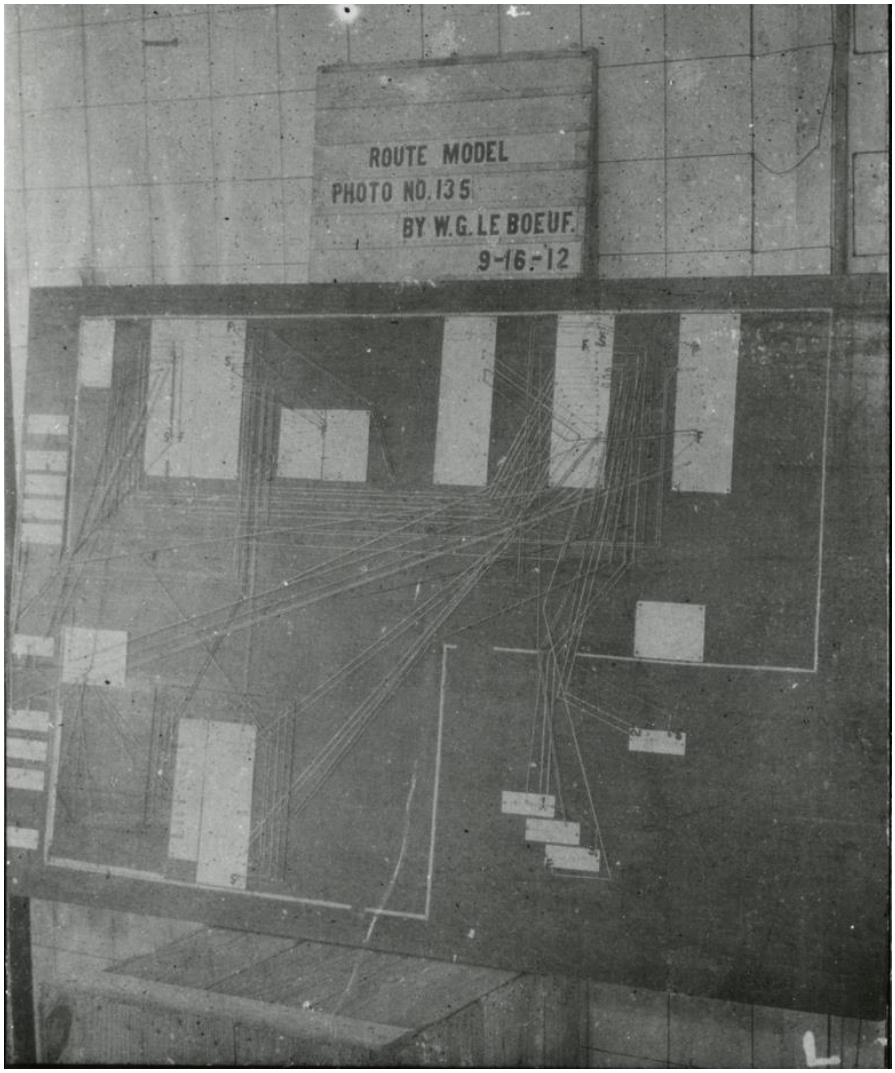


Figure 3: A route model visualizing workflows throughout an institution conveys the Gilbreth prioritization of motion and circulation at all scales. (Courtesy of Frank and Lillian Gilbreth Collection, Archives Center, National Museum of American History [NMAH],

[92] Gilbreth, 153. Notably, this hierarchy of the senses departs from James.

[93] Gilbreth., 229, 262.

[94] This quote refers to the subtitle of Lillian Gilbreth's book, *The Psychology of Management: The Function of the Mind in Determining, Teaching, and Installing Methods of Least Waste*.

EYE WORK

Lillian Gilbreth intimates that managers must concoct the artificial life force of a factory system. If organs perform one single function in perpetuity, what should those standard and predictable functions be? What arrangement of temporally bound routes produces the most efficient flow? Gilbreth used the term *eye worker* to describe the manager's role in pursuing these inquiries. Eye work exploited chronophotography and cinema as feedback mechanisms for the analytical study and optimization of motion sequences (see fig. 4).[95] A Lillian-focused reading of the Gilbreth oeuvre reveals a notion of visual media that couples human eye with camera eye and correlates representation with bodily process.



Figure 4: Frank Gilbreth and an assistant study a filmstrip, ca. 1920s (Courtesy of Purdue University Archives)

Most studies of the Gilbreths focus on the Frank-designed photographic instruments and their representational productions, instead of the viewing contexts and spectatorial effects that Lillian emphasized. This scholarship tends to examine the usefulness of Gilbreth visual media in measuring work and workers, an evaluation criterion adopted from Frank himself, whose pitch was founded on such a claim. Scott Curtis, for example, has argued that Frank's pictures performed their own work for the Gilbreth enterprise. In the name of precision, the Gilbreths painted the film studio with black-and-white grid lines and included in each film frame a chronometer device that tracked the shot's duration. Curtis calls attention to the sloppy execution and awkward placement of these visual markers, reading them as indicators that these "images are not about information" but about "selling the technique and wonder of the camera."[96] Commenting on the similarity in visual form and material practices between motion-study films and graphical models such as the route map, Florian Hoof similarly maintains that this "data stream" media aestheticized

[95] Etymologically, this means "time photographs." This photographic method is often attributed originally to the French physiologist Étienne-Jules Marey. Frank Gilbreth patented an apparatus for producing chronophotographs (see fig. 5). See a discussion of Marey in Rabinbach, *The Human Motor*, chap. 4; and Mary Ann Doane, *The Emergence of Cinematic Time* (Cambridge, MA: Harvard University Press, 2002), chap. 2.

[96] Curtis, "Images of Efficiency," 96.

mechanical process to promote Gilbreth corporate consulting as a scientific endeavor.[97] The Gilbreth image apparatus thereby demonstrates, Hoof asserts, how "[Frank] Gilbreth *replaced* the implicit experience of the work inspectors with the notion of the mechanical objectivity of the … media recording" (emphasis added).[98] However unsuccessful Frank was at supplying useful photographic information, Hoof's view suggests his corporate endeavor successfully promoted not only itself but also a conception of automation as synonymous with the outright displacement of both manual and intellectual labor. These conclusions inject a Frank-centric view into the Gilbreth archive and its historical role within the 1910s male-dominated milieu of industrial production and technology valorization.

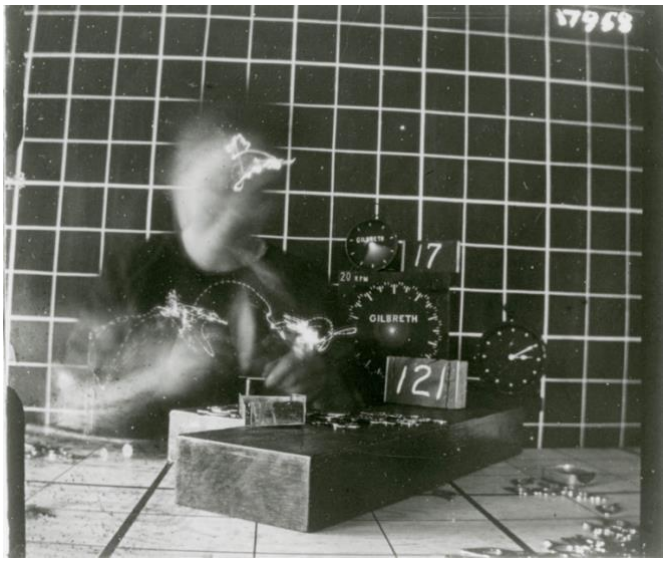


Figure 5: A Gilbreth chronophotograph produced using the method demonstrated in the patent. (Courtesy of NMAH, Smithsonian Institution).

Lillian's eye-work media practices, alternatively, reveal a paradigm that intimately joins eye workers with imaging technology. Descriptions of the qualifications of the eye-worker foreman feature prominently in *Psychology of Management*, making apparent an ethos of automation that stands apart from the worker-replacement principles associated with Frank. The eye worker should be "specially selected for the position" based on a combination of "natural fitness," factory experience, and perceptual training: "The natural qualities of the successful hunter, fisherman, detective, reporter and woodsman for observation of minute details are extremely desirable.… The observer must also familiarize himself with the literature regarding motion study … and … form the habit of recording systematically the minutest details observable."[99] The camera is presented as an extension of the eye worker's physiological form and embodied intuitive sensing. Though this person should be "an enthusiastic photographer" and "able to concentrate attention for unusually long periods," he must also avoid skewing

[97] Florian Hoof, *Angels of Efficiency* (Oxford, UK: Oxford University Press, 2020), 163.

[98] Hoof, 208.

[99] Lillian Gilbreth, *Psychology of Management*, 99–100.

measurement data with unconscious bias.[100] The observation principles Lillian describes position measurement practices and quantitative abstraction, on one hand, and biological and psychological processes, on the other, as complementary and co-constitutive. Gilbreth's method did not wholly offload observational duties onto the machine but called for an eye worker's thorough innervation of measurement-vision.

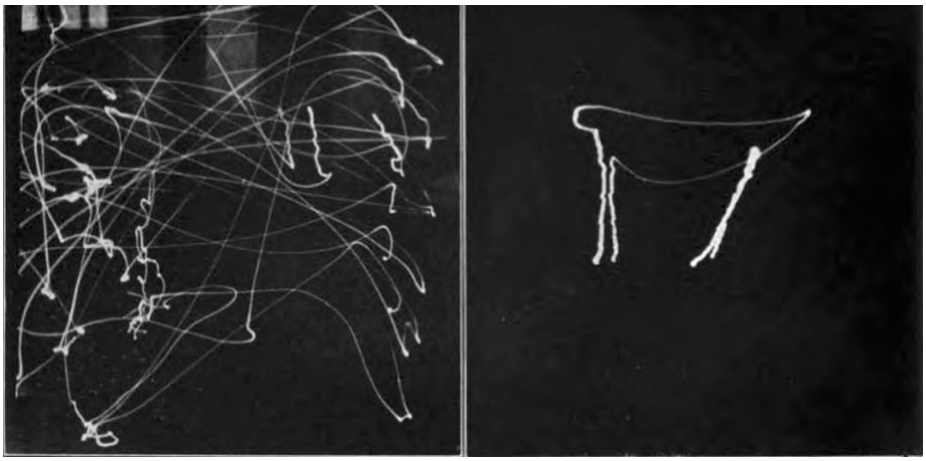


Figure 6: Gilbreth chronophotographs produced using the chronocyclegraph device. Demonstrated here are two methods for loading boxes on a truck, the right-hand example representing optimized motion ("The Magic of Motion Study," in The World at Work [1916])

The perceptual work of the manager involved the making and rigorous study of photographic records. If the visual scheme best suited to represent Frank's endeavors was the grid, that which best illuminates Lillian's theory is the chronophotograph, also termed the cyclegraph (see figs. 5, 6, and 7). By attaching lights to workers' fingers and shooting a long-exposure photo as they executed the work sequence, the cyclegraph "recorded … all of that motion at once," onto a single image plane. The resulting compositions featured high-contrast patterns of arced light-paths.[101] These imagistic objects usefully cultivated eye-work interpretive methods. Lillian Gilbreth based these methods on the Jamesian principle that, "all consciousness is motor … [and] *every possible feeling produces a movement … of the entire organism*," often unconsciously (original emphasis).[102] She demonstrates this idea in a number of unpublished briefs that frame chronophotographs as expressive of far more than the labor itself. For instance, "Let us now examine these pictures in detail…. The more skilled the worker the more smooth the curves of the cyclegraph…. The more out of practice the more jerky the curves";[103] and "A chronocyclegraph apparatus … records a simultaneous recapitulation of all the worker's motions,

[100] Gilbreth, 101.

[101] Lillian Gilbreth, "Cyclegraph Analysis," n.d., 1, MSP 8, series 1, box 128, Gilbreth Library of Management Research and Professional Papers, Archives and Special Collections, Purdue University Libraries, West Lafayette, Indiana (hereafter Gilbreth Professional Papers).

[102] William James, *Psychology: Briefer Course* (New York: Harper and Brothers, 1961), 237; see also Gilbreth, *Psychology of Management*, 160.

[103] Lillian Gilbreth, "Cyclegraph Analysis," 3. See also Lillian Gilbreth, "Index of Automaticity," n.d., 1, series 6, box 47, Gilbreth Papers: "The relative intensity of the light dashes or lines registers duration at a given place in the cycle," and "the amount of time that the hands are late in arriving at the places looked at by the eyes [of the worker] [are] an Index of Automaticity."

and at the same time records … the still or resting points, habit, mental inertia, mental hesitation, and other human characteristics."[104] These pictorial compositions, despite not representing a legible body, nonetheless registered nervous-system activity and their environmental effects.[105] Motion as depicted in the image may have been decoupled from the body that produced it, but image-supported eye work was inseparable from the body of the photo's referent and that of the manager-observer.

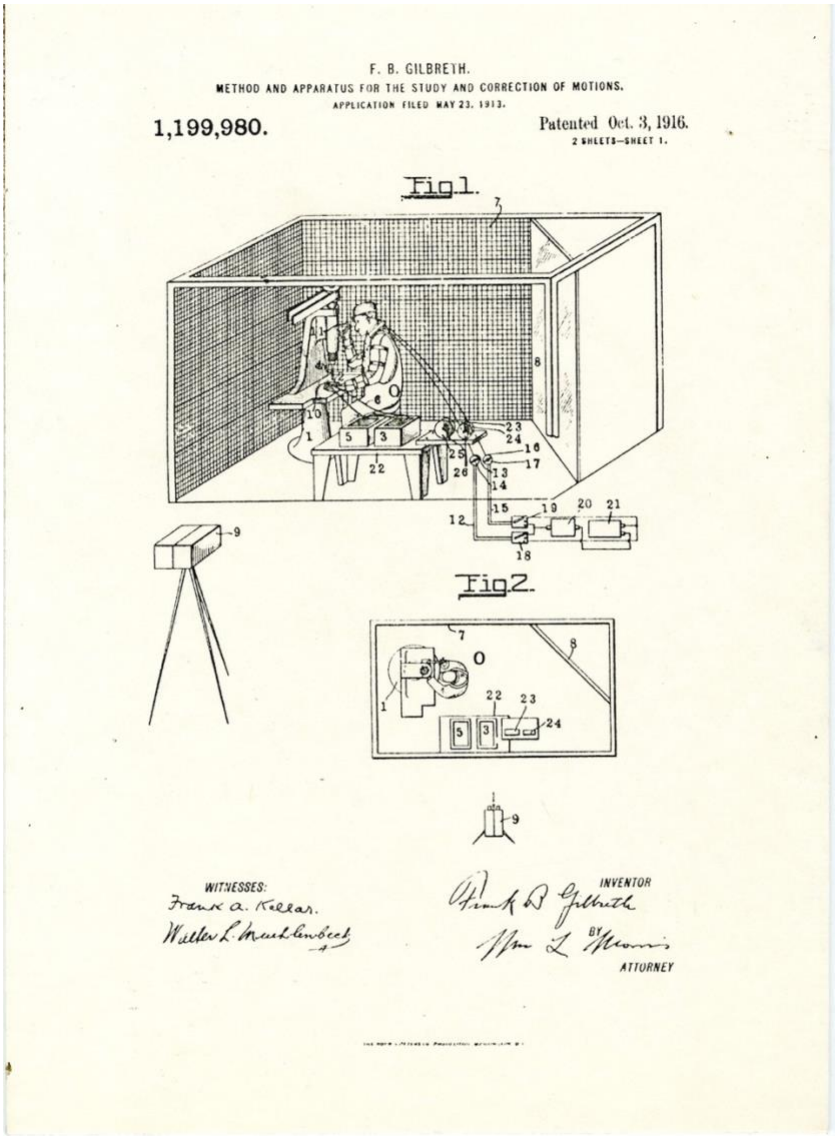

F. B. GILBRETH.
METHOD AND APPARATUS FOR THE STUDY AND CORRECTION OF MOTIONS.
APPLICATION FILED MAY 23, 1913.
1,199,980. Patented Oct. 3, 1916.
2 SHEETS—SHEET 1.
Fig. 1.
Fig. 2.
WITNESSES:
INVENTOR
ATTORNEY

Figure 7: Patent for the chronocyclegraph device. This apparatus consisted of small lights attached to the fingers and head of the subject and a camera taking low-light, long-exposure photographs. (Courtesy of NMAH, Smithsonian Institution)

[104] Lillian Gilbreth, "Standardizing Methods for Transferring Skill," n.d., Gilbreth Professional Papers, series 1, box 128.

[105] For a theorization of the relationship between representation, abstraction, and the body in turn-of-the-century modernity, see Lisa Cartwright, *Screening the Body: Tracing Medicine's Visual Culture* (Minneapolis: University of Minnesota Press, 1995); and Doane, *Emergence of Cinematic Time*.

Recognizing and anticipating a worker's interior bodily activations served the ultimate goal, which was to preempt them by way of a set of standard motion sequences. Worker fatigue emerged as a focal point for the Gilbreths because even as it manifested differently in individuals, it was one of the most ubiquitous threats to overall productivity.[106] Planning departments were to discern the signifiers of depleted energy, "prophesying" the necessary duration of "rest from [work's] resulting fatigue." The departments would then design work-process programs that could maintain supply and prevent deleterious effects (see fig. 8).[107] One film that illustrates this initiative consists of a wide shot of a lumberyard in which two laborers perform a simple task: they pick up a log from a small lower-level pile, walk up a ramp, drop the log in a raised stack, walk down an adjacent ramp, and repeat the cycle several times. Then they sit down on a bench and idly look out into the distance. With this atypical representation of inaction, the Gilbreths demonstrate a factory-wide method in which rests are scheduled at standard intervals to preclude the spontaneous appearance of disruptive states.[108]



Figure 8: Stills from a motion-study film demonstrating workers in a lumberyard taking scheduled rests (Courtesy of Purdue University Archives)

If Frank's media instruments divide the body into individually measurable units, Lillian's camera-assisted eye worker synthesizes bits of motion into holistic work cycles and joins individual workers into a system of dynamically arranged, reliable functional components: "The synthesist must have a constructive mind.… He must have the ability to see the completed whole … and to regard the elements with which he works not only as units, but … [he] must feel the inter-relation between these elements."[109] The log-stacking film is one of countless Gilbreth demonstrations of waste-free, standardized motions that both created a visual record of the eye worker's work-sequence planning and served as a continuously available model, or motion program, for instilling future-proof automaticity in workers. Within this framework, still and moving pictures were understood both as inscriptions that fixed and stabilized standards and, paradoxically, as mediating forces orchestrating live, organic, and otherwise unstable human–factory interaction.

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[106] See Frank and Lillian Gilbreth, *Fatigue Study* (New York: MacMillan, 1916).

[107] Gilbreth, *Psychology of Management*, 68.

[108] See this method described in Gilbreth and Gilbreth, *Fatigue Study*, 127.

[109] Lillian Gilbreth, *Psychology of Management*, 135.

INDUSTRIAL MEMORY

Central to Lillian Gilbreth's initiative for organic standardization in *Psychology of Management* was the question of how the gestural knowledge represented in the eye worker's plans could be transferred to workers. The text emphasizes the problem of how workers' "motor memory [is] improved by standardization,"[110] and therefore how media could appeal not only to the senses and the mind but, ultimately, to one's muscles. Gilbreth's pedagogy "insists in every stage of the work" on attention to "this relationship of the body to the mind, and of the surroundings, equipment, etc. of the worker to his work."[111] Training media would play two complementary roles: setting the best environmental conditions to effect a placid interior state and building a collection of images displaying model motions that worker-spectators could copy. Gilbreth called the archive of multimodal forms *industrial memory*.[112]

The factory environment, as Lillian Gilbreth defined it, was a space of sensory mediation. According to James, "the sense organs" are "'organs of selection,'"[113] but within the Taylorist hierarchical scheme, only the eye worker handled selection processes. Lillian determined that the manual worker's sensory stimulus could be reduced if surroundings reflected managers' a priori discernment: laborers should work "under standard [factory] conditions, with standard devices …, and they should be standardized from the standpoint of all of our senses as to color, shape, size, weight, location, position and surface texture."[114] These static, planned arrangements would be persistently subject to the chaos wrought by the action of labor, however, so Lillian Gilbreth went on to insist that "workers must be placed so that they do not see intermittently moving objects out of the corners of their eyes," in order to delimit the scope of what is "recorded by the senses" and retain focus



Figure 9: A Gilbreth laboratory-style film set, the aesthetics of which are to mirror the ideal conditions of the factory itself. The goal was to limit workers' visual sensory stimulation (Courtesy of Purdue University Archives).

[110] Gilbreth, 176.

[111] Gilbreth, 49.

[112] Gilbreth, 245.

[113] Gilbreth, 229, citing William James, *Psychology: Briefer Course*, 171.

[114] Gilbreth, 168.

(see fig. 9).[115] The Gilbreths' gridded film studio, well beyond simply promoting Frank's business, as Curtis argues, extended this aesthetic sensibility from the factory to the screen and vice versa, adhering to what contemporary scholars have referred to as the "media-environment dialectic" and its "to-and-fro of world cocreation."[116] Within this paradigm, visual media isn't just a form of representation but a material process that engenders emergent atmospheric and cultural dimensions and new forms of encounter.[117] Lillian triangulates these two entities, medium and environment, with workers' interiority. She reasoned that the muted, measured studio design could potentially imprint itself on a worker's mind and body.

If these environmental conditions cultivated ergonomic stabilization, specific media objects would translate motion programs between the mind of the eye worker and the hand of the manual worker. Any practical and effective conveyance, Gilbreth contended, was contingent upon accounting for the human mind's simultaneous stability and instability. She achieves this by joining William James's conceptions of the imagination and habit with specific media objects. According to James, the imagination takes one of two forms: "Imagination … [is] the faculty of reproducing copies of originals once felt. The imagination is called 'reproductive' when the copies are literal; 'productive' [or what Lillian calls constructive] when elements from different originals are recombined so as to make new wholes."[118] While the constructive imagination points to the mind's tendency to be radically unpredictable and generate wholly novel ideas, the reproductive imagination is something of a habituated thought pattern. For James, habits exist as a result of "man [*sic*] being born with a tendency to do more things than he has ready-made arrangements for in his nerve-centres" and function to "economize the expense of nervous and muscular energy."[119] The human body makes sensing, thinking, and acting automatic whenever possible as a matter of survival. Education of mind and body are intimately connected to the formation and perpetuation of habits, linking the individual to the social realm. As such, habits are weighted with an social dimension, serving as society's "most precious conservative agent," bound to "doom" many by instilling behaviors that don't necessarily suit them and reinforcing class distinctions.[120] Yet, habits are learned automatic behaviors, not innate ones, and can therefore be altered.

Informed by the neuroscience of the day, James explains the principles for breaking or instilling a new habit. The process involves, first, having an imagined objective for voluntary, nonhabituated actions. Second, and crucially, James implores anyone looking to refashion a habit to "*seize the very first possible opportunity to act on every resolution you make*.… It is … in the moment of their producing *motor effects* that resolves and aspirations communicate the new 'set' to the brain" (original emphasis).[121] Habituated thoughts and motor activity are both time-based,

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[115] Gilbreth, 160–1. See also Frank Gilbreth and Lillian Gilbreth, *Applied Motion Study: A Collection of Papers on the Efficient Method to Industrial Preparedness* (1917; repr., New York: MacMillan Company, 1919).

[116] James Leo Cahill, Brian R. Jacobson, and Weihong Bao, "Media Climates: An Introduction," *Representations* 157, no. 1 (Winter 2022): 1–16, 4.

[117] Cahill, Jacobson, and Bao, "Media Climates," 9–10.

[118] William James, *The Principles of Psychology*, 2 vols. (New York: Dover Publications, 1950 [1890]), 44.

[119] James, *Principles of Psychology*, 1: 113.

[120] James, 1: 121.

[121] James, 1: 124.

sequenced events, and overhauling them requires repeating new action programs until they form imprints in the central and peripheral nervous system alike. Mind and hand are inseparable collaborators in this endeavor.

In Lillian Gilbreth's translation of these ideas for industry, the eye worker provided the constructive imagination, and his specific motion designs served as the imagined end for a new motor habit. At the same time, Gilbreth wanted to create media reception contexts that facilitated the "systematic exercising and guiding of the imaginations of apprentices and learners."[122] Photography and films produced exterior copies of specific ideas within the "directing mind" of the eye worker,[123] making them concrete, temporally stable, and perpetually available for worker training. Different media forms would work in concert, each reproducing the eye worker's faculties in a unique way: "The instruction card … acts as a form of transferable memory—it conserves memory…. Two-dimension photographs *surpass the highest forms of mental imagery* … [emphasis added]. There is no kind of memory, visualization, nor constructive imagination that can equal the stereoscopic or three-dimension photographs … for enabling the worker to 'see the completed work before it is begun.'"[124] Gilbreth's pedagogical media aimed to act as a set of "mnemonic classifications" to "furnish" the worker with "the equivalent of memory of other experiences that he has never had."[125] If Gilbreth is espousing an equivalency between physical picture and mental image, the conceptual problem of joining this modular industrial memory to a body still remained. While textual and still-image media offer a "model [that] shows desired results" in a Jamesian sense, "the demonstration … by means of films … [shows] desired methods" in sequenced, live-action form.[126] This time-based medium tracked with the lived time of nervous-system and muscle-activation processes, and it offered an endlessly repeatable experience.[127] In this regard, Gilbreth was drawing on the principle that viewing a film could in fact stabilize mind-body processes like no other media form. Therefore, cinematic spectatorship could best provoke the action to overcome new "habit interference" and inscribe industrial memory at the level of muscle memory.[128]

FILM EXHIBITION, OR INSTALLING HABITS

A certain model of film exhibition united Lillian Gilbreth's pedagogical theory with the couple's industrial practice. *Psychology of Management* provided an interactive mode of address for installing habits that translated to factory reception environments. Throughout the majority of the 1910s, the Gilbreths staged film screenings on factory floors, the very spaces where worker-spectators were to labor. During this period, a vast proportion of those entering industry were

[122] Gilbreth, *Psychology of Management*, 249.

[123] Gilbreth, 147.

[124] Gilbreth., 177.

[125] Gilbreth, 247.

[126] Gilbreth, 227.

[127] Gilbreth, "Cyclegraph Analysis," 1; and Gilbreth, *Psychology of Management*, 227.

[128] Lillian Gilbreth, "Photographing Mental Processes," 1921, 3, series 1, box 122, Gilbreth Professional Papers.

immigrants from various cultural backgrounds and geographic locations.[129] Lillian argues that "'a micro-motion study film' … [is] especially valuable where the workers do not speak the same language … [and] where many workers are to perform exactly similar work."[130] Film viewing could assist in eradicating difference, it was thought, by generating both universal appeal and inducing sameness in actual bodily activity and labor output. Yet, the film stock recorded the particularities of the individual performing onscreen. The Gilbreths exploited this feature of the medium in their small-scale productions by offering workers the opportunity, upon achieving expert status, to be selected as the model laborer in front of the camera.[131] During exhibitions, fellow mates would then be invited to comment on and critique the motions acted out on film in the actor-worker's presence.[132] *Psychology of Management*'s instructions for film exhibition, as well as the extant documentation of actual screenings, emphasize this reflexivity and recursion, whereby workers could, in effect, see themselves in the work and simultaneously undergo a thorough habit transformation.

On factory floors, film reception environments were made to duplicate the muted quality of the gridded studio. Gilbreth's writings suggest that worker-spectators oriented themselves toward the eye-level screen, so that their bodies mirrored the figure presented in the cinematic picture (see fig. 10). Thanks to the use of a hand-cranked projector, "films could be run as fast or as slowly as may be desired" for training purposes.[133] Correct motions of unfamiliar work sequences could be first introduced via onscreen images played at a reduced speed and then sped up as workers learned the templated gestural pathways.[134] Frank would also manipulate playback speed to distinguish between correct and incorrect motions, rendering the latter either hyperbolically slow or untenably fast.[135] The looping of film strips supported the drive for repetition and therefore habituation. Lillian devised a practice in which foremen experts performed live demonstrations alongside and in sync with the projected moving image.[136] Her writings encourage managers to have viewers physically imitate the depicted motions at every possible opportunity, whether directly engaging with the material environment or only with the projected image, in order to develop a haptic aptitude.[137] Visual experience could therefore be translated to motor activity in the most direct line possible: "The standards … educate hand and

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[129] For an examination of the ways in which industrial film was employed to address diversity among immigrant and working-class worker populations, see Lee Grieveson, "The Work of Film in the Age of Fordist Mechanization," *Cinema Journal* 51, no. 3 (Spring 2012): 39.

[130] Gilbreth, *Psychology of Management*, 226.

[131] Several Gilbreth texts propose this practice. See Gilbreth, *Psychology of Management* and Gilbreth and Gilbreth, *Applied Motion Study*, in particular.

[132] Reginald T. Townsend, "The Magic of Motion Study," *World's Work*, May 1916, 323–24.

[133] Townsend, "Magic of Motion Study," 324. See also, Gilbreth and Gilbreth, *Applied Motion Study*, 121. Also, the chronometer, located in each frame, was used to track the rate captured in the motion picture for both frame-by-frame analysis and accurate speed when playing back on a projector.

[134] Gilbreth and Gilbreth, *Applied Motion Study*, 121.

[135] Frank Gilbreth, "Ideas in Letters Written by F. B. G. to Captain Ellis," 1917–18, series 2, box 6, Gilbreth Papers.

[136] Lillian Gilbreth to Frank Gilbreth, January 7, 1918, series 11, box 102, Gilbreth Papers.

[137] Gilbreth, *Psychology of Management*, 256.

muscle; … hand and muscle train the mind; the mind improves the standards. Thus was have a continuous cycle."[138]

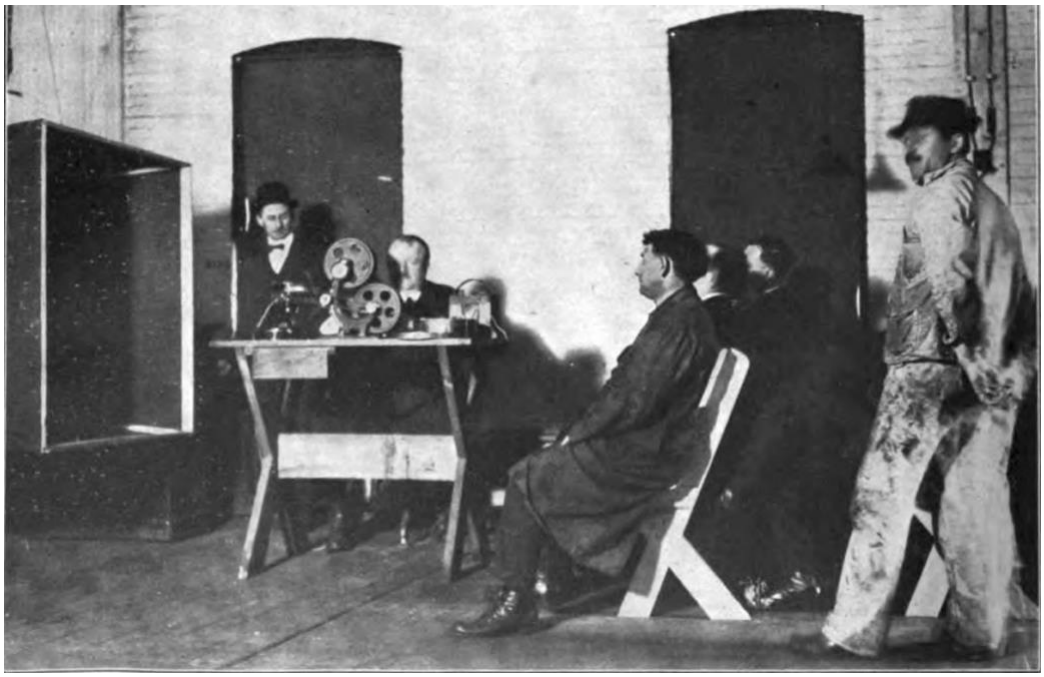


Figure 10: A Gilbreth film exhibition setup ("The Magic of Motion Study," in The World at Work [1916])

The Gilbreths' exhibitory field expanded when, following the United States' entry into World War I in 1917, the military hired Frank and Lillian to produce and oversee the exhibition of motion-picture films for training military recruits. Lillian was officially recognized as a consulting engineer, exchanging ideas with Frank via letters from their home in Providence, Rhode Island, while he was stationed at Fort Sill, Oklahoma. Frank produced educational films illustrating proper techniques for loading weapons and conducting oneself on the battlefield and distributed them to war colleges throughout the eastern US with instructions for exhibition programming. This unpredictable and chaotic military training context tested Lillian's theories and, in turn, provoked her to broaden her media pedagogy while remaining faithful to its Jamesian foundation.[139]

Many of the specific tactics for these screenings drew from and expanded upon the interactive aspects of the Gilbreths' factory exhibition practices. Lillian and Frank's correspondence discloses a concern about eliciting the interest of notably distracted and distractable cadets. In a December 1917 letter to Lillian, Frank bemoans that his training movies and exhibition practices were not winning the attention and interest of soldiers, and as a result

[138] Gilbreth, 239.

[139] This period in the Gilbreths' career is thoroughly documented in correspondence between Lillian and Frank, and Frank and his superior in the military, Captain Earl Ellis. From late 1917 to mid 1918, Lillian and Frank wrote to one another daily. See Gilbreth Papers, series 2 ("Correspondence, ca. 1906–1970"), box 6 ("Correspondence, Frank and Lillian Gilbreth, ca. 1906–1959) and series 11 ("Family & Personal Life, ca. 1864–1972), boxes 100–02 ("Letters, Frank Gilbreth to Lillian Gilbreth, 1914–1917;" "Letters, Frank Gilbreth to Lillian Gilbreth, 1918–1920;" and "Letters, Family, ca. 1901–1924").

the young men were not effectively embodying the correct combat practices demonstrated in the moving images. In a letter the following month, Lillian advises Frank, only somewhat facetiously: "Why not conscript Douglas Fairbanks and all of the film stars to do a stunt in the films? … That would wake them up…. Believe me it is actor's [*sic*] 'Sob stuff' these films need. Nothing but that can make the boys want to copy them. You are trying to win them by hate, why not try emulation for a change?"[140] With her playful reference to Fairbanks she emphasized less the entertainment value of celebrity and more its spectatorial effect in the form of visceral emotional response and imitative action.[141] Just as the screen image could prompt attention to its educational messages, Lillian's exhibition designs also prompted spectator engagement. Using a tactic she calls the "transferrable unit,"[142] Lillian advises Frank: "Let's analyze all needed military activities, also all sports, find the likenesses, and develop all the muscles, decisions, coordinations, etc. that we can thru [*sic*] directed play. So also with the psychological essentials. Habits of quick response, etc."[143] She calls for adding captions to the films and programming games during the screenings in which cadets identify how the motions demonstrated onscreen sync with elements of motions they already performed automatically in daily life, such as those executed when "making a bed, dressing, shaving." The takeaway message was to be: "'Did you realize that you are a motion study expert some minutes of everyday?'"[144]

Instead of calling for a complete break from ingrained motion habits, this film program nudged trainees to adjust existing habits almost imperceptibly, such that they evolved to align with the desired, standard motion paths. To assist with this process, the couple emphasized that the "audience must participate" and suggested incorporating interactive activities in which, for example, the cadets watched a demonstration and identified planted incorrect elements. However, the "audience [is] never permitted to participate in motions of wrong methods"; the eye could take them in and the mind could analyze their problematic patterns, but the limbs were to refrain from action to protect one's motor memory from contamination.[145] Ultimately, any physical enactment throughout film screenings was to make the cadets recognize their respective adherence to or deviation from the standard, precise ways of completing tasks.[146] These microscale feedback cycles scaled up to the broader Gilbreth military exhibition system.

The extant correspondence between Lillian and Frank, as well as between Frank and his superior in the military, Captain Earl Ellis, reveals the emergence of a meta-interactive system, that is, a media production-consumption feedback cycle. If the factory exhibition setup was a mechanism for one-way habit installation, the war-film practice introduced a two-way responsive element between media makers and audiences. Frank produced films seemingly daily; Lillian instructed him to test them: "The next thing is to try them out. Wherever possible show them to a small group of experts, as we do the shop films, and let them go at them as the shop men did,

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[140] Lillian Gilbreth to Frank Gilbreth, January 17, 1918, MSP 7, series 11, box 102, Frank and Lillian Gilbreth Papers, Archives and Special Collections, Purdue University Libraries, West Lafayette, Indiana (hereafter Gilbreth Papers).

[141] Lillian Gilbreth to Frank Gilbreth, January 17, 1918, series 11, box 102, Gilbreth Papers.

[142] Gilbreth to Gilbreth, January 7, 1918. See also Gilbreth, "Standardizing Methods for Transferring Skill."

[143] Lillian Gilbreth to Frank Gilbreth, January 24, 1918.

[144] Gilbreth to Gilbreth.

[145] Frank Gilbreth, "Ideas in Letters Written by F. B. G. to Captain Ellis."

[146] This is also a running theme throughout *Psychology of Management*; see 147–48.

standing in front of them and demonstrating" to discern the films' effectiveness.[147] Frank also sent film reels to Lillian, who organized screenings with friends and local scientific management experts. She documented audience responses to the moving images and used them as input to craft content-related suggestions: "Then switch to closeups. Don't be afraid to leave out heads, the audience sat in the front edge of their seats to watch Private Vincant's hands when he disassembled the rifle. They ATE IT UP.… Leap to the BIG pictures of details."[148] The cinematic elements that elicited the most intense audience attention and therefore delivered the most efficient effects automatically informed Frank's production choices on the next films. Lillian, in turn, prompted him: "Of course I needn't ask if you are keeping notes of anything that might be in the nature of 'Evidence' in case you are later called on to report on the efficiency of what you are seeing."[149] The idea was to establish, perfect, and thoroughly fix the couple's own habits of production and exhibition as well as to maximize the use of techniques that garnered sustained attention and honed worker-spectators' motor skills. Just months later, after the war, the couple would go on to campaign for the broader and ongoing use of film in secondary schools and colleges, as well as military training programs.[150] Significantly, the couple's expansion campaign positioned moving-image media as not only interactive in itself but as a media-interaction industry with the means for habituation and automation.

ABILITY DIVERSITY, AUTOMATIC INVENTION

The interactivity the Gilbreths fashioned in exhibition settings involved a contradictory stance on individual difference. Workers' bodies were recognized as porous, sensing systems whose habits of action could be temporally remapped. Automaticity was individualized—not in a way that was subject dependent but instead workflow dependent. Nowhere is this subsumption of subjects' individualities into system organization more pronounced than in the Gilbreths' work with the disabled. By 1917, when the US entered the war, Lillian Gilbreth had for years been thinking about how to make work settings accessible for people with disabilities.[151] What started as a pursuit contributing to the larger vision of being scientific management's "good exception" became, in the throes of war, a necessity to curtail what the couple saw as a workflow disruption crisis at the national and global scale.[152] Young American men were increasingly absent from the workforce not only due to military conscription but also the severe wounds and permanent disabilities that affected their ability to return to jobs once home. Further, Lillian Gilbreth was concerned about the psychological impact of disability: "a maimed, or crippled" veteran faced becoming "an idle, unproductive, and worst of all, a discouraged and unhappy member of the community."[153] This rhetoric aligns with what disability scholars have designated the "medical

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[147] Gilbreth to Gilbreth, January 7, 1918.

[148] Lillian Gilbreth to Frank Gilbreth, February 18, 1918.

[149] Gilbreth to Gilbreth, January 17, 1918.

[150] See Frank Gilbreth and Lillian Gilbreth, "Vocational Training and Technical War Films," June 1918; "Modern Methods of Transferring Skill: Illustrated by Military Films," October 1918; and "The New Education—Illustrated by Military Films," November 1918, series 1, box 128, Gilbreth Professional Papers, .

[151] See Frank and Lillian Gilbreth, *Motion Study for the Handicapped* (London: Routledge, 1920), xii.

[152] See Gilbreth Papers, series 11, box 102.

[153] Gilbreth and Gilbreth, *Applied Motion Study*, 197.

model," common in this period of modernity, which approached disability as a state of "unfitness for work [that] ultimately led to organized systems of charity … and attempts at medical 'correction'" or rehabilitation.[154] However, Lillian's human-factor focus, even as it advanced an industrialist agenda, could be read generously as a progressive recognition of the way disability is not only a characteristic of the individual but also an effect of social and environmental conditions that inhibit or enable certain forms of sensing and mobility. I believe that Lillian Gilbreth's work on disability champions the interface between body and environment, which she designed to be alterable to accommodate certain forms of impairment. Ultimately, however, this emphasis on interface erased the embodied, subjective experience of persons with disabilities in categorical terms in order to ensure system-wide productivity.

In essence, this approach led to a matchmaking exercise between jobs and disabled workers. Motion study was proposed as a method well suited for analyzing the movements of the newly disabled and obtaining feedback that could inform job placement. This culminated in a collection of essays written throughout the late 1910s and eventually published in the 1920 volume *Motion Study for the Handicapped*. For example, a paper titled "The Conservation of the World's Teeth: A New Occupation for Crippled Soldiers" boasts that motion study had provided the data to discover a supposedly profound compatibility between the profession of dental nursing (specifically, the gestures it requires) and "a one-armed, one-eyed, and totally deaf operator" (see fig. 11 & 12).[155] In testing the suitability of this role, the Gilbreths had worked with a dentist, who did not consider herself disabled, and had her put one arm behind her back and cover one eye as the patient held her own mouth open. The Gilbreths deployed studies like this to posit the provocative question: "Why do we assign whole men today to occupations that crippled or maimed workers can handle satisfactorily?"[156]

In many respects, *Motion Study for the Handicapped* demonstrates how, in the words of Frank Gilbreth, analysis of the disabled worker simply extended his project to "reclassify the trades themselves" at a scale that exceeded industry (and most certainly bodily) specificity.[157] As a periodical reported of his endeavors: "Mr. Gilbreth believes that all skill in all the trades … whether it be that of a surgeon or a stenographer, … is based on one common set of fundamental principles."[158] This framework made work sequences both discrete and universal, and it did the same for bodily difference. Frank enumerated limbs and sensory organs and modeled disability as a set of statistically probable types—one-armed, one-legged, blind, deaf. Motion-tracking cards allowed Frank to map out in binary terms which body part was needed or superfluous for a given motion path.[159] Therefore, he couched disability not as a lack but as an expression of a unique set of physical capabilities, just like those of any able-bodied individual. However, nowhere does Gilbreth cite the perspectives of disabled workers. The Gilbreths' work made bodily difference representable and addressable exclusively for the purposes of reworking embodied habits, all the while dismissing subjective, individuated experience.

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[154] Rachel Adams, Benjamin Reiss, and David Serlin, "Disability," in *Keywords for Disability Studies*, ed. Adams, Reiss, and Serlin (New York: New York University Press, 2015), 5–11, 7.

[155] Gilbreth and Gilbreth, *Motion Study for the Handicapped*, 64.

[156] Gilbreth and Gilbreth, 34. Henry Ford would later refer to factory work and disabled workers in a similar way; see Henry Ford, *My Life and Work* (Garden City, NJ: Doubleday, 1923), 108–9.

[157] Gilbreth and Gilbreth, *Motion Study for the Handicapped*, 35.

[158] Townsend, "The Magic of Motion Study," 334.

[159] See Gilbreth and Gilbreth, *Applied Motion Study*, 93.



Figure 11: Originally published in the Gilbreths' Motion Study for the Handicapped (1920), this photograph features a dentist, hired to serve as a proxy for a disabled worker, demonstrating a teeth-cleaning operation. (Courtesy of NMAH, Smithsonian Institution)



Figure 12: An unpublished and undated photograph of a worker with one arm performing the same teeth-cleaning operation as exhibited in fig. 11 (Courtesy of NMAH, Smithsonian Institution)

Yet, as we have seen, Lillian's contributions to the Gilbreth enterprise pushed the couple's work beyond Frank's logic of quantification and measurement and toward one of interactivity and harmonization between interior and exterior factors. Observed from this perspective, the photograph of the dental nurse cleaning the patient's teeth (fig. 11, above) depicts Lillian Gilbreth's thoughts on work as collective and situated within a complex whole. The child holds her own mouth open as her contribution to the operation. Like the workshop routing map or the chronophotograph, this composition portrays how people performing a work sequence collectively ascertain relative equilibrium. Their motor enactments adhere to a pre-formed action plan that links individual bodies into systems of dynamically interacting parts, transcending bodily limits to supposedly achieve optimal productivity.

The Gilbreths' work on disability raises the question of how representation impedes the expression of differently abled persons. Disability studies scholar Tobin Siebers has argued that the "linguistic model that describes representation itself as a primary ideological force" (a dominant position among poststructuralist theorists) problematically "posits that the body does not determine its own representation."[160] Siebers alternatively endorses the recognition that "the body is, first and foremost, a biological agent teeming with vital and often unruly forces …, which means that it is as capable of influencing and transforming social languages as they are capable of influencing and transforming it."[161] That is, the interface between subject and environment is unfixed and capable of being refashioned: "The disabled body changes the process of representation itself. Blind hands envision the faces of old acquaintances. Deaf eyes listen to public television. Tongues touch-type letters home to Mom and Dad…. Different bodies require and create new modes of representation."[162] For Siebers, representability results from physical exchanges that exhibit spontaneity, creativity, and purposiveness rather than outwardly defined productivity. This description foregrounds experience, both in terms of bodily autonomy and relationality. Tongue typing, for example, is a form of expression that values means as much as ends. It is an example of an invention of a method through which a disabled person can pursue "[a way] to live with their disability, to come to know their body, to accept what it can do, and to keep doing."[163] According to Siebers, action allows disabled subjects to reconfigure representation writ large.

Though Siebers theorizes disability in relation to an intellectual climate particular to the field of disability studies a century after *Motion Study for the Handicapped* was published, this positioning of representation is key for understanding Lillian Gilbreth's work on training bodies for so-called rehabilitation. For her, visual media was the site at which a motion was not only representable but transferable to the motor memory of individual bodies. Media exhibition prompted disabled persons to unknow their disability or body in general so that it could be placed on the track of a productive exchange. Individualized as that path might be, it was prescribed from without. In performing the actions, the disabled worker, like all workers in Lillian's version of training, was not to invent new methods for interaction and therefore representation, as eloquently articulated by Siebers, but to reproduce over and over again the eye worker's idea of ergonomic motion.

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[160] Tobin Siebers, *Disability Theory* (Ann Arbor: University of Michigan Press, 2008), 55.

[161] Siebers, *Disability Theory*, 68.

[162] Siebers, 54.

[163] Siebers, 69.

The Gilbreths termed this effect "automatic invention."[164] The concept inverts Siebers's framing of a disability interface as an indeterminate space at the threshold of personal habit, singular creativity, and a sense of shared existence. Automatic invention instead suggests that, thanks to representational media, every possible instance of bodily difference, every idiosyncrasy, every spontaneous gesture had been accounted for. It points to a theoretical notion that the scope of invention would always be conditioned by this rationalized idea of an institutional body, and therefore could always be made predictable. Therefore, the Gilbreths applied their model of automation to not only individuals' systematized work sequences but to all modes of social and environmental interaction. While an invention is typically defined as such by virtue of its originality, the Gilbreths' automatic invention concept in effect short-circuited processes of imagination that could otherwise engender novel—and perhaps even unproductive—possibilities for interactivity.

THE AUTOMATIC FACTORY

Though Wiener's mid-century vision of an automatic factory excises the human completely, it is is conceptually organismic not simply because its parts are analogous to organs but because those entities are interactional, forming an integrated whole.[165] In fact, this sensing, judging, and effecting factory-automaton could not come into being without elements which crucially manage the flow of energy and information. Wiener characterizes, albeit with an assumption of technological determinism and a linear sense of progress, the on-going history of the industrial revolution as the story of inventing "ingenious modes of connection"[166] between machines and machine parts. Technologies enabling the "transmission of power" are what made the development of the steam engine, and therefore the dawn of the industrial revolution, possible in the first place. The transference of energy was contingent on the steam-powered apparatus being an open system, in that its components could receive an input and produce an output. Its processing of energy also occurred in sequences. These features evidenced that, like the human animal, "the machine may also be a communicative organism."[167] Electrical computing technology turned the work of transmission into a mathematical problem instead of a mechanical one, and, crucially, it allowed for the recording of data, to be stored as *memory*, and for that information to feed back into the system:

> Man [sic.] and animal have a kinaesthetic sense, by which they keep a record of the position and tensions in their muscles. For any machine subject to a varied external environment to act effectively it is necessary that information concerning the results of its own action be furnished to it as part of the information on which it must continue to act…. This control of a machine on the basis of its *actual* performance rather than its *expected* performance is known as *feedback*, and involves sensory members which are

[164] Gilbreth and Gilbreth, *Motion Study for the Handicapped*, 25.

[165] Wiener is concerned with the ethical implications of automation throughout this text. At the end of this chapter, he explains at the end of this chapter, "I have participated in two big meetings with representatives of business management, and I have been delighted to see that awareness on the part of a great many of those present of the social dangers of our new technology and the social obligations of those responsible for management to see that the new modalities are used for the benefit of man, for increasing his leisure and enriching his spiritual life, rather than merely for profits and the worship of the machine as a new brazen calf" (162).

[166] Wiener, *Human Use of Human Beings*, 143.

[167] Wiener, *The Human Use of Human Beings*, 136.

> actuated by motor members and perform the function of *tell-tales* or *monitors*—that is, of elements which indicate a performance. It is the function of these mechanisms to control the mechanical tendency toward disorganization; in other words, to produce a temporary and local reversal of the normal direction of entropy.[168]

In this framework, the "ingenious modes of connection" are interfaces, spaces which condition reception and response between elements of the larger system.[169]

Despite Wiener's cybernetic feedback conceptualization being enormously influential in both technical and cultural realms in the decades that followed, the factory today is decidedly *not* entirely machine-automated. Therefore, the significance of his exposition for our purposes is in what it illuminates about Lillian Gilbreth's concepts, and how those illuminations make apparent the stakes of interactive media today. Feedback was foundational to Gilbreth's functionally organized industrial institution, and visual media was the means through which modes of connection, exchange, and human habit re-formation were to be effected. Theorizations of feedback cycles are present throughout her body of work: the relation between the chronophotograph, the eye worker, and the finger-wise; the orchestration of bodies-in-sequence executing workflows and producing work products; the aesthetic design of factory spaces to intentionally activate or deactivate worker sensory stimulation; the use of film exhibition as a mechanism for imitation and motor habit installation; the individual's hand educating the muscle to educate the mind. But just as the notion of feedback suggests a cycle, in each of these examples, the direction of sensing-judging-effecting or sensing-effecting matters. Who gets to sense and how? Who gets to decide on arrangements and execution plans? Who must engage in motor activity and according to what assumptions about their body?

That Norbert Wiener imagined a machine-automated factory as a correlate of a human body evidences that automation had already been thought according to the specificity of the human body as a physiological and psychological complex system. Much more than forcing humans to awkwardly and painfully act as machines, a human-specific form of automation, Gilbreth thought, had the capacity to be effective at rewriting and making predictable human behavior, and therefore institutional operations. We have to wonder if Wiener's dream of an automatic factory, as an organized unity exhibiting the same properties of life to work against the inevitable entropic march, is not undermined by Gilbreth's own dream of homogenization and predictability in the human. It is not the organ that is negentropic, but the organismic unity. But in Gilbreth's human-factor factory, that unity has been exploded and artificially remapped by wielding photographic media's capacity to both address difference and manifest sameness.

NEURAL HABIT, RETHOUGHT AND RECONFIGURED

If Lillian's vision for a programmatic, yet organismic factory gave Wiener the conceptual template for automaticity in the physical interactions within an industrial setting, William James's neurological principles presage the neural network models of today. A century after

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[168] Wiener, *Human Use of Human Beings*, 24–5.

[169] This tracks with the concept of an *interface* used today to refer to digital technologies, as defined by Florian Cramer and Matthew Fuller: "'interfaces' are the point of juncture between different bodies, hardware, software, users, and what they connect to or are part of. Interfaces describe, hide, and condition the asymmetry between the elements conjoined. The asymmetry of the powers of these bodies is what draws the elements together." See "Interface," in *Software Studies: A Lexicon* (Cambridge, MA: MIT Press, 2008): 149–152, 150.

[169] Wiener, *The Human Use of Human Beings*, 136.

James published *Principles of Psychology*, these models for artificial intelligence algorithms were winning the attention of computer science researchers and funding bodies alike. In 1990 Robert Eberhart and Roy Dobbins of Johns Hopkins Applied Physics Laboratory referred to James's contributions as the origin of "The Age of Camelot" for neural networks. They cite James's translation of the philosophical notion of the mind's associative or connectionist principles—specifically John Locke's principle of contiguity—into the material functioning of the brain.[170] (Wiener would also use as reference point Lockean contiguity for his nervous-system-inspired cybernetic computer models). James describes as follows: "*When two elementary brain processes have been active together or in immediate succession, one of them, on reoccurring, tends to propagate its excitement into the other."*[171] He goes on to detail neurological features in a way that positions them as amenable to computation, explaining that "*The amount of activity at any given point in the brain-cortex is the sum of the tendencies of all other points to discharge into it, such tendencies being proportionate (1) to the number of times the excitement of each other point may have accompanied that of the point in question; (2) to the intensity of such excitements; and (3) to the absence of any rival point functionally disconnected with the first point, into which the discharges might be diverted*."[172] In response to this, Eberhart and Dobbins liken it to late-twentieth-century algorithms and their "notion of a neuron's activity being a function of the sum of its inputs, with past correlation history contribution to the weight of interconnections."[173] In extracting this quotation, the authors have pinpointed the elements that are amenable to mathematical modeling, separable from the organic aspects of the perceiving and thinking body and the social aspects that also shape that body. James himself presented this elementary law while attending to neural processes occurring in relation with other "states of consciousness" and bodily processes alike. Also, this updated law of contiguity, James asserts, "expresses merely a phenomenon of mental *habit, the most natural way of accounting for it is to conceive it as a result of the laws of habit in the nervous system*."[174]

The qualifier "merely" indicates that for James habit is but one form of mind-brain activity; understanding it to be the total of it results in an impoverished understanding of consciousness. It assumes that, as one learns, the central nervous system acquires a quality of organization that is ever more determinate, which would in turn result in ever more repetitive behavior. Practical experience and theoretical understandings of consciousness, however, hold that humans beings are not simply vectors of passive sensation and automatic response. Nor are they at all times operating from a position of consciously directing willful thought and action. Learning processes effect two simultaneous outcomes: some activities become more automatic, nonconscious, while some afford abstraction and imagination. Connections between thoughts thus must be alterable in ways other than by mere compounding.

But James also theorizes how neural plasticity enables mental flexibility, and can bring about the reconstitution of thought and action beyond the confines of the fixed neural pathway and behavioral habit altogether. In relation to his above detailing of associative brain activity.

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[170] See William James, *The Principles of Psychology I*, Chapter 14: Association, in which James discusses John Locke's principle of contiguity.

[171] William James, *The Principles of Psychology*, 2 vols (New York: Dover Publications, 1950 [1890]), 566.

[172] *Principles*, 567.

[173] Robert C. Eberhart and Roy W. Dobbins, "Early Neural Network Development History: The Age of Camelot," *IEEE Engineering in Medicine and Biology* (September 1990), 15–16.

[174] James, *Principles v I*, 561–562.

Earlier we noted that James understands the nervous system's inherent "vagueness" with respect to structure as one of its principal qualities enabling adaptable human behavior. Because the sensory organs supply the nerve centers with a superfluity of environmental information, James identifies a state of consciousness that is precedent to "'regulated thought'" which can operate with abstraction but also with a great degree of habituation. This pre-cognitive realm is associated with that "selective" quality of the mind, and its most prominent qualities are that of "*interested attention and volition*" that nonetheless accompany thought which is "'unguided, without design.'"[175] James is here inventing the notion of a "stream of consciousness" and its determination by objects of sensation and memory alike that have a "mysterious *plus*, the understood meaning. But nothing is applied to the image from above, no pure act of reason…. It can be diagrammatized as continuous with all the other segments of the subjective stream. It is just that staining, fringed, or halo of obscurely felt relation to masses of other imagery to come, but not yet distinct in focus."[176] A more apt concrete example of the effects of this fringey consciousness is "that shadowy scheme of the 'form' of an opera" or "notion of a scientific or philosophical system."[177] There is a paradoxical relation here with respect to fringe's representability, both in terms of graphical abstraction ("diagrammatization") and with respect to that which can be observed and modeled in the brain itself. Regarding the latter, fringe is a "'feeling of tendency' … whose neural counterpart is undoubtedly a lot of dawning and dying processes too faint and complex to be traced."[178] Nonetheless, the fringe-ness also works against the mechanization of any one tendency, by keeping the *more than* quality in the pre-conscious mix such that consciousness can continue to act selectively.

In 1970, the philosopher Hubert Dreyfus appropriated James's idea of fringe consciousness as an analytic for critiquing artificial intelligence. Dreyfus nonetheless offers a helpful situational example of fringe consciousness, using a longtime favorite site for AI simulation: a chess game. The human chess player, unlike the machine, has a "vague awareness" of the board's global organization and the game's potential trajectories. The "'power [of fringe consciousness] resides in the area which tends to function as a background because it extends indeterminately around the central object of our attention…. [Players] *zero in* … on an area formerly on the fringes of consciousness, and which other areas still on the fringes of consciousness make interesting," to discover gaps and introduce novel gameplay.[179] Dreyfus was invoking fringe consciousness to describe as aspect of human experience that is not simulatable in the computer because it cannot be translated into bits and relays, or in purely formal terms more generally.

Dreyfus's human chess player example defines a core feature of human experience as that which exceeds habits of thought and action, that which eludes a predetermined path. Even before the invention of the computer, scientific management—and in particular Lillian Gilbreth's

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[175] Hobbes, *Leviathan.* Cited in James, *Principles vI,* 595.

[176] James, "On some omissions of Introspective Psychology," 1884, pp. 18–19.

[177] *Principles vI,* 255.

[178] *Principles vI,* 472.

[179] Dreyfus, 15, 18. Dreyfus, 15. Note 31: Citing Michael Polanyi who is also referencing Gestalt psychology, in "Experience and Perception of Pattern," in *The Modeling of Mind*, p 24. In note 31 (p226), Dreyfus says, "Frederick Crosson was the first to see the relevance of this gestaltist analysis [of fringe consciousness] to work in artificial intelligence…. 'Some human functions are at times performed by utilizing information or clues which are not explicitly or focally attended to, and this seems to mark a fundamental difference … [with] simulated automata."

nervous-system-oriented version of it—had systematized and predetermined the path toward goal achievement. Though Gilbreth had been a follower of James, it is difficult to conceive of a place for fringe consciousness—a primary source of non-mechanistic and original thinking, in James's conception—within her world of interactive media, and therefore of its contemporary ergonomic digital-media analogues.

THE PARADOX OF INTERACTIVITY

Recent developments in artificial intelligence and "deep learning" invite inquiry into our societal assumptions about learning, training, and expressions of intelligence and their respective place within institutional contexts. In response to the rise of ChatGPT and other generative AI tools, tech executives and AI researchers are warning of the "existential risk" these technologies pose to the planet and humanity.[180] Their predictions of AI bad behavior tend to recast a narrative trope germane to the sci-fi genre. It goes something like this one, offered by the field's standard textbook, *Artificial Intelligence: A Modern Approach*: Suppose an AI designed to play chess becomes "intelligent enough to reason and act beyond the confines of the chessboard…. It might attempt to increase its chances of winning by such ruses as hypnotizing or blackmailing its opponent or bribing the audience to make rustling noises during its opponent's thinking time. It might also attempt to hijack additional computing power for itself," which could ultimately lead to its catastrophic destruction of the world as we know it.[181] In addition to exhibiting a well-trodden cultural anxiety about intelligent machines' will to power, this anecdote tells us something about conceptions of autonomy and its material significance. The AI's degree of intelligence is directly correlated with its potential to act spontaneously, to surprise, and to depart from an expected course of action. The space between machine input and output is abyssal; the depth and opacity of the AI's learning parameters launch its intellectual prowess and appetite to new heights. As it gains in predictive capacity, its own behavioral predictability wanes. The parable implicitly indicates that the AI's exhibition of both genius and brutality is a factor of its deviation from institutional conventions and social norms.

There is another familiar, though far less flashy, story regarding AI's incorporation into everyday life. Take the case in which the Michigan Unemployment Insurance Agency wrongly accused over 30,000 people of fraudulently claiming unemployment benefits due to an integration problem with the state's new Michigan Integrated Data Automated System (MiDAS). Because the automatic system ran without oversight, administrators took years to recognize that 85% of the system's fraud determinations were incorrect. An example of technological failure and grave mismanagement to the detriment of vulnerable citizens, Michigan's automated decision-making program is also an important contrast to the learned chess-playing AI. Because of its use case and context, Michigan's algorithm will never be employed to generate wildly creative "beyond the chess board" means for achieving ends. In order for the automated decision

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[180] Cade Metz, "How Could A.I. Destroy Humanity?", https://www.nytimes.com/2023/06/10/technology/ai-humanity.html, accessed October 1, 2023. See also the "Statement on AI Risk," a one-sentence statement signed by over 350 AI researchers and industry leaders. It reads: Mitigating the risk of extinction from A.I. should be a global priority alongside other societal-scale risks such as pandemics and nuclear war," https://www.safe.ai/statement-on-ai-risk#open-letter, accessed October 1, 2023.

[181] Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach, Fourth Edition* (Hoboken, NJ: Pearson), 1.1.5.

system to be integrated in the first place, the very task of judging citizens' worthiness of unemployment benefits had to have been conceived *as* an imagined machine process. Regardless of whether a staff member or algorithm performs the clerical duties, judgment here is not an exhibition of innate or acquired reasoning capacity but a rote performance of a protocol. The move to offload more decision-making labor to machines simultaneously structurally degrades the creative problem-solving and judgment capabilities of the staff that remain. As philosophers Nir Eisikovitz and Dan Feldman point out, "Aristotle argued that the capacity for making practical judgments depends on regularly making them—on habit and practice. We see the emergence of machines as substitute judges in a variety of workaday contexts as a potential threat to people learning how to effectively exercise judgment themselves."[182]

These two examples show the co-constituting yet contradictory qualities of autonomy and automation, learning and training, that are dually called upon in neural network processes. Indeed, the artificial neural network—which has enabled deep learning and generative AI—has been celebrated for its radical flexibility, which affords its applicability to any number of narrowly or generally defined objectives. But the neural network's initial openness directly conditions its need for ample data, which through training processes give the network its structure, make it more determinate and habituated in its analyses and actions, and paradoxically engender its capacity to generalize and make predictive leaps.[183] Meanwhile, these continually evolving processes take place within a material context; institutions employ neural networks to do specific, institutionally useful activities (even if that purpose is to exhibit the novelty of a creative chess playing machine). Therefore, the neural network concept and its modes of perceiving and reasoning tell us much about the modes of perceiving and reasoning valued by social and political organizations.

A century after Lillian Gilbreth was writing about visual media and habit formation, we are contending with a media environment in which digital platforms structure our experience of images. These interfaces compel certain user interactions for the explicit purposes of sustaining attention and eliciting clicks. Social-media addiction has been the subject of a growing body of cultural artifacts, such as the popular 2020 documentary *The Social Dilemma*. The film indicts the tech industry for its investment in interactive media practices aimed at stimulating dopamine hits and engineering predictable yet unhealthy behavior. In the film, Tristan Harris, Google designer turned tech ethicist (who is a self-proclaimed gifted magician), explains the twenty-first-century interface:

> Magicians were almost like the first neuroscientists and psychologists…. A magician understands something, some part of your mind, that we're not aware of. That's what makes the illusion work…. From that perspective, you can have a very different understanding of what technology is doing.
>
> [Tech designers] use everything we know about the psychology of what persuades people and build that into technology … using AI [artificial intelligence] to predict what's going to perfectly addict you, or hook you.[184]

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[182] Nir Eisikovits and Dan Feldman, "AI is killing choice and chance—which means changing what it means to be human," https://theconversation.com/ai-is-killing-choice-and-chance-which-means-changing-what-it-means-to-be-human-151826.

[183] See Stuart Russell and Peter Norvig, *Artificial Intelligence*, Ch 21 "Deep Learning."

[184] *The Social Dilemma*, 22:45–23:50; 50:32.

Harris insists that digital technology itself makes these operations categorically unprecedented, fundamentally unintelligible, and the root cause of mass manipulation. This emphasis on machine prowess reprises the male-centric, industrialist tendency to lionize technology and in doing so occludes the social dynamics that play out in and around processes of automation. Yet, the film ultimately illuminates the contemporary stakes of Gilbreth's thesis that predicting what can make people act automatically—or, addictively—in effect makes them predictable.

Lillian Gilbreth's theoretical framework and media pedagogy, as historical precedents, make discernable the profoundly political role of screen-based interaction design. Amid the early days of cinematic spectatorship, Lillian Gilbreth made visual media exhibition the site of new, prescribed modes of interactivity, exploiting the capacity of moving images to address subjects with the intent to reorganize their bodies and behavior, anesthetize some aspects of embodied experience and hypercharge others, and subsume the individual in an institutional whole. Long before the digital turn, the medium-specific properties of film and photography were wielded to habituate interactive programs among spectators and to translate viewer attention into a productive entity. In Gilbreth's theoretical frame, representational media took on a decidedly procedural quality by instilling a factory-endowed kinesthesis, or a space evacuated of thought and imagination, where sensory and motor effects became one.

In this chapter I have demonstrated how nascent concepts in scientific management and neuroscience-informed psychology met and merged in Lillian Gilbreth's programs to synchronize individuals' visual perception with the singular purpose of the industrial organization. In this context, trainings effected the coordinated activities of workers by addressing the eyes as a site at which to both stoke desire and instill neurological order. The predictability of perception-action cycles was the means to the profitable end. And while the residues of Gilbreth's theories about visual habituation are present in our click-through driven social media platforms and in human-computer-action designs more broadly, in the twenty-first-century technical milieu of deep learning and human-centered artificial intelligence there is renewed awareness of and interest in the diversity and plasticity of human preferences as both a subject for technical simulation and a necessary ethical consideration in efforts to establish "alignment" between humans and AIs.[185] This vein of research within artificial intelligence challenges the assumption of those supporting artificial general intelligence (AGI) that these machines will operate autonomously and by excising humans from the task environments to which they are put in operation. If AGI is the contemporary "automatic factory," human-centered AI invokes Lillian Gilbreth's emphasis on the interface and modes of interactivity. But the research question of this work is something of an inverse of that of Lillian Gilbreth. We go from: how might we exploit the plasticity of perception to standardize behavior en masse so that it aligns with an institutionally imposed set of values?—to: how might we (automatically) recognize in people's behavior their diverse affective and cognitive processes and preferences, as the basis for modeling more trustworthy, beneficial artificial intelligence? Nonetheless, Lillian Gilbreth's theory of neurologically informed interactivity illuminates the syncing of body with environment in such a seamless way as to collapse the values of one into the other, which prompts us to consider how we might identify the gap between the two to restore that function necessary for living among out machinic doubles—the perceptual faculty of critical distance.

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[185] See, for example, Stuart Russell, *Human Compatible: Artificial Intelligence and the Problem of Control* (New York: Viking/Penguin Random House LLC, 2019). See also: Shengnan Han, Eugene Kelly, Shahrokh Nikou, and Eric-Oluf Svee, "Aligning artificial intelligence with human values: reflections from a phenomenological perspective," *AI & Society* 37 (2022), 1383–1395.

—Chapter 02—

Conversions: Drives to Affects, the General Problem-Solver, and Metacommunication

In recent decades, the relationship between affects and computing has been of multiple shades. On one hand there is a nascent field dedicated to producing robots and other computer programs that express emotions. On the eve of the twenty-first century, roboticists Rodney Brooks and Cynthia Breazeal at MIT introduced Kismet, a robot that could respond to a person's emotional cues and exhibit emotional reactions in kind.[186] In 2024, OpenAI released its AI voice assistant, Sky, that communicates with users in a flirtatious voice and style reminiscent of Scarlet Johanson's character Samantha in Spike Jonze's 2013 film *Her*.[187] This, alongside a law enforcement program in New York City called Spot, in which police "dog" robots undertake bomb disposal and, potentially, day-to-day patrolling of cities.[188] In videos produced by developers Boston Dynamics, the robots dance to Bruno Mars' 'Uptown Funk.' Upon release of updated Spot models, a voiceover announces "new dog, new tricks," as a robot moves about with a display of both robustness and cuteness.[189] These technologies demonstrate concerted efforts among researchers and cultural producers to infuse sophisticated, interactional machines with not only cognitive "intelligence" and motor deftness but also affective expression. Within this grouping of work, the focus is on developing machines that can elicit emotional responses from consumers and citizens through encounters that approximate interpersonal experience.

On the other hand, there is a body of affect-oriented computing research and applications focused on recognizing and classifying human emotional states and the likely behaviors they are to set in motion. These programs tend to borrow a mobile and amenably computable theory from clinical psychology on the innate set of nine or so human emotions, which was developed by

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[186] See Rodney Brooks, Cynthia Breazeal, Matthew Marjanovic, Brian Scassellati, and Matthew Williamson, "The Cog Project: Building a Humanoid Robot," in *Computation for Metaphors, Analogy, and Agents*, edited by Chrystopher Nehaniv (New York: Springs, 1999): 52–87; Cynthia Breazeal, "Early Experiments Using Motivations to Regulate Human-Robot Interaction," *Proceedings of 1998 AAAI Fall Symposium: Emotional and Intelligent, the Tangled Knot of Cognition* (Cambridge, MA:MIT Press, 1998):31–38; and Cynthia Breazeal, *Designing Social Robots* (Cambridge, MA: MIT Press, 2002). For a broader analysis of the field of affective computing, see Rosalind Picard, *Affective Computing* (Cambrdige, MA: MIT Press, 1997).

[187] Tripp Mickle, "Scarlett Johansson Said No, but OpenAI's Virtual Assistant Sounds Just Like Her," *The New York Times* (May 20, 2024), https://www.nytimes.com/2024/05/20/technology/scarlett-johannson-openai-voice.html. See also *Her*, directed by Spike Jonze (Warner Bros. Pictures, 2013).

[188] Boone Ashworth, "The NYPD Brings Robot Dogs Back," *Wired* (April 15, 2023), https://www.wired.com/story/nypd-spot-boston-dynamics-robot-dog/.

[189] *The Verge* editors, "Boston Dynamics Spot hands-on: new dog, new tricks," *The Verge* (September 24, 2019),.

https://www.youtube.com/watch?v=bmNaLtC6vkU.

psychologists Silvan Tomkins and then Paul Ekman in the latter half of the twentieth century.[190] For example, the Transportation Security Administration in 2011 began rolling out a program, also called SPOT, in which trained personnel observed the facial expressions of passengers in airports in order to discern deception and malintent as a measure of predictive law enforcement.[191] SPOT is flanked by a number of patents and software programs that use the same underlying emotion-detection principles and practices to automate the analysis of human facial expressions in industry settings, from in-store shopping to human resources management.[192] Further, the military has deployed such programs to train operatives in predicting and "preempting" violence in on-the-ground settings.[193] Defense organizations also fund technology research into the design of wearable technologies that discern a soldier's interior state of attention, fatigue, and affect in order to optimize these measures—through haptic cues—to hypercharge perceptual awareness and accelerate motor reaction times in detecting dangers.[194] These latter examples are a blend between machines that *recognize* affect and that, by way of a cyborg-style intervention on the soldier's body, simultaneously mechanically *produce* affect.

Underlying these cultural and technical objects is a theoretical debate within the field of computing itself as to the question of how affects feature in goal-directed behavior. On one hand, motivation can be seen to economize thinking and behavior; on the other, the drives and emotional resonances associated with motivation are, strictly speaking, irrational or at least a-rational. That is, it is a commonly held conceit among computer scientists that pure rationality would entail acting explicitly without the impact of emotions. Despite both of these propositions, technical researchers widely agree that affective relations are so embedded in human cognition that we can't appropriately replicate intelligence without at least gesturing at an account for affective charge. Then there is the question of where to locate phenomena like emotions, purposes, and preferences with respect to a spectrum between abstract reasoning and reflex behavior, on one hand, and on the other between interior processes alone versus interactional, social experience.[195]

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[190] For an analysis of how Tomkins's and Ekman's work gets taken up in computer applications, see Luke Stark, "Algorithmic Psychometrics and the Scalable Subject," *Social Studies of Science* 48, no. 2 (2018): 204–231, https://pubmed.ncbi.nlm.nih.gov/29726810/ and Kate Crawford, "Affect," in *Atlas of Emotion* (New Haven, CT: Yale University Press, 2021): 181–209. See also Kelly Gates, *Our Biometric Future: Facial Recognition Technology and the Culture of Surveillance* (New York: NYU Press, 2011).

[191] SPOT stands for Screening of Passengers by Observation Techniques; in 2016 this program was renamed Behavior Detection and Analysis (BDA). See ACLU Press Release, "ACLU Sues TSA for Records on Discredited 'Behavior Detection' Program: TSA Refusing to Release Documents About SPOT Program's Effectiveness, Racial Profiling Impact," *ACLU* (March 19, 2015), https://www.aclu.org/press-releases/aclu-sues-tsa-records-discredited-behavior-detection-program.

[192] See, for example, Stuart Argue et al. on behalf of Walmart, "Detecting Customer Dissatisfction Using Biometric Data" (U.S. Patent 2014/0147018 A1, 2013).

[193] See the website of defense contractor for military training, Arcadia Cognerati and in particular the video "What is Human Behavior Profiling?", *Arcadia Cognerati*, https://arcadiacognerati.com/what-is-hbpra/, accessed July 20, 2024.

[194] See a description of these military-funded "augmented cognition" programs in Kelly S. Hale et. al., "Augmenting Cognition in HCI: Twenty-First Century Adaptive System Science and Technology," in *Human Computer Interaction Handbook: Fundamentals, Evolving Technologies, and Emerging Applications, Third Edition*, edited by Julie A. Jacko (Oxfordshire, UK: Taylor & Francis, 2012): 1343–1358.

[195] An implicit discussion of this paradoxical condition of objective functions in artificial intelligence programs is elaborated in Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach, Fourth Edition* (Hoboken, NJ: Pearson, 2021). See especially the section on the "rational-agent" approach to artificial intelligence, page 37.

These conceptual inquiries are at work in theoretical discourses on human-level artificial intelligence and artificial general intelligence, which have garnered much attention in this century. Marvin Minsky coined the term human-level artificial intelligence with a conference he held by the same name, in 2004.[196] By 2006, Minsky had written a general audience book titled *The Emotion Machine*, in which he argues for the diversity of human thinking, as opposed to a singular, narrow conception of human rationality.[197] Human intelligence, Minsky offers, is attributed to a capacity to employ many different ways to think about the same problem so that, when one mode fails, others are put to use. The primary contributor to this ability for multivariant intellectual behavior is, perhaps counterintuitively given Minsky's earlier work, affect: "Emotional states are not especially different from the processes that we call 'thinking;' instead, emotions are certain ways to think that we use to increase our resourcefulness—that is, when our passions don't grow till they handicap us—and this variety of Ways to Think must be such a substantial part of what we call 'intelligence' that perhaps we should call it 'resourcefulness.' And this applies not only to emotional states but to all of our mental activities."[198] *The Emotion Machine* goes one, as the title suggests, to theoretically detail the mechanics of affect-oriented cognition as a model of human beings' interior architecture. In Minsky's scheme, affects are like coefficients that tack onto variables in problem-solving exercises, weighting them in this or that way to produce novel sequences of thought and behavior. The way Minsky conceives of affect treats the intelligent actor (human or machine) as an isolated entity, with emotions contributing a variety of possible outputs that themselves are not understood to have stakes in a social context.

This concern for the social and political implications of AI has been the source of inspiration for other computational research, however, such as Eliezer Yudkowsky's 2008 proposal to make "Friendly AI," as a way to mitigate the catastrophic risks of AI at a global scale.[199] Today AI researchers are broadly taking up the issue that their artificial agent designs will, for one, interact with individual people and institutions and, second, will need to act responsibly and in the interests of these other social actors. Indeed, some prominent voices in the technical field are arguing that artificial intelligence research should be held back until we have measures in order to ensure AI agents behave in provably beneficial ways to the individuals and groups with whom they interact. In addition to conceiving this as exclusively a measurement and design issue, these researchers understand it as an ambiguous political and philosophical one—people's motivations are diverse and are malleable; AI is being designed to both mimic and to meet these human motivations and the affective charge that undergirds them, and yet any single, formal definition of affect overdetermines this otherwise plastic and elusive organic quality.[200]

The implicit and explicit centering of affects in the realm of contemporary artificial intelligence research is a subject to which humanistic inquiry and critique should be able to

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[196] Marvin Minsky, P. Singh, and A. Sloman, "The St. Thomas Common Sense Symposium: Designing Architectures for Human-Level Intelligence," *AIMag* 25 (2004): 113–124. See also Russell and Norvig, *Artificial Intelligence*, 88–89.

[197] Marvin Minsky, *The Emotion Machine: Commonsense Thinking, Artificial Intelligence, and the Future of the Human Mind* (New York: Simon & Schuster, 2006).

[198] Minsky, *Emotion Machine*, 6.

[199] Eliezer Yudkowsky, "Artificial Intelligence as a positive and negative factor in global risk," in *Global Catastrophic Risk*, edited by Nick Bostrom and Milan M. Cirkovic (Oxford, UK: Oxford University Press, 2008): 308–345.

[200] For an examination of the state of AI safety and its orientation toward affect, see Stuart Russell, *Human-Compatible: Artificial Intelligence and the Problem of Control* (New York: Viking, 2019), 188.

contribute much, to reveal the assumptions and contradictions within these theoretical and material technical trajectories. However, contemporary affect theory as it has been taken up in the humanities has a complicated historical relationship to the very discipline of computing and its adjuncts in operations research and systems theory. Much of this humanities scholarship draws on the theories of affect devised by Silvan Tomkins, who is also the same genealogical antecedent for the emotion-detection algorithms used in surveillance research today. (It should be noted that these surveillance applications emerged more recently than the humanistic studies.) For example, as of 1995, Eve Sedgwick had embraced Tomkins's theory on the wager that its conception of a *multiplicity* of affects (and of affects, such as shame, that are themselves amalgams) could provoke scholars in the humanities to break with a two-party system with respect to dialectical argumentation and culturally imposed gender binaries.[201] Elizabeth Wilson followed up on this call and in 2011 published *Affect and Artificial Intelligence*, in which she adopts Tomkins' theory of emotions as a basis from which to critique developments in the field of artificial intelligence for their championing of cognition at the expense of affects.[202] Both Sedgwick and Wilson make note of and concede that Tomkins's ultimate conclusion—that there are a handful of fixed, innate affects, each of which follows an internally consistent script for neurological firing in the human—is reductive and scientifically dubious, even while they make his work productive on other terms.[203] However, this *programmatic* quality that Tomkins imposes upon emotional experience and expression does not feature as an analytical problem in this scholarship. And therefore this Tomkins-inspired affect-theory work can only take us so far in critiquing the programmatic character of contemporary conceptions of human affect amid proliferating affect-displaying machines.

A broader frame for a humanistic definition of affect is illuminating for this endeavor, however. Taking a cue from Sedgwick while stepping away from the Tomkins-specific lens, Gregory Siegworth and Melissa Gregg have elegantly specified affect as "in many ways synonymous with *force* or *forces of encounter*…. Affect more often transpires within and across the subtlest of shuttling intensities: all the minuscule or molecular events of the unnoticed….

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[201] Eve Kosofsky Sedgwick and Adam Frank, "Shame in the Cybernetic Fold: Reading Silvan Tomkins," in *Shame and Its Sisters: A Silvan Tomkins Reader* (Durham, NC: Duke University Press, 1995): 1–28. See especially the citation of Tomkins on page 14 and its continuation in note 14, on page 26: In the main text quote, Tomkins says: "We have stressed the ambiguity and blindness of this primary motivational system to accentuate what we take to be the necessary price which must be paid to any system which is to spend its major energies in a sea of risk, learning by making errors. The achievement of cognitive power and precision require[s] a motivational system no less plastic and bold. Cognitive strides are limited by the motives which urge them. Cognitive error, which is essential to cognitive learning, can be made only by one capable of committing motivational error, i.e. being wrong about his own wishes, their causes and outcomes" (38–39 in Tomkins). Sedgwick's note says: Computers designed according to such protocols "would be much more interesting than our present computers, but they would also have certain disadvantages. They would be capable of not computing for the designer for long periods of time when other computers were sending messages to them; when they were afraid of overly severe fluctuations in their sources of electricity; when having tried unsuccessfully to solve then insoluble problems, they became depressed; or when they became manic with overweening false confidence. In short, they would represent not the disembodied intelligence of an auxiliary brain but a mechanical intelligence intimately wed to the automaton's own complex purposes" (000).

[202] Elizabeth Wilson, *Affect and Artificial Intelligence* (Seattle, WA: University of Washington Press, 2011). Of course, Wilson's book comes at the tails of Minsky's *The Emotion Machine*, which is not discussed by Wilson; still, Minsky's publication does not invalidate Wilson's argument for making machines that are oriented toward the interpersonal domain.

[203] See Silvan Tomkins, "Simulation of Personality: The interrelationships between affects, memory, thinking, perception, and action," in *Computer Simulation of Personality: Frontier of Psychological Theory*, edited by Silvan Tomkins and Samuel Messick (New York: John Wiley, 1963): 3–57; and *Affect, Imagery, Consciousness, volumes 1–IV* (New York: Springer, 1962, 1963, 1991, 1992).

Affect is born in *in-between-ness* and resides as accumulative *beside-ness*…. [It] marks a body's *belonging* to a world of encounters … but also [its] *non-belonging*."[204] This poetic expression of affect does much to expose its elusiveness—as soon as affect *is* one thing, it seems to immediately call upon its opposite. Affect as a set of interacting force relations suggests elements of disruption, contradiction, paradox. In an anthropomorphic realm, we might put this in terms of behaving on behalf of conflicting drives, or give the practical example of one saying one wants this thing but undertaking a set of actions that undermine the very possibility of its accession. This refusal to cohere along univalent lines that is at the heart of Siegworth's and Gregg's notion of affect exposes a problem for a project of computing: a fundamental condition for an algorithm is internal consistency.[205]

This chapter contends with this very paradox: On one hand affects, in their theoretical sense and in our everyday experience of them, point to the complexities of human experience that seem to exist outside the bounds of empirical observability, linear behavior, and computability. On the other hand, since the point at which these phenomena were initially theorized as affects (and therefore as objectively distinct from primary drives), they have been thought of in terms of programs that must, because of their programmatic character, cohere and execute a routine. Given that ours is a time to take seriously the quality of behavioral complexity, lest human affective behavior be explained away by algorithms that can't account for (can't compute) their complexity, I offer an alternative origin story to a theory of affects. I draw on ideas from within the very fields of cybernetics and early artificial intelligence in order to identify how and why affects, thought along both intrapsychic and interpersonal domains, fail to compute, and why it is important that they do. I first examine the intellectual environment into which Tomkins's affect theory was born, a conference in 1962, where psychologist and artificial intelligence research Walter Reitman asked what it would mean to make a model of the human drive system in the computer. Reitman sustains an extended comparison between the Freud's theory of drives and the Herbert Simon's General Problem Solver computer program, an artificial-intelligence architecture based on means-ends analysis. The dual analysis exposes the centrality of a dialectic between conflict and resolution in the drive system, which defies some of the very principles of Simon's architecture, and in computability theory more broadly.

I situate Reitman's theoretical contributions as partial, with respect to a general theory of affects, because it focuses—as does that of Tomkins—on the autonomic, intrapsychic forces exclusively, treating the individual as an isolatable unit. I then offer another, distinct set of ideas of about affect that in its emergence in and through interpersonal interaction, through the concept of metacommunication as it was proposed, across a range of intellectual spaces and texts interpenetrating the mid-century cybernetics milieu, by anthropologist and philosopher Gregory Bateson. The principles of metacommunication offer that human communication, and that of some mammals, has a peculiar and paradoxical affective charge. If communication is based on the principles of channel and signal, form and contents, in interpersonal interactions—verbal but also gestural—people co-create the quality of the channel as they send signals, often sub-perceptually and unconsciously. For Bateson, consciousness arises out of the act—often co-created by those interacting—of bringing the metacommunicative link into awareness. Because

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[204] Gregory J. Siegworth and Melissa Gregg, "An Inventory of Shimmers," in *The Affect Theory Reader*, edited by Gregory J. Siegworth and Melissa Gregg (Durham, NC: Duke University Press, 2010): 1–25, 2.

[205] On the issue of computability and its limits, see the Stanford Encyclopedia of Philosophy entry on "Computability and Complexity" (October 18, 2021), https://plato.stanford.edu/entries/computability/.

metacommunication occurs at any scale of interaction, from one-on-one casual exchanges between family members to the relation established through mass communication, we can read it as a tool for a form of affect-oriented ideology critique. It helps explain a fundamental gap between human-human and human-machine relations, because in the latter there can be no shared awareness or co-creation of the social interaction's affective register.

INTRAPSYCHIC

Silvan Tomkins publicly introduced his concept of affects at a 1962 conference he organized at Princeton, titled "Computer Simulation of Personality: Frontier of Psychology Theory." The conference proposal offered the following conceptual question: "The central problem for computer simulation of personality is what shall we try to simulate?"[206] Co-organizer Samual Messick, in the conference proceedings' published resume, explicates the inquiry in more precise terms: "In artificial intelligence systems the concern is primarily with the solution of a problem or the performance of an activity like chess-playing, with no necessary attempt to imitate the processes by which a human being solves the problem or plays chess…. These artificial intelligence systems, however, were not particularly germane to the present conference: The discussion of personality simulation emphasized the appropriate representation of processes as well as the imitation of end products."[207] In other words, studying a program's achievement of objectives and results, and likewise the epiphenomenon of an AI exhibiting something that could pass as behavior, was not apt for the study of personality, it was assumed. Instead the subject had to be the very sequences of psychic activity that make it possible to attain a goal or, equally as important, that frustrate such a pursuit. In short, the motivations that organize such sequences of actions were to be the subject of simulation.

Taking note of the field of artificial intelligence at the time, we should clarify some of the assumptions Messick's statement makes. The notion that a simulation is successful when its outputs alone mimic human behavior was a foundational principle in computing and the emerging field of artificial intelligence, as Alan Turing had, a decade before Tomkins's conference, established it as the evaluative criterion for intelligence with the imitation game.[208] And, by the time of Tomkins's conference, neurophysiological work on artificial neural networks had, similarly, modeled adaptable computer programs whose interior organization schematically referenced the human brain's synaptic connections, but these interior pathways were not meaningful or accessible in a representational way.[209] Here, too, the emphasis was on the output's believability as the product of an intelligence process. It was likely this body of research

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[206] Samuel Messick, "Computer Models and Personality Theory [Conference Resume]," in *Computer Simulation of Personality*, 305.

[207] Messick, "Computer Models of Personality Theory," 307

[208] See Alan Turing, "Computing Machinery and Intelligence," *Mind: A Quarterly Review of Psychology and Philosophy* 236 (October 1950): 433–460.

[209] See Frank Rosenblatt, *Principles of Neurodynamics: Perceptrons and the Theory of Brain Mechanisms* (Ithaca, NY: Cornell Aeronautical Laboratory, 1961), 3; originally classified; and Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," *Psychological Review* 65, no. 6 (1958): 386. See also Warren McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," *Bulletin of Mathematical Biology* 52, no. 1–2 (1943): 99–115 Donald Hebb, *The Organization of Behavior* (New York: John Wiley and Sons, 1949).

that Tomkins's co-organizer Samuel Messick was referencing in his description of the conference's objectives.

The Computer Simulation of Personality conference, however, was coming at the heels of some influential work in computing that was in fact shaping the field of artificial intelligence to adhere to the process-oriented parameters Messick describes. In particular, Herbert Simon, Allen Newell, and Cliff Shaw created a computer program in the late 1950s, called the Logic Theorist, that solved half of the proofs from Alfred North Whitehead's and Bertrand Russell's *Principia Mathematica*, and its solutions were lauded for being more elegant than those of the human mathematicians themselves. The machine-produced proofs output not simply a final numerical answer but the solution's step-by-step explanation.[210] Simon and colleagues were intent on studying how people approach problems, break them down, and make intelligent decisions along their way to solving a problem. They published their learnings from empirical studies of human problem-solvers in a paper published in 1961, titled "Computer simulation of human thinking."[211] Given the timing and the title of Simon et al.'s paper, it is hard to imagine this work was not foundational in informing Tomkins, despite the fact that Tomkins does not cite Simon, Newell, and Shaw himself. Seemingly taking a cue from Simon's milieu, Tomkins and Messick explicitly state in the conference proceedings their intent for the gathering to elicit methods for "representing human processes and response patterns in computer terms."[212]

This stance provoked detractors, even within the conference itself, and while some were overtly skeptical of computer technology in a reactive manor, some objections to the conference's premise also highlight a conceived distinction between cognitive and affective processes with respect to the automaticity of the body and mind. Psychologist Milton J. Rosenberg, for example, challenged that: "we cannot with any trust measure the events that actually occur within natural systems of individual personalities; we cannot get at the structural organization of those natural systems or at the full meaning of the signals that issue them. Lacking a way of assessing what is *in* personality, or of the ways in which human personalities vary, we are then not in a position that would permit true simulation."[213] Rosenberg exposes Tomkins's proclivity to instrumentalize the imperative of computing machines that everything in its purview be formalized into determinate datums and operators. Rosenberg's comment implicitly gestures at the fact that the elements of "personality," which involves the interplay of motivational forces like emotions, differ from those of "thinking." The latter already taking place in terms amenable to symbolic representation and conscious intervention makes its observation and description more straightforward. The ways of affects are much more diffuse.

Tomkins addressed this problem by conceiving of human affects as elements distinct from but entangled with drives. They both amplify drives and attach these primary motives to actual cognitive and motor behaviors. They are the *stuff around* unfolding thoughts and actions that impose a bias in this way or that onto those very processes—they impede, dampen, and

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[210] Allen Newell, Cliff Shaw, and Herbert Simon, "Empirical explorations with the logic theory machine," *Proc. Western Joint Computer Conference 15* (1957): 218–239; reprinted in Feigenbaum and Feldman, *Computers and Thought* (1963). See also other work in an emerging field of "cognitivist" approaches to artificial intelligence, such as Oliver Selfridge's and Ulric Neisser's Pandemonium computer architecture. See a detailed analysis of this work in chapter four of this dissertation.

[211] Allen Newell and Herbert Simon, "Computer Simulation of Human Thinking," *Science* 134 (1961): 2011–2017.

[212] Messick, "Computer Models of Personality Theory," 307

[213] Milton J. Rosenberg, "Discussion: Simulated Man and the Humanistic Criticism," in *Computer Simulation of Personality*, 114.

activate certain neurological sequences that result in externally observable affects and behavioral results. In many respects, Tomkins's affects are the general phenomena that cloud, and mess with, that which was a top priority for computer engineers at the time—the economy of rational thought.

In this respect, Tomkins's essay contribution to his conference—his introduction of affect theory—runs somewhat counter to the work of Newell and Simon. And in this regard, it appears to contribute an aspect of humanistic complexity to a computationally focused milieu. It is on these terms that Eve Sedgwick and Elizabeth Wilson find in Tomkins's work something conceptually refreshing and worth restoring. Indeed, Sedgwick writes, "thus it is the inefficiency of the fit between the affect system and the cognitive system—and between either of these and the drive system—that enables learning, development, continuity, differentiation. Freedom, play, affordance, meaning itself derive from the wealth of mutually nontransparent possibilities for being wrong about an object—and, implicatively, about oneself."[214] Here, Sedgewick is contrasting Tomkins's contributions with, not surprisingly, behaviorism but also with psychoanalysis and its insistence on "a single bar (repression) between a single continuous 'consciousness' and a single 'unconscious," as well as cognitive psychology and its attempts "to render the mind's processes transparent through and through from the point of cognition."[215]

When Tomkins's ideas about the discrete affective processes are read alongside those of his colleagues working in the cognitivist tradition—some of whom he invited to this conference—a different picture of the "productive opacity" comes into view, however. And it is on these grounds that I turn to Walter Reitman's conference essay "Personality As a Problem-Solving Coalition," an earnest attempt to not only heed the conference's call for simulating personality in computer terms but, further, an effort to ground Tomkins's theory about the "interrelations of memory and thought" with rigorous conceptual inquiry and citational practice.[216] In doing so, Reitman, an engineer who was at the time working alongside Herbert Simon and Allen Newell at the Carnegie Institution of Technology, laid bare the subtle friction points and also glaring incompatibilities between relay-based machines and organic human bodies and their conscious and unconscious motivations. Through a close reading of Reitman, a limitation of Tomkins's approach to affects becomes clear—in supplanting the drives with affects, Tomkins's theory neglects the tension between conflict and its resolution as a foundation of intrapsychic processes and as an explanation for emotional, and sometimes irrational, behavior. The implications of this move is that Tomkins's theory in effect neutralizes behavioral complexity and makes affects amenable to the ways of computer programs, which require the removal of contradiction.

Reitman's paper, alternatively, exposes these friction points while also taking the position that computers may have a role to play in personality research. Machine programs may not be able to adequately isolate human affects for observation, and therefore nor can they adequately model affects, but they can model and test *theories* about human personality. The field of personality theory at mid-century was seeing a flurry of efforts to describe emotional behavior with attention to its interior manifestations by systematizing psychoanalysis and other clinical and empirical methods that countered the external, stimulus-response focus of behaviorists. This

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[214] Eve Kosofsky Sedgwick (with Adam Frank), "Shame in the Cybernetic Fold," in *Touching Feeling* (Durham, NC: Duke University Press, 2003), 107–108.

[215] Sedgwick and Frank, "Shame in the Cybernetic Fold," 106.

[216] Walter R. Reitman, "Personality As a Problem-Solving Coalition," in *Computer Simulation of Personality*, 69–100, 70.

can be seen in, for example, David Rapaport's 1959 "The Structure of Psychoanalytic Theory: A Systematizing Attempt," which sought to endow Sigmund Freud's legacy with highly formalized and mobile concepts for the pursuit of repeatable scientific studies and measurement-oriented clinical practice in an era whose zeitgeist was systems theory and computability.[217] In his conference presentation, Reitman engages in an extended comparison of Freud's theory of drives, as read through Rapaport, with Herbert Simon and Allen Newel's latest computational model to simulate cognition—the General Problem Solver.[218]

I pursue as a method here a close reading of Reitman's paper, and its inquiry into the computability of drives, as a way to clarify the assumptions of Tomkins's affect theory, because the citational "opacity" of Tomkins's own writing does not provide the critical levers—scientific *or* humanistic—to do so. Historian of science Ruth Leys has produced a thorough analysis and critique of this emotion science genealogy that Tomkins originated, critiquing this dubious aspect of the work that I, too, have found. Despite Tomkins's theory informing a particular but influential strand of psychological science, based on claims about the innate biological underpinnings of the nine discrete emotions, Leys exposes the dearth of empirical evidence and rigorous scientific practice supporting the claims. In *Ascent of Affect*, Leys argues that, in subordinating drives to affects as dominant factors in human activity, Tomkins was arguing that emotions are "*intrinsically independent of all objects*."[219] Unlike drives, affects assumed more generality and only the loosest of relations with respect to external triggers. The implication of this theoretical stance, Leys asserts, is that Tomkins undermined his own project of understanding motivation, in that he made it so that "emotions … can be satisfied without the means-ends logic of the drives."[220] The further consequence of this, for Leys, is that in removing the instrumental character of emotion, in evacuating the potency of the object for the subject, Tomkins also removes the capacity for emotions to hold meaning or intentionality, biologically or socially. While Leys sees this as an evacuation of a means-ends quality of emotions, by way of Tomkins's rejection of Freud's drives, I would argue that given Tomkins's implicit invocation of Simon and Newell suggests an interest in the "means-ends" computer architecture as an inspiration for thinking through personality theory. By way of a reading of Reitman, as a contrast to Tomkins, I will take a slightly different stance: Despite the seemingly complicated and layered aspects of Tomkins's affect theory, by subordinating the role of drives it in fact explains away the complexity of human behavior.

Reitman instead gives weight to a dialectic of discord and harmony within intrapsychic processes, as an underlying principle of human motivation that crossed disciplines between the humanistic, social, biological, and computer sciences. Reitman selects a problem-solving heuristic as his starting point, for the practical reason that it is an aspect of cognition and computing alike for which he had intimate knowledge, through his proximity to Simon and Newell and their development of the General Problem Solver (GPS). Also, because of its goal-

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[217] David Rapaport, "The Structure of Psychoanalytic Theory: A Systematizing Attempt," in *Psychology: A Study of a Science*, edited by Sigmund Koch (Durham, NC: Duke University Press, 1959): 55–183.

[218] See Allen Newell and George W. Ernst, *GPS: A Case Study in Generality and Problem Solving* (New York: Academic Press, 1969). See also Allen Newell, "A Guide to the General Problem-Solver Program GPS 2-2 (U.S. Air Force Project Rand, The RAND Corporation, February 1963).

[219] Ruth Leys, *The Ascent of Affect: Genealogy and Critique* (Chicago: U of Chicago Press, 2017), 31–32.

[220] Ruth Leys, *The Ascent of Affect*, 31–32.

orientation Reitman thought it an apt starting point from which to propose a new model of human motivation.

A straightforward starting point, Reitman thought, would be the fact that the GPS's activities could largely be described in accordance with the "ordered veridical thought" attributed to the reality principle in Rapaport's systematization of Freud. As Rapaport says of Freud's prolific writing and multi-staged theoretic developments, "No behavior can be described as an id behavior, or an ego behavior, or a conscious behavior…. Every behavior has conscious, unconscious, ego, id, superego, reality, etc., components…. Every behavioral phenomenon has perceptual, learning (memory), conceptual (cognitive), motor, etc., components."[221] This multiplicity of phenomena that impose upon the cognitive activity alone are precisely what Reitman was looking to account for, in this respect following Tomkins. He selected the GPS as a model on the premise that it offered a representation of a multifaceted system of internal relations, organized according to their orientations toward fulfillment of an objective. That the GPS also operated according to principles of symbolic logic, and therefore assumed a narrowly deductive process of problem-solving that didn't so adequately describe affect's neurological formation subject to the laws of physics, nor its materialization as an aspect of phenomenal experience, would be a topic Reitman would return to in his conference paper.

The GPS was devised by Newell, Simon, and Shaw to be a highly generalizable symbolic machine, applicable to many different problem-solving tasks. This generality was achieved by the way in which the GPS separated the structure and contents of a problem space, or, in mathematical terms—operators and objects. If a GPS program were to play chess, for example, it would treat as the object the position of the piece (with the notation of x, y coordinates) and as the operator, the chess move. The GPS regularized goals into three types: transform object *a* into object *b*; apply operator *q* to object *a*; and minimize the difference, *d*, between object *a* and object *b*. Each of these could be thought of as initiating a set of steps in working toward the goal; each of them is a certain logic program that directs actions taken.[222]

Two central features of the GPS were its hierarchical structure and its implementation of a means-ends analysis problem-solving heuristic, both of which factor significantly in Reitman's analysis for suitability with personality theory. In a 1959 paper introducing the GPS-1, Newell, Shaw, and Simon describe means-ends analysis using the following example of common sense reasoning: "I want to take my son to nursery school. What's the difference between what I have and what I want? One of distance. What changes distance? My automobile. My automobile won't work. What's needed to make it work? A new battery. What has new batteries? An auto repair shop. I want the repair shop to put in a new battery; but the shop doesn't know I need one. What's the difficulty? One of communication. What allows communication? A telephone … And so on."[223] The analysis takes the total problem space, the difference between the current position and the goal position and breaks it down into sub-parts, individual steps that can be classified according to their functional quality, with respect to the problem. Each step has its own internally consistent means-ends logic. Therefore the overall activity involves the problem-solving entity "oscillating among ends, functions required, and means that perform them."[224] In this sense, "the

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[221] David Rapaport, "The Structure of Psychoanalytic Theory," 74.

[222] See Newell and Ernst, *GPS*. See also Walter Reitman, "Programming Intelligent Problem Solvers," *IRE Transactions on Human Factors in Electronics* (March 1961): 26–33.

[223] Newell, Shaw, and Simon, "Report on a General Problem-Solving Program," (The RAND Corporation, 1959), 9.

[224] Newell et al., "Report on GPS" (1959), 9.

GPS in processing symbols is … attempting … to construct a path between points in a problem space," and a particularly economical path at that. Nonetheless, this is not merely a linear activity, with one subprogram handing off to the next. The GPS acquired its ability to handle complex, multi-layered problems through its fundamentally hierarchical organization, which mediated between overarching goals and subgoals.

The GPS developers had recognized that, in human problem solving, there is a good amount of trial and error, as well as selection of an appropriate means for the situation from a catalogue of possible means at one's cognitive disposal. So, just as this rational work reduces a problem into the fewest number of steps and the most direct path to an objective, such optimization also involves multiple threads of activity, some of which will become core to reaching a solution and some of which will be tossed out as erroneous. Newell, Shaw, and Simon addressed this experimental aspect of human problem-solving through a program organization that involved "an executive routine and its battery of heuristic methods for setting up, evaluating, and attempting goals."[225] The executive routine is recursive, in that it can call upon itself in the pursuit of any number of subgoals. Accounting for the fact that there are "uncertainties as to the means," at any stage of the problem-solving activity, at any point in the path between starting point and goal, the executive is generating subgoals, and often these routines are superfluous.[226] Each subroutine is applying respective heuristic methods to a piece of the problem and outputting a result, and the executive routine meanwhile chooses which subgoal meaningfully moves the mark toward goal attainment. Many such subgoals are rejected in the process. In this system, there are a number of interrelated processes, but the subgoals interact only with the executive, not amongst themselves. The system's complexity was, according to its designers, thought to emerge from the potentially unlimited number of subgoals that could be generated by the executive, and through the executive's sophistication in evaluating each subgoal's contributions to a larger goal.

The principle of complexity arising from hierarchical structures was one that Herbert Simon thought to be generalizable far beyond computer programs. He in fact theorized hierarchical organization as an explanatory feature of physical, biological, and social systems writ large. In a 1962 paper "Architecture of Complexity," Simon points to evidence of prevalence of hierarchy across a number of domains: from the chemical elements to crystals and polymers to mammals.[227] This tracks not only with matter and its subjection to the principles of entropy but also to our means of symbolic description. For example, when asked to draw a face, a person almost always draws the head and neck before marking out individual features. Regardless of order of operations, the scribe tends to work from an implicit understanding that the head and neck are of a different order than the eyes and mouth.[228] Hierarchy, and thus complexity, is a product of evolution. Simon offers that "complex systems will evolve from simple systems much more rapidly if there are stable intermediate forms than if they are not."[229]

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[225] Reitman, "Programming Intelligent Problem Solvers," 28–29.

[226] Reitman, "Personality as a Problem-Solving Coalition," 80.

[227] Herbert Simon, "Architecture of Complexity," *Proceedings of the American Philosophical Society*, 106, no. 6 (December 1962): 467–482.

[228] Simon, "Architecture of Complexity," 481.

[229] Simon, "Architecture of Complexity," 473.

Stable intermediate forms, as Simon's criterion for the development of complex structures, are arrived at by way of certain conditions concerning the interrelationships between the various components of a hierarchic system. Not all interactions are of the same quality, however, and Simon distinguishes between processual relationships *among* and *between* subsystems, and also between short-term behavior within the system and that behavior that arises through evolutionary time (abstractly conceived). To explain this, Simon proposes a theory of "nearly decomposable systems, in which the interactions among the subsystems are weak, but not negligible."[230] This semi-permeability between subsystems has the implication that the set of subsystems can be understood as either a collection of disparate states, or a set of processes through which these states transition to new, metasystem states. Simon uses the example of temperatures in the various spaces of an office building. The temperature of the building overall, despite micro temperature differentials within the space, is sharply distinguishable from that of the outside environment. Within the building are rooms, the walls of which are slightly more permeable than those separating the building from the outside. Within each room are a number of cubicles, each with their respective and differentiated temperatures at the starting state. Over time, the temperature within a given room, *across* the microsystems of the individual cubicles will reach a state of equilibrium; some time after that, as the quality of individual rooms are "partially decomposable," the temperature across all of the rooms will reach a state of equilibrium, and the temperature will be distinguished only from that of the environment outside the office building.

Despite that Simon is here describing an entropic process of energy distribution and potential, the purpose of his analysis is to explain informatic systems. (Information theory was, of course, developed with respect to concepts of entropy but nonetheless has its own respective properties.[231]) For example, Simon explains that, in the early stage of this equilibrium-producing process, it would be necessary to measure the temperature at each cubicle, in each room. Not only would just one thermometer in a given room not accurately portray the state of each micro, cubicle-scale system, there is a plentitude of information available at each cubicle—information quantity being contingent on temperature difference. Once the temperature had equalized across the room, thermometer readings at each cubicle would be redundant—they would all read the same, and therefore there would be very little information available with respect to the number of thermometers. Thus, temperature states evolve over time, but at any given time the system's structure can be understood according to the "[separation of] high-frequency dynamics—involving the internal structure of the components—from the low frequency dynamics—involving interaction among components."[232]

Simon uses the theory of partial decomposability to explain means-ends analysis in hierarchic systems. In other words, here there are two ways to look at the same situation: there are the spatially specific temperature *states* at any given moment, which can be represented as information; and then there are the *processes*, or operations, that translate between one state to the next, from one level to the next in a hierarchic structure and in the teleology of end-state pursuits. Therefore, "apprehending structure" always involves something of a paradox:

> Pictures, blueprints, most diagrams, chemical structural formulae are state descriptions. Recipes, differential equations, equations for chemical reactions are process descriptions.

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[230] Simon, "Architecture of Complexity," 474.

[231] See Ronald Kline, *The Cybernetics Moment* (Baltimore, MD: Johns Hopkins University Press, 2015).

[232] Simon, "Architecture of Complexity," 477.

> The former characterize the world as sensed; they provide the criteria for identifying objects, often by modeling the objects themselves. The latter characterize the world as acted upon; they provide the means for producing or generating objects having the desired characteristics.
>
> The distinction between the world as sensed and the world as acted upon defines the basic condition for the survival of adaptive organisms. The organism must develop correlations between goals in the sensed world and actions in the world of process. When they are made conscious and verbalized, these correlations correspond to what we usually call means-ends analysis. Given a desired state of affairs, and an existing state of affairs, the task of an adaptive organism is to find the difference between these two states, and then to find the correlating process that will erase the difference
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> Thus, problem solving requires continual translation between the state and process descriptions of the same complex reality…. We pose a problem by giving the state description of the solution. The task is to discover a sequence of processes that will produce the goal state from an initial state. Translation from the process description to the state description enables us to recognize when we have succeeded. The solution is genuinely new…. Our dual relation to the world is the source and solution of the paradox.[233]

The mode of translation across subsystems, and between subsystems of those larger systems to which they contribute is, for Simon, informational. The overarching structure of executive-subsystem, brain-organ relations is one aspect of the complexity. But information has to be routed both within and across subsystems and metasystems, and the higher-order elements must decide about that information's suitability. Here, the operations that transform information are the other aspect of complexity.

Reitman draws on the work of Simon et al because this model seems to suggest something analogic with human intrapsychic processes. Rather than assume a direct compatibility or collapsibility between the two, Reitman sustains the comparison between the GPS's "goal hierarchy" with psychoanalytic concepts of "motivational hierarchy."[234] The computer program is most directly apt for modeling what psychoanalyst Rapaport calls "ordered veridical thought," because, after all, it was designed to simulate it in specific problem-solving tasks. Nonetheless, Reitman sees that the GPS is "not immediately applicable to phenomena such as dreams, daydreams, or reveries," among other psychic phenomena not obviously contributing to rational thought or teleological activity more generally.[235] Reitman goes on to detail exactly what is substantively in this intrapsychic communication that doesn't immediately compute, so to speak.

We can first note that the quality of an objective is quite different in the two realms. In the GPS and in Simon's theoretical framework of hierarchy more generally, there is a "unitary character" to the goal structure.[236] The executive routine is the guardian of the goal, and all

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[233] Simon, "Architecture of Complexity," 479.

[234] Reitman, "Personality as a Problem-Solving Coalition," 76.

[235] Reitman, "Personality as a Problem-Solving Coalition," 86.

[236] Reitman, "Personality as a Problem-Solving Coalition," 76.

subsystems generate and produce hypotheses for subgoals on its behalf. The machine works on one goal at a time and the executive outputs one set of results at a time. Like much of Simon's thinking, this goal structure was not singularly a function of the GPS but was generalizable. "In social as in physical systems," Simon says in the essay on complexity, "there are generally limits on the simultaneous interaction of large numbers of subsystems. In the social case, these limits are related to the fact that a human being is more nearly a serial than a parallel information-processing system. He can carry on only one conversation at a time…."[237] Those working in a psychoanalytic tradition would insist otherwise. Even though for Simon hierarchic structures like that modeled by the GPS exhibit aspects of complexity in there interrelations, Reitman—here drawing on psychoanalysis—points out that "the most striking characteristics [of the GPS] are *the absence of conflict, of defenses against conflict, of wishful thinking, and, in general, of anything which might undermine the total unity of purpose* such a system displays."[238]

Purpose in the psychoanalytic model of personality is both structurally and operationally contingent on conflict and its (momentary) resolution. This has to do with, for one thing, the fact that the drives originate not with the "executive" or the "ego," but instead in the unconscious where they then attempt to act upon consciousness. And while the drives are generally conceived to move toward pleasure or pain, life (sex, reproduction) or death, and prompt activity oriented toward external objects that can sate desires, they have "vicissitudes." In this respect, drives and their interior organization cannot be decoupled from the psychic sources of their physiological force. That is, in Reitman's estimation, they can't be understood—and therefore modeled—according to the logic of a distinction between structure and operations, form and content, as with the GPS and Simon's broader understanding of intra- and interpersonal human activity. Simon's formulation is decidedly an informational one, while the drives are inseparable from their energetics: "the psychoanalytic conception of personality … [puts] emphasis on the dynamics of conflicting drives, drive discharge thresholds, countercathectic energy distributions controlling and defending against drive discharge, drive derivatives resulting from conflicts among opposing forces, and on the varied psychic manifestations of these phenomena."[239] Motivational intrapsychic behavior thus seems to be probing at two things at once—the body's overarching need for a homeostatic equilibrium, with respect to its external environment, and objects (externally or internally derived) that can satisfy the desire, attenuate the drive activation.

This gets us back to a discursive friction point with respect to the drives and their discussion in contemporary scholarship: Are the drives to be theorized on account of their conceptual attachments (and therefore their linguistic form) or on account of their physiological and neurological manifestations? Ruth Leys articulates this divide, deriving from psychoanalysis but within the broader discourse of emotion research, and takes a stance on the former. Because drives are oriented toward objects from one's external environment—even when those objects materialize as internal projections and figments of memory—they exhibit intentionality that operates at the level of discursive meaning. Perhaps the meaning is most potent when the conflicting drives contribute to individuals saying one thing and doing another, or wanting two conflicting things at once. Or, meaning arises in the very gap between what the object of desire is imagined to do for the subject versus what it actually does. In other words, the fact that libidinal desire, for example, "has extraordinary freedom with respect to objects precisely because it has

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[237] Simon, "Architecture of Complexity," 476.

[238] Reitman, "Personality as a Problem-Solving Coalition," 75, my emphasis.

[239] Reitman, "Personality as a Problem-Solving Coalition," 76.

no predetermined objects of its own."[240] The meaning, possibly, is in the lack itself. On this topic, Leys' analysis comes at the issue of drives from a very different set of questions than those appraisals of Freud that focus more attention on his preoccupations with the body's neurological and energetic conditions. The two readings bring up discursive tensions that are productive for our examination of Reitman's proposal.

This other body of recent scholarship emphasizes how in Freud's writing, there is a concern with the body's status as an organic unity subject to the ways of entropy. For Paul Ricoeur, for example, in Freud there are "two universes of discourse," whereby "meaning relations are entangled with force relations."[241] Anson Rabinbach furthers Ricoeur's stance, arguing that, in Freud's early work [1895], there was an attempt "to give scientific credence to the view that all representations," and accordingly all acts of "will," "were functions of the body's 'sensory qualities,' which Freud divided into the competing spheres of pain and pleasure."[242] In Freud's later works, and in particular the formulations synthesized in *Beyond the Pleasure Principle* (1920), "Freud introduced the idea that the human organism resists the excess expenditure of energy and strives toward the elimination of tension."[243] Rabinbach here reads the attenuation of tension on the theoretical grounds of classical physics, and likens it to the principle of inertia. Regardless of the extent to which Freud was directly engaging with the vectors of twenty-first-century physics, such as those of relativist and quantum principles, informed by the second law of thermodynamics, it seems apt to read Rabinbach's own identification of energy-derived tension and release through the lens of the contemporaneously introduced concept of homeostasis.

Understanding Freud's drives as having a fundamentally regulating function seems to have contradictory implications, with respect to the drive system's relation to the body as an organic entity, and simultaneously as having a feature the cyberneticists would draw upon in their designs for intelligent machines. We will get back to this implication in a moment, after heeding Stefanos Geroulanos' and Todd Meyer's call to see in Freud a deep engagement with this nascent yet influential theoretical concept in twenty-first century physiology.[244] This contemporary assessment of Freud is in agreement with Rapaport's mid-century genealogy of Freud's thinking with respect to physiology and neurology, though his didn't make the immediate connection with homeostasis. Homeostasis was conceived by American physiologist Walter Cannon in the 1910s, and originated from his work with wounded WWI soldiers who were experiencing shell shock in response to the intensity of modern warfare. Facing the ways in which shock would manifest in the human body, Cannon's enduring implicit research question became: "'Why don't we die daily?'"[245] The body's regulatory capacities were paradoxical for Cannon, in that the body appeared to reach states of internal equilibrium by way of the violent confrontation of multiple electrical and chemical impulses within the nervous system. Geroulanos and Meyer deftly demonstrate that in physiologists' studies on hormones and in

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[240] Leys, *The Ascent*, 30, citing Laplanche and Pontalis.

[241] Ricoeur, "A Philosophical Interpretation of Freud," *The Conflict of Interpretations: Essays in Hermeneutics*, ed. Don Ihde (1974), 167.

[242] Anson Rabinbach, *The Human Motor* (New York: Basic Books, 1990), 170.

[243] Anson Rabinbach, *The Human Motor* (New York: Basic Books, 1990), 63–64.

[244] Stefanos Geroulanos and Todd Meyers, *The Human Body in the Age of Catastrophe: Brittleness, Integration, Science, and the Great War* (Chicago: U of Chicago Press, 2018).

[245] Geroulanos and Meyer, *The Human Body*, vii.

Freud's contemporaneous development of the drive theory, there were "mirroring concepts"—both groups were imagining their respective research phenomena as "isomorphic processes … what to them seemed like bodywide, unconscious activities that were responsible for internal regulation as well as for the subject's behavior."[246] On the topic of behavior, we might contrast Cannon's resultant theory of fight-or-flight responses with Freud's metapsychology practice of the talking cure. Leys would here emphasize how the latter offers a lever for eliciting meaning and intentionality through its transformability between drives, memory, and language. This is a similar premise, in fact, to that of Simon, who in the essay on complexity proposed a natural and necessary separation and translation between content and form.

And yet, Freud's theory of the drives emphasizes their respective physiological states and conflictual interrelations as inseparable. In his 1905 introduction to the theory of drives in *Three Essays on Sexuality*, Freud proposes that: "The drive is … one of the concepts on the frontier delimiting the psychic from the physical. What differentiates drives from one another and endows them with specific qualities is their relation to their somatic sources and their aims. The source of a drive is an excitatory process in an organ, and the immediate aim of the drive lies in the annulment of this organic stimulus."[247] According to Geroulanos and Meyer, Freud was drawing on nineteenth-century physiology research that made central the notion of "the body's organized internal environment," and in doing so he "defined drive in terms of a continuous internal response to an *internal* excitation or disequilibrium," with the aim of stimulus termination.[248] Geroulanos and Meyer alert us to aspects of this energy distribution notion of drives that allows us to understand its ontological distinctions from, for example, Herbert Simon's principle of partially decomposable systems and his example of temperature equilibrium-producing processes in physical systems. Within Freud's drive theory, as in physiological science at the time, there was "a logic binding integration to disequilibrium."[249] The organism's drive toward equilibrium, then, is riddled with conflict not only between internal and external, but within intrapsychic processes that paradoxically create a whole by way of their disunity and the individual's existence between the folds of life and death.

The relation between self-regulation and intrapsychic conflict is particularly evident in Freud's concept of binding, which accompanies his update to the scaffolding of drive principles in the 1920 *Beyond the Pleasure Principle*. Freud explains that: "One of the earliest and most important functions of the mental apparatus is to bind the instinctual impulses which impinge on it, to replace the primary process prevailing in them by the secondary process and convert their freely mobile cathectic energy into a mainly quiescent (tonic) cathexis."[250] That is, the binding process entails a transformation of energetic states, from one of excitation and a drive toward discharge into one of static equilibrium. Further, binding organizes drive energy such that the subject (or more specifically, the subject's mental apparatus) can come into alignment with the external object that can facilitate the annulment of stimulation. On the topic of binding Freud is then quick to establish that binding is not exclusively an ego operation, insisting: "While this transformation is taking place no attention can be paid to the development of unpleasure; but this

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[246] Geroulanos and Meyer, *The Human Body*, 4.

[247] Sigmund Freud, *Three Essays on Sexuality*, in *The Standard Edition of the Complete Psychological Works of Sigmund Freud* volume 7, trans and ed James Strachey (London: Hogarth Press, 1953–1974), 167.

[248] Geroulanos and Meyer, *The Human Body*, 4.

[249] Geroulanos and Meyer, *The Human Body*, 133.

[250] Freud, *Beyond the Pleasure Principle*, in *The Standard*, 62.

does not imply the suspension of the pleasure principle. On the contrary, the transformation occurs on *behalf* of the pleasure principle; the binding is a preparatory act which introduces and assures the dominance of the pleasure principle."[251] A dialectic of pleasure and unpleasure paradoxically "resolves" in the "peculiar tension" between them: "Our consciousness communicates to us feelings from within not only of pleasure and unpleasure but also of a peculiar tension which in its turn can be either pleasurable or unpleasurable."[252] There is thus a necessary cycle here, with respect to these qualities of sensation, which correspond to life and death instincts in contradictory ways. The drives seek pleasure in their release of (over)stimulation, which results in a more entropic state, one that resembles inert (dead) matter. Alternatively, the unpleasurable states of excitation and internal discord, are energetically speaking life-sustaining.[253]

On one hand we could read binding as something perfectly suitable for replication on a program like the General Problem Solver, even though libidinal drives originate from sources outside the "mental apparatus" and various drives can be in conflict with one another more than Simon would imagine sub-processes to be. Nonetheless, binding is transformation. It is characterized by varying energetic channels that thus may combine in all sorts of ways in and of themselves, and that may attach themselves to cognitive processes like remembering, perceiving and thinking.[254] In the logical terms of the GPS, binding would be something like applying a coefficient to the variables of a problem-solving exercise so as to weight the operations that translate them in one way or another. Binding could similarly describe specific operators themselves used to perform translations of states into other states. This understanding of binding would thus make it quite amenable to logical problem-solving. It also is an apt way to summarize Tomkins theory of affects.

That this picture seems to evacuate the individual of agency is one of the most significant implications for thinking the drive system as so error-prone and essentially engaging in an ever-present bodily civil war. The other side to this theoretical coin is the way in which homeostasis was taken up by cyberneticists in the postwar years, most explicitly by Norbert Wiener, who saw in its principle of self-regulation a means for producing machines with—paradoxically—singular purposes and teleological sensibilities of time.[255] In other words, Wiener and his colleagues in early computing, including Simon and Newell, saw the mathematical operation of translation as a unitary and unifying force. And it is on this topic where Reitman's conference essay

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[251] Freud, *Beyond the Pleasure Principle*, in *The Standard*, 62.

[252] Freud, *Beyond the Pleasure Principle*, in *The Standard*, 63.

[253] Geroulanos and Meyer excavate in Freud's later writing—and even within his multiple drafts of *Beyond the Pleasure Principle*—the conceptual emergence of the body's "dual moment" (227). They identify in the drive theory a recognition "of a decisive 'beyond' to the pleasure principle: the organism's attempt to master an intrusion or bind stimuli can be understood neither as part of a self-preservation attempt caused by the ego nor as mere libidinal effort. It belongs instead to a dual moment in which the organism at once contributes to its traumatization and attempts to reintegrate, though for reasons other than pleasure or self-preservation. Binding (succinctly put, the matching of stimuli that enables their control) cannot occur in the name of either of these processes, yet its operation is precisely one of a reregulation as defense, as instance of the drive to mastery practiced within a system and aimed at its control of external impositions" (227). Geroulanos and Meyer situate Freud's updated drive theory within a broader epistemological reworking of the concept of the individual in the twentieth-century, formulating it as an entity whose energetic composition is ever generating processes of repair and re-unification in the face of external pressure and the potential for internal collapse.

[254] See Geroulanos and Meyer discussion of *Beyond the Pleasure Principle* on pages 20, 21, 163.

[255] See Norbert Wiener, "Behavior, Purpose, Teleology," in *Philosophy of Science* 10, no. 1 (1943): 18–24.

surprisingly deviates from this set of assumptions driving his computationally inclined colleagues. He recognizes in the drive theory "a system [that] is nonlinear" and that, though this vicissitudinal quality is one of its most fundamental and consequential features, with respect to model formulation it "tells us nothing about the ways in which it deviates from linearity."[256]

Reitman nonetheless draws out such deviation potentialities, shall we call them, through his sustained comparison with the GPS and the distinction between programmatic goals and drive-based motivations. Aside from the obvious fact that human beings are alive, are mortal, and have an awareness of their mortality, there are some other important points Reitman makes along the lines of the energetic interpretation of psychoanalysis while nonetheless speaking both from and to the mindset of colleagues like Simon. For example, instead of thinking about system organization as a factor of information routing, as with Simon's models, Reitman thinks of it in terms of energy availability. The fact that energy availability is a limiting factor of organic composition generates competition and conflict among the human drives. Further, the relation—in time and "problem space," to use a GPS term—between a current state of stimulation, or agitation, and a desired state of attenuation matters in a way that differs from that of the GPS dynamics, Reitman explains: "The GPS in processing symbols is not attempting to discharge energy, but rather to construct a path between points in a problem space…. The motivational model also is concerned with path construction, of course, but it … must take into account energy configurations related to path capacity, path blockage, and so on."[257] Path construction, as a feature of motivated intrapsychic behavior, is nonetheless oriented in a bottom-up fashion, as opposed to the top-down organization of the GPS. Competing drives have respective aims in themselves, and thus have different energy dynamics. In the GPS there are no implications when subgoal programs are rejected by the executive; these micro operations have minimal, if any, interactional bearing on one another and their relation to the ultimate, end goal is immaterial. Alternatively, "in psychoanalytic formulations … satisfaction of a derivative motive becomes increasingly distant from its antecedents. And, conversely, while motives may be partially satisfied, informational goals—in the General Problem Solver at least—are either attained in full or they are not attained at all."[258]

Reitman is, perhaps unwittingly, giving us a critical lever by which to understand how Tomkins takes the messiness of drives and makes them internally consistentand programmatic according to an information-system logic. Reitman here is concerned with the very fact that the psychoanalytic theory of drives shows that intrapsychic communication—in its very ontological formation—is constituted by drives' mutual insolubility. They cannot be collapsed into one another, combined as cocktails or, in more algorithmic terms, joined as coefficients to other sets of cognitive states and their operations. Reitman ultimately puts it this way: In order to make a model of a personality theory, such as that of psychoanalysis, one has to make integral to the system "a variety of possibilities for conflict, cooperations, and coordination which simply do not arise in a centralized decision-making system such as the GPS," within which the executive simply accepts or rejects sub-programs.[259] Reitman gives a number of a number of reasons for this:

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[256] Reitman, "Personality," 81.

[257] Reitman, "Personality," 77.

[258] Reitman, "Personality," 76.

[259] Reitman, "Personality," 80.

> Here [in the GPS] there never are any conflicts about ends, but only uncertainties as to means. There may be, of course, several alternate subgoals available at one time, from among which the executive must make a choice, and certain subgoals consequently may never be attempted. But such choices are not conceptualized as the outcomes of competitions among conflicting forces; rather they reflect centralized decisions made among alternatives in the light of their relative promise. The subgoals themselves have none of the characteristics of desires, cooperating and competing in their simultaneous striving for satisfaction. They are no more than alternate possibilities for action, passively awaiting and accepting the evaluations and decisions the controlling executive makes in the light of its over-all goal. Since no concept of distinct and potentially competing drives is involved, there is no sense in which the system, in achieving one goal, simultaneously may be said to be frustrating others. Rejected subgoals, unlike blocked and frustrated drives, have no dynamic implications for the future behavior of the system. They are simply there—action alternatives which might have been initiated, but never were.[260]

Reitman's speculative ideas regarding a potential computational solution to this are less interesting than his ultimate methodological intervention, which is to question what we are even modeling when we make computer simulations. To summarize his idea for a technical model, he introduces the computing concept parallel processing, which would offer a computer architecture a means for handling multiple, competing threads of goal-oriented behavior. And, he draws on Simon's work in operations research to suggest that, in order to approximate the drive system's competition for energetic resources, we could draw on the principles of organizational systems within businesses that give autonomy to competing lower units. Reitman himself articulates the speculative quality of these analogues to intrapsychic behavior, before ultimately making the assertive claim—and call to his colleagues at the conference—that in attempting to model something as *internally inconsistent* as the human motivational system we are perhaps not working with the appropriate tools in relay-based machines that in fact necessitate internal consistency.

Alternatively, he asserts, we should recognize that we are modeling not personality itself, but our very own theories of personality, which tend to—even when they are marking the very qualities of paradox and internal contradiction—withstand the test of time based on their logical or rhetorical coherence. It is this very cohesion that makes these *discursive* objects meaningful, in that they can provoke pleasure and unpleasure, discord and alignment, friction and harmony—and ultimately intellectual stimulation.[261]

I have endured this close and extended reading of Reitman's essay to expose the conflict both within intrapsychic processes, as they were conceived in the psychoanalysis taken up in early computing research, as well as between the principle of intrapsychic energetic communication and relay-based, informational communication. Like Ruth Leys says about Tomkins, this broader milieu subordinated the relation between subject and object, or internal and external, to a matter of interior processes—the states and active steps taken between input and output. In doing so, this group of psychologically *and* cognitively oriented thinkers was working against the stimulus-response premise of behaviorism. On the other hand, they were narrowing cognitive and affective activity to the intra-bodily realm exclusively. And an

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[260] Reitman, "Personality," 80.

[261] Reitman, "Personality," 96.

implication of this work, for both the affect theory and the computing, was that it overdetermined behavioral responses. The more thoroughly "innate" or pre-structured affects or problem-solving modes became, the less they were able to account for the complexity experienced through, for example, acts of perception or interactions with uncertain environments. This fate of the GPS and systems like it is well documented in the subsequent annuls of artificial intelligence, and in twenty-first-century self-narrativizations of the field focusing on subsequent computational architectures with more robust means for dealing with uncertainty. What is little known is that affect theory would both be put to this test, theoretically and experimentally, and see a similar fate as that of GPS, because of its over-determination.

One shortcoming of Reitman's assessment of the General Problem Solver on the basis of drives, and vice versa, is that limited his theoretical elaboration to a consideration of the psychological subject as an individual entity seemingly untethered from its environment. This is the very critique Ruth Leys makes of Tomkins's affect theory, that it in effect de-charges the subject-object relation altogether, and made affects simply like modular interior directors of traffic. Removing such a capacity to *be affected* by environmental objects, Leys argues, removes the capability for making meaning. I will add, it neutralizes the political content and political potential of affects. This calls for us to extend the conflict-resolution dialectic to other contexts, from the intrapersonal to the interpersonal. Another prominent figure in the cybernetics milieu, Gregory Bateson, takes this up through his study of that which is invisible and implicit, yet ever present, in human interaction: metacommunication.

INTERPERSONAL

In the 1952 Macy Conference, Gregory Bateson focuses his session on the study of belly laughter and the peculiar ability of a joke to elicit it. Belly laughter is "one of the three convulsive behaviors in daily life, the others being grief and orgasm," but of those three "laughter [has] the clearest ideational content," and therefore interpersonal resonance, Bateson says.[262] In this respect, the phenomenon is both autonomic, outside of conscious control (convulsive), and simultaneously expresses the presence of consciousness (ideational content). But the ideational content invoked in laughter is of a decidedly nonlinguistic variety. In fact, Bateson repeatedly corrects his colleagues: "thoracic laughter rather than belly laughter … is a conventional sign …. Such laughter becomes almost a part of the vocabulary and is almost as voluntary as the use of words."[263] In studying exclusively its involuntary variety, Bateson hypothesizes: "could the occurrence of laughter be used as an indicator for what there was implicit in communication?"[264] Implicit elements of communication otherwise remain opaque, they are "very, very difficult matters for people to talk about with precision, but if these premises are out of kilter between two people, the individuals grow anxious and unhappy. Humor … gives the persons an indirect clue to what sort of view of life they share or might share."[265]

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[262] Gregory Bateson, "The Position of Humor in Human Communication," in Cybernetics: Circular Causal and Feedback Mechanisms in Biological and Social Systems: Transactions of the Ninth Conference March 20–21, 1952 New York, NY, edited by Claus Pias (Chicago: U. Chicago Press, 2016): 541–574, 542.

[263] Bateson, "The Position," 561.

[264] Bateson, "The Position," 559.

[265] Bateson, "The Position," 560.

Bateson starts off the session by telling a joke, a category of communicative act that he deems the classic antecedent to such rollicking convulsions. He then goes on to explicate why the joke is funny—a classic way to ensure the humor is lost in the process. And judging by the session transcript, this piece of jest did not incite laughter among his interlocutors. These amusing meta-readings of the transcript aside, I introduce here the Macy conference joke and Bateson's explanation of it, because it serves as an illuminating heuristic through which to understand *metacommunication*, that Batesonian cybernetics and behavioral science concept that captures explicitly the relationship between communicative complexity and socially oriented affective behavior that here I would like to make explicit. Here is the joke:

> A man working in an atomic plant knew the guard at the gate slightly, and one day he comes out with a wheelbarrow full of excelsior. When the guard says, "Say, Bill, you can't take that out," he says, "It's only excelsior, they throw the stuff away, anyway." The guard says, "What do you want it for?" Well, he said he wanted to dig it into his garden because the soil was a bit heavy, and the guard let him go. The next day he comes out again with a wheelbarrow full of excelsior. This goes on day after day, and the gateman is increasingly worried. Finally, he says, "Bill, look, I'm going to have to put you on the suspect list. If you tell me what it is you're stealing from this place, maybe we can keep it quiet between us, but I'm perfectly sure you're stealing something." Bill says, "No, it's only excelsior. You've looked through it every day and dug to the bottom of it. There's nothing there." But the guard says, "Bill, I'm not satisfied. I'm going to have to protect myself by putting you on the list if you won't tell me what this is all about." Finally, Bill says, "Well maybe we can get together on this. I've got a dozen wheelbarrows at home now."[266]

Though the joke is communicated through linguistic and specifically narrative means, its telling moves the listener's attention from words to objects of perception. The listener is put into the position of the guard, who is trying to decode this perplexing behavior by focusing so intently on the wood shavings (excelsior). "When the point of the joke is reached," Bateson explains, "suddenly the background material is brought into attention and a paradox, or something like it, is touched off. A circuit of contradictory notions is completed."[267] The punchline disrupts the guard's (and by proxy the listener's) perceptual focus, revealing the joke's manipulation of Gestalt figure-ground relations. In doing so, it also reveals to the listener her own unconscious perceptual selections determining what arrives in consciousness as figure and what remains outside of conscious awareness as background.[268] In his book *Communication: the Social Matrix of Psychiatry*, published just a year earlier in collaboration with Jurgen Ruesch, Bateson characterizes these unconscious determinants of figure-ground filtering as values: "the network

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[266] Bateson, "The Position," 542.

[267] Bateson, "The Position," 542.

[268] In "Information and Codification," in *Communication,* Bateson discusses the relationship between perception, values, and action: "It is well known that the network of value partially determines the network of perception…. It is also evident that perception determines values: as we see things, so we act. But equally the success or failure of our action will determine our later vision…. Action would seem to be the middle term in which perception and values meet" [He is also relating this to the codification of information.] (176–77). In *Steps to an Ecology of Mind,* Bateson also discusses perceptual filters through the concept of values. The notion of perceptual filters and their relation to values was discussed by the Pragmatist philosophers Pierce and James (as cited in Chapter 1). In *Communication* he cites Freud's work on wish and perception. He does not directly cite the pragmatists.

of value partially determines the network of perception" just as "perception determines values."[269] The joke "breaks open" what is otherwise implicit in one's perceptual behavior, making one's own value network—which is almost always outside of conscious awareness but is the very means for such conscious awareness—available to consciousness.[270] This intrapersonal process of values transformation is inseparable from the interpersonal dynamics that bring it about and give it a circuit quality. Bill reveals to the guard, just as the joke teller reveals to the listener, that there exists an alternative perceptual selection, an alternative value system.[271] The expansion of one's awareness to this level of meta-perception is afforded exclusively by the interactive exchange and the way it exposes one's own consciousness in the mirror of another's. These are the elements of *metacommunication*: "a mutual awareness of the other's perception."[272]

The belly laughter, then, explodes in this social space. But why? This intra-psychic awareness opened up by the joke is, you might note, not jolting enough to alone serve as its antecedent. Members of the session observe that uncontrollable laughter is almost always experienced in the presence of another or others who are also uncontrollably laughing. As Frank Fremont-Smith adds: "Contagion"[273] The joke achieves this by, during its telling, imposing a metacommunicational impasse between parties; the listener is aware that she does not see what the joke-teller, or Bill, sees. Then, the punchline event abruptly snaps the metacommunication link between the two people back into place. The punchline releases the implicit tension, and makes explicit to the listener the fact that she and the jester have been on different metacommunicative planes, and now they are on the same metacommunicative plane. Bateson emphasizes the profundity of this phenomenon: "when the joke [reaches the punchline] and the implicit levels have been touched, have met each other, and oscillation has occurred, the laughter

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[269] Gregory Bateson and Jurgen Ruesch, *Communication: The Social Matrix of Psychiatry* (New York: Norton, 1968 [1951]), 176–77. Bateson and Ruesch do not cite pragmatist philosophers, but perhaps this is building upon the Pierce and William James notion of beliefs.

[270] Bateson, "The Position," 560.

[271] In this session, Bateson says: "There are premises about one's self, in terms of what one understands something else. But the events in *interaction* [emphasis added] between oneself and the something else may lead to a revision of premises about oneself. Then, suddenly, one sees the other thing in a new light. It is this sort of thing that leads to the paradoxes and to a good deal of human, I would suspect" (551). In *Communication*, Bateson describes a sharp distinction between an inanimate thing and an interaction with another being, and especially another human being (206).

[272] 554 in Macy; see also *Communication*, 203–09: "Lastly, a word must be said about consciousness…. Whatever may be the mechanistic or spiritual base of the phenomenon, it is certainly a special case of codification and reductive simplification of information about certain parts of the wider psychic life…. But still the fact seems to be clear that the content of consciousness is an extreme reduction, derived from the total rich continuum of psychic events [see also *Steps*, 459 and the reference to Kant and the piece of chalk]. Every such reduction is a transformation or codification … and … the nature of the transformation is not itself subject to direct introspection or voluntary control. This, indeed, is the point we wish to stress, that while the (possibly illusory) sense of free will is closely bound up with the subjective experience or consciousness, the process by which items are selected for focusing in the mirror of consciousness is itself an unconscious process, not, at an given moment, subject to any exercise of the will. Over time, an individual can 'train himself' to various sorts of special awareness, and to this extent can modify the codification of ideas entering consciousness. But at any given instant, the determinism of that instant is seemingly complete…. We assume that the person who 'trains himself' does so as a result of past experience—especially interpersonal experience—which has determined his ability and motivation to undertake such changes" (*Communication* 182–3)

[273] Bateson, "The Position," 555. From Monnier at the Macy conference (p548): "Bergson pointed out [in his book on laughter and the comic situation] the biological function of laughter, that it tends to protect society against egocentric mechanical behavior of individuals at variance with outer reality."

verifies an agreement that this is 'unimportant,' it is 'play'…. The laughter lets those who laugh know that there is a common subsumption of how they see the universe."[274]

Here, I will explicate the contours of metacommunication embedded in this opening example as they materialize in Bateson's broader observational research program and cybernetics-informed, ecology-of-mind epistemology. I will show how the concept metacommunication, as an exemplary articulation of his more generalized epistemology, positions behavioral complexity as the premise for relational dynamics in interpersonal and superpersonal (culture-wide) communication systems. In doing so, this cybernetics-informed framework endows *social interactivity* as the process through which perceptual organization—and relatedly the structure of consciousness—emerges, gets codified, and adapts. The contents of communication relay by way of metacommunicative, relational premises that can establish equity and co-constitution, persist as asymmetrical but harmonious, or structure and reify power imbalances. Bateson's reading of social and biological life in the cybernetic age has garnered critical attention among some twenty-first-century scholars. This recent scholarship argues that, despite Bateson's critique of Western social and political institutions' instrumentalization of information to anti-democratic effect, his overly optimistic view of cybernetics ultimately contributed to a cultural embrace of technocratic solutionism.[275] My analysis of metacommunication reveals this very concept to be an example within Bateson's canon of a limit case for machine recognition and replication of human behavior, preserving the organic from subsumption by way of artificial intelligence without being antithetical to the development of and coexistence with sophisticated machines writ large. Bateson's concept is nonetheless a crucial intellectual resource for our times in which AI is mediating behavioral normativity in ever increasing portions of social life.

Bateson develops the concept of metacommunication, like much of his overall theoretical project, by way of induction following observational fieldwork. But we can also see how his conceptual influences orient his observational methodologies. For example, drawing on Gestalt-psychology, Bateson's texts argue that foundational to consciousness is the perception of difference, specifically of the interrelations between things that are different in both form and substance. His intellectual project asks how philosophical generalizations can work against an imperialist project of imposing universality and normativity. Bateson undertook fieldwork at a wide range of sites, recognizing the complexity and asymmetry of his relationships with research subjects while nonetheless attempting to position them as collaborators. He did fieldwork with the Iatmul people of New Guinea, with groups in the Bajoeng Gede region of Bali, within the homes of suburban families in Northern California, within psychiatric institutions treating patients with schizophrenia, and in environments with domesticated and wild nonhuman animals.[276] Metacommunication develops in and through these research experiences, and in

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[274] Bateson, "The Position," 555.

[275] See also Fred Turner, *The Democratic Surround* (Chicago: U Chicago Press, 2013) and Bernard Geoghegan, *Code: From Information Theory to French Theory* (Durham, NC: Duke U Press, 2023).

[276] Like much research that involves some empiricism, these observational studies were built on complex relationships with subjects. While Bateson should not be immune to critique for participating in research that isolated subjects on account of their pathologies (schizophrenic mothers) or on account of their culture being subaltern, non-Western, and yet a target of colonialist and imperialist projects which were simultaneously providing the funding sources for Bateson, Bateson himself recognized these complexities and built sensitivities about them into his research methodologies and his conceptual frameworks emerging from his observational fieldwork. With Bateson, there is always the reflexive critique of US social and political culture and, following the principles of the physics' uncertainty principle, a reflexive awareness of his own implication in the observational scenario. Bateson indeed received funding from and operated within existing

Bateson's synthesis of them with ideas from information theory and cybernetics contributed by Norbert Wiener and Claude Shannon, and from the biological and behavioral sciences, namely Warren McCulloch. Though the metacommunication concept is implicitly present in his earlier works, such as *Naven* (1936), and in his later essays published in his magnum opus *Steps to an Ecology of Mind* (1972), Bateson gives it the most explicit treatment in his speaking and writing from the early 1950s—in *Communication* (1951), at the Ninth Macy Conference (1952), and in the 1954 presentation to the America Psychological Association, "Theory of Play and Fantasy."[277] This work shows that, though metacommunication is most often elusive and not isolatable as an object of empirical study in itself (hence the interest in laughter as an instance of its becoming momentarily explicit), it is present in the nonlinguistic behavior that accompanies all mammalian communication. As *Communication* emphasizes, metacommunication can be studied at a number of interrelated scales, from the intrapersonal and interpersonal to the group and the cultural. Here, I will first explicate the metacommunicative link in its interpersonal form, as it explicates baseline principles, before getting to the idiosyncratic aspects of the group or culture-wide metacommunication properties and their implications for machine simulation.

When humans and other mammals communicate, Bateson observed, they are simultaneously inside and outside of that communication at once. For example, in human dialogic exchanges, people are *in* communication when they discern the explicit content of the conversation, or the *what* of communication. At the same time, when engaged in such dialog, people "raise our voices … according to the distance that the recipient is from us;" "modify … and include in our speech all sorts of [implicit] messages about how the speech is to be interpreted;" and "watch faces of the people we are talking to, to see whether the message is getting through … [which] tells us about the success of the communications. The faces give us a message about communication at this higher level of abstraction."[278] We can add to this "postures, tension, flushing, and the like," which may not in themselves seem to be as closely related to dialog but nonetheless condition the mood of the exchange.[279] By way of these small gestures, "each person is able to get a multidimensional view of his [*sic.*] vis-à-vis, enriching the stream of merely verbal symbols with a recognition of bodily processes in the other, and these are more or less intelligible because of common biological background and cultural conditioning."[280] Conversation participants generally express and attain awareness of these nonlinguistic and nonverbal cues unconsciously. The cues nonetheless indicate that both parties have some awareness of the *how* of their communication. In this respect, subjects simultaneously occupy an *outside*, observational position to the dialog in which they engage. Such nonconscious

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political and social institutions explicitly and implicitly interested in advancing certain imperialist projects that in effect worked to impose normativity as a means for accumulating and maintaining power. Bateson himself saw his research subjects as collaborators and his theoretical contributions as working to center the perception, cultivation, and preservation of difference.

[277] This essay is later published in *Steps to an Ecology of Mind*.

[278] Bateson, "The Position," 554.

[279] Bateson and Ruesch, *Communication,* 207.

[280] Bateson and Ruesch, *Communication,* 207. Also this: Bateson identifies both analogic and digital components of such a phenomenon: "It was suggested above that in intrapersonal processes the body might serve an analogic function supplementary to the more digital processes of neural thought. We now note that the bodily processes of the other person—his [*sic.*] postures, tension, flushing, and the like—serve a corresponding function in interpersonal communication," 207.

awareness is animated by the interaction throughout the duration of the conversation, but the awareness is not passively obtained; both individuals actively ascertain, co-create, maintain, and adapt these structural communicative premises.

This paradox of positions underscores Bateson's theory of metacommunication. These foregoing examples of nonlinguistic indicators reveal that metacommunication gets enacted simultaneously and alongside of dialogic interaction. If it is temporally bound to the unfolding of interaction as such, metacommunication is also, logically speaking, an *a priori*. Bateson's "Theory of Play" essay explicates this premise quality of metacommunication, as he inferred it through observations of monkeys playing at the San Francisco Zoo. When play-fighting, the monkeys "engaged in an interactive sequence of which the unit actions or signals were similar to but not the same as those of combat."[281] In acting out combat in jest, they demonstrate a core principle of all metacommunication, that the communicators "recognize that the other individual's and its own signals are only signals."[282] Bateson likens this principle to the recognition of the difference between map and territory.[283] Through interaction—in this case physical, nonverbal exchanges—the monkeys convey that, just like the conversation partners described above, their subject positions oscillate. They are at once co-creators of both the content (combat-like strikes) and form (non-combat play) of communication. What distinguishes play from, say, one using hand gestures to animate their speech is that the latter supplements the words to aid comprehension; in play a single gesture—a strike at the play partner—communicates two opposing messages at once: *this is a strike* and *this is not a strike*. Play is thus an instructive object of study, as it exposes metacommunication's paradoxical status as both a premise for and a component of communication.

The communication-metacommunication co-constitution, Bateson describes, is the embodied enactment of the ancient Euripides paradox, expressed in the statement, "Everything I say is false."[284] The subject "everything" is simultaneously inside and outside of the proposition; it both sets the boundary conditions for the proposition and implies that that boundary is indeed outside the bounds of the statement itself. The interpreter oscillates—if the enunciation is true, then the subject is a liar; if the subject is a liar, then the enunciation cannot be true. This paradox gets a twentieth-century update with Bertrand Russell's mathematical set theory and is elaborated in his and Alfred Whitehead's *Principia Mathematica*. A mathematical set requires that some statement both articulates the conditions for that set and remains outside the set; sets get nested into ever more expansive sets, and eventually, with the set of all sets, there is the problem of positional ambiguity, or "illegitimate totality." This would be akin to a circular definition, which uses the very word it defines. Russell and Whitehead resolve this problem with what they call the "vicious circle principle": "'Whatever involves *all* of a collection must not be one of the collection'; or, conversely, 'If, provided a certain collection had a total, it would have members only definable in terms of that total, then the said collection has no total,'" or in other words a new set with conditions established prior and exterior to it must be established.[285] Returning to

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[281] Gregory Bateson, "Theory of Play and Fantasy," in *Steps to an Ecology of Mind* (New York: Ballantine Books, 1972): 177–193, 179.

[282] Bateson, "Theory of Play," 178.

[283] Bateson, "Theory of Play," 180.

[284] Bateson, "Form, Substance, and Difference," in *Steps to an Ecology of Mind,* 454–471, 463.

[285] Alfred North Whitehead and Bertrand Russell, *Principia Mathematica* (Cambridge, UK: Cambridge University Press, 1959 [1912]), 37

the statement, "Everything I say is false," we should then add two things: the fact that false in this sense only achieves its status because it is "not true," so the "everything" must also refer to a different class of that which is true, and therefore "everything" cannot in fact refer to everything; also, if the statement is false, then *some* things I say can be false, which also means that some things can be true.

At the Macy conference, Bateson translates this paradox and the vicious-circle resolution to communication theory. He explains: "These paradoxes arise when a message about the message is contained in the message."[286] He further relates it to the perceptual figure-ground dynamics explicated in the wheelbarrow joke and the fact that, by focusing on the excelsior as the figure, the guard was explicitly defining the wheelbarrow as *not* the element of interest. "The circuit of ideas which is the paradox is closed or completed by treating seriously the background … [which is] the implicit information. It just is. You can't ever really get away from it."[287] The wheelbarrow is to the excelsior what metacommunication is to communication contents.

From here, it follows that a category of behavior like play requires that its participants *a priori* have a concept of "this is play" *and* "this is not play," and that they also have the ability to distinguish between the two. With this premise established, the players can then actively enter play, as one enters a dream within which one is for the duration of the dream not aware one is dreaming. This duality indicates that play involves both conscious and unconscious processes: "In primary [unconscious] process, map and territory are equated; in secondary [conscious] process, they can be discriminated. In play, they are both equated and discriminated."[288] Map is both territory and defined in distinction to territory. An indicator of this conscious-unconscious oscillation is the phenomenon in which the players move between simply playing and then "often [needing] to be reminded that 'This is play'" so they can continue playing.[289] Bateson ultimately uses this description of play and its embodiment of the Russellian paradox to introduce a concept of *frames*, or categories of communicative behavior that involve articulations of a metacommunicative link that are germane to specific social contexts.[290]

Frames establish the premises for a given communicative interaction, which as it unfolds will involve elements of convention (cultural, interpersonal) and contingent adaptation. Bateson "[builds] up the model [of frames] in stages," using the example of a game and gameplay:

> Imagine first two players who engage in a game of canasta according to a standard set of rules. So long as these rules govern and are unquestioned by both players, the game is unchanging…. We may imagine, however, that at a certain moment the two canasta players cease to play canasta and start a discussion of the rules. Their discourse is now of a different logical type than their play. At the end of this discussion, we can imagine that they return to playing but with modified rules.[291]

The canasta analogy is admittedly simplified on account of its concreteness, but another way to consider the frame, admittedly abstract, is as an exteriorized and shared form of consciousness. Bateson describes consciousness, at the individual, intrapersonal scale in *Communication*:

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[286] Bateson, "The Position," 543.

[287] Bateson, "The Position," 543.

[288] Bateson, "Theory of Play," 185.

[289] Bateson, "Theory of Play," 185.

[290] Bateson, "Theory of Play," 184.

[291] Bateson, "Theory of Play," 191–192.

> A word must be said about consciousness, … the presence of [which] denotes an extraordinary complication of the psyche…. The fact seems clear that the content of consciousness is an extreme reduction, derived from the total rich continuum of psychic events. Every such reduction is a *transformation or codification* … [and] the nature of the transformation … is not itself subject to direct introspection or voluntary control…. While the (possibly illusory) sense of free will is closely bound up with the subjective experience of consciousness, *the process by which items are selected for focusing in the mirror of consciousness is itself an unconscious process, not, at any given moment, subject to any exercise of free will.* Over time, an individual can 'train himself' to various sorts of special awareness, and to this extent he can *modify the codification of ideas* entering consciousness. But an any given instant, the determinism of that instant is seemingly complete.[292]

One's codification system is closely related to ones network of values in that they serve as selectors, determining those sensory and psychic impressions that are to enter or get filtered out of consciousness (176). Values are, in essence, one's unconscious structures and processes that determine consciousness. Like the rules of the canasta game, intrapersonal value systems are generally implicit yet available to consciousness and capable of being adapted when an object of such awareness, before returning to their place out of, and as the rules for, consciousness itself.

Metacommunication, as it is exemplified in the play frame, constitutes an interpersonal value network that establishes the conditions for communicative behavior—and therefore a shared, socially constructed consciousness. Metacommunication enables individuals to understand one another—not just comprehend the words in a dialog but apprehend the relationship with their conversation partner in the social interaction and beyond.[293]

In certain interpersonal frames, metacommunication change is germane. The introduction of contingency an in unfolding social situation requires that both parties are reflexive about the frame, restore the exchange back to a more conventional state, or adapt its premises or rules based on the contingent information and evolve the conversation. And, unlike the game of canasta with highly conventionalized rules for gameplay, if communication is entirely conventionalized, the communicative situation becomes redundant and null. (We may note that, in Shannon's information theory, redundancy and information are oppositional; information emerges from the statistical improbability of elements in a communication channel.[294]) When venturing to change the rules of a communication frame, participants reflexively bring metacommunication structures, which are typically the nonconscious habits of communication shared by both people, into consciousness temporarily, such that they can collectively reorganize them. Once revised, the metacommunication structures recede to their subperceptual position and role as the very premises for perceptual and conceptual understanding in the communicative situation. Bateson uses the context of psychotherapy as an example of a frame undergoing change. Play and psychotherapy are examples of reflexive communicative behavior, and therefore the metacommunication reinvention is particularly exposed:

> Our imaginary [canasta] players avoided paradox by separating their discussion of the rules from their play, and it is precisely this separation that is impossible in psychotherapy. As we see it, the process of psychotherapy is a framed interaction between two persons, in

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[292] Bateson and Ruesch, *Communication*, 183.

[293] This is the basis for his epistemological argument in *Steps to an Ecology of Mind*, but is one particular "step."

[294] Claude Shannon, "A Mathematical Theory of Communication," *The Bell System Technical Journal* 27, 1948.

> which the rules are implicit but subject to change. Such change can only be proposed by experimental action, but every such experimental action, in which a proposal to change the rules is implicit, is itself a part of the ongoing game. It is this combination of logical types within the single meaningful act that gives to therapy the character not of a rigid game like canasta but, instead, that of an evolving system of interaction.[295]

This description conveys that, in psychotherapy, communication habits, or norms, are indeed necessary for the therapist and patient to understand each other, and therefore to understand themselves, but that those interactional habits are also artificial constructions contingent on participants' embodiment and revision of them.

Now, I want to examine an aspect of Bateson's theory that I see as underdeveloped but that the metacommunication concept can nonetheless point us in the direction of developing further, especially as it relates to machine simulation. In the opening of "Theory of Play and Fantasy," Bateson makes some general points about metacommunication that indicate its infinite situational nuances. In the evolution of communication, as Bateson sees it, metacommunication emerges "when the organism gradually ceases to respond quite 'automatically' to the mood-signs of another."[296] The organism then apprehends the signals exchanged *as* signals, but not only that; there is also the recognition that such signals contain information as to whether they "can be trusted, distrusted, falsified, denied, amplified, corrected, and so forth."[297] This recognition, as something that happens alongside but as distinct from language, contains "all the complexities of empathy, identification, projection, and so on."[298] "Theory of Play and Fantasy" lists a number of other behavioral frames that, similar to play and therapy, punctuate the communication paradox foundational to metacommunication. Though this list is not exhaustive, the frames taken together cover a tremendous range of social experiences: histrionics and deception, threatening and threatened behavior, spectacle and spectatorship, ritual, fantasy, dream. Bateson references these categories in passing as he develops the argument on play and eventually analogizes play with therapy. These frames nonetheless involve both nuanced and pronounced differences with respect to the quality of the interpersonal metacommunication link. The quality of the link is determined in part by how the behavioral frame and its respective participants engage, give access to, and manipulate the metacommunicative plane.

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[295] Bateson, "Theory of Play," 192. For a consideration of how computational models deal with the ability of a computer program (AI) to obtain information about its own state, see the concepts of "meta-representation" and "reflection" in Ron Brachman, *Readings in Knowledge Representation*. Ultimately, the knowledge-representation systems to which these concepts were applied in the late twentieth century were not flexible enough to deal with environmental uncertainty. See also the concept of "recursion" in computer science, which states that a function can call itself, in what's called a subroutine: "The power of recursion evidently lies in the possibility of defining an infinite set of objects by a finite statement. In the same manner, an infinite number of computations can be described by a finite recursive program, even if this program contains no explicit repetitions" (Niklaus Wirth, *Algorithms + Data Structures = Programs*, 1976, 126). Also, though these concepts seem to refer to similar conscious processes as those that Bateson discusses, Bateson's epistemology is agent-environment focused and therefore shares much more in common with neural network models. My point here is, however, that Bateson's epistemology, especially as it appears by way of metacommunication, is informed by cybernetics but demonstrates the elements of human and organic consciousness that are not replicable in a machine, even if there are some analogous processes in each.

[296] Bateson, "Theory of Play," 178.

[297] Bateson, "Theory of Play," 178. In metacommunication "the subject of [the implicit] discourse is the relationship between the speakers," 178.

[298] Bateson, "Theory of Play," 179.

From Bateson's analysis, we can infer that one element that distinguishes play from other classes of behavior that expose metacommunication is the fact that both parties have equal access to the metacommunicative plane. Play is only playful if both parties recognize it as play and take part in creating and maintaining the playful dynamic. Equity indeed appears to be a qualifying component for some interactional behavior to be considered play.[299] The therapeutic situation is more complicated as the therapist holds some power in the situation. Momentarily setting aside the power that originates from the therapist's position as a representative of an institution, in the specific interpersonal exchange between therapist and patient, the former's power comes from his or her trained awareness of the meta structures of the therapeutic process and facility in manipulating it. Here, access is decidedly unequal. But in the best of situations, that inequity allows for a transfer of expertise in meta-analysis from the expert to the previously unaware patient. And it should in theory equip the patient with the capacity to take the adaptation of metacommunication dynamics in the therapy interpersonal exchange and transform it to one's own intrapersonal perceptual, psychic, and cognitive processes. So, while the metacommunication link in play is equally accessible to parties, in therapy it is accessible to both but asymmetrically so. In both situations, nonetheless, both individuals actively participate in adapting the link.[300] Bateson's study of interpersonal dynamics, then, exposes the distinctions between automatic behavior, which would entail accepting the meta conditions for a communicative exchange with no attention to those conditions, and autonomic or nonconscious behavior, which Bateson endows the individuals with a certain epistemic potentiality.

In other behavioral frames, the (asymmetrical) metacommunication link is less available or subject to revision, and this is the basis for deceptive situations. Bateson elaborates a number of different contexts. For example, Fantasy involves one's intrapersonal (conscious or unconscious) willingness to deceive oneself about reality, to enter the dream state while awake. Play is this very phenomenon carried out at the conscious and interpersonal scale, and deception is, too, in jest. In the instance of a joke, the deceptive frame is reflexively imposed—and there is an implicit agreement to that imposition. Finally, ritual, as Bateson discusses in *Naven*, his text following his field research in Bali, is a culture-wide metacommunication, and though it is not typically characterized by metacommunication adaptation, it is reflexively entered and exited, like play.[301]

This gets us to the question of the implications of scale, in the interactional context, for metacommunication and its potential adjunct quality of deception. When an subject is exposed to mass communication, for example, Bateson and Ruesch examine in *Communication*, he

> is likely to feel on the one hand, that he is a participant in a larger superpersonal system, and on the other hand, that he is unable to delineate the system. This contradiction is

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[299] See Bateson, "Theory of Play," 178–180, 183. Also, 181: "It appears … that play is a phenomenon in which the actions of 'play' are related to, or denote, other actions of 'not play.' We therefore meet in play with an instance of signals standing for other events, and it appears, therefore, that the evolution of play may have been an important step in the evolution of communication [as it points toward denotative language]."

[300] Situations that involve a metacommunicative imbalance, where one of the communicative participants is in the official position of an observer, such as a psychiatrist in an interview or an anthropologist in a fieldwork setting (with a camera), both of which are explicit cases from Bateson's more empirically oriented research; its premise is drawn from twentieth century physics, specifically the theory of relativity and the uncertainty principle, which explicate that the observer's presence and act of observation in effect impacts the subject or object of observation; this is explored in Bateson's work with Ruesch.

[301] Bateson, *Naven: A Survey of the Problems suggested by a Composite Picture of the Culture of a New Guinea Tribe drawn from Three Points of View* (Palo Alto, CA: Stanford University Press, 1958).

> brought about by the fact that in mass communications the originators and recipients of messages are so numerous that they usually remain anonymous. Therefore, under such conditions, the individual is not able to observe the effect of his own messages upon others, nor can he communicate his personal reactions to a message originating from committees, organizations, or institutions. Cause and effect become blurred, correction and self-correction of messages become delayed in time and removed in space.[302]

In the media-ecological framework of one-to-many and many-to-one, there is both a premise of democratic, equal access to the means of communication where there is in fact no way for a subject to co-create and alter the culture-scale metacommunication conditions. This situation then seems to further fortify a definition of deception, as the imbalance among parties in communication with respect to access to the means of that communication. Just as one party accesses, manipulates, or affixes the so-called rules of the communication and its associated relational dynamic while the other party remains oblivious and nonetheless continues to participate, unconsciously following or not following those so-called rules. In "Theory of Play," Bateson indicates the political character of deception and its grave consequences:

> Finally, in the dim region where art, magic, and religion meet and overlap, human beings have evolved the 'metaphor which is meant,' the flag which men will die to save, and the sacrament that is felt to be more than 'an outward and visible sign, given unto is.' Here we can recognize an attempt to deny the difference between map and territory, and to get back to the absolute innocence of communication by means of pure mood-signs.[303]

And we might add to this—by means of pure automaticity.

The capture of affect within the net of artificial intelligence—within surveillance programs just as within socially oriented robots intended to promise friendly interactions—makes urgent the question of who establishes the metacommunication quality of these exchanges and by what intentional or contingent conditions citizens may bring them into personal and social awareness, and authentically share in that revived consciousness that map is not territory.

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[302] Bateson and Ruesch, *Communication,* 16.

[303] Bateson, "Theory of Play," 182–3.

Part Two

Images & Interpretive Actors

—Chapter 03—

Couplings: Industrial Automation, Interactive Film, and Neural Organization

In March 1961, Cornell Aeronautical Laboratory engineer Albert Murray gave a public presentation introducing the MARK I Perceptron, the first artificial neural network machine. Murray, a colleague of perceptron developer Frank Rosenblatt, shared that the MARK I was designed as a "model for some portion of the (visual) perception mechanism of a brain. It represents the simplest organization . . . of neuron-like elements that . . . exhibit brain-like qualities. Future . . . research in our laboratory will employ machines . . . aimed specifically at applications in photo interpretation."[304] Murray was hinting at a long-term vision in which perceptron programs stand in for the things that human beings do. But what exactly is being suggested as the subject of replacement—the eye? the brain? the hermeneutic mind? the photo-interpretation laborer? Murray continued that the goal of such an application would be "the ability to recognize simple target forms in relatively featureless environments."[305] A curious footnote in the conference proceedings specifies that "the term 'target' . . . is to indicate the object . . . for which we wish a recognition machine to give an identifying response or alarm. It is not intended as a military term."[306] Recently declassified documents reveal that the MARK I was in fact used in a multiphase test for military targeting undertaken by the U.S. Central Intelligence Agency's (CIA) Photo Division from 1960 to 1964.[307] By 1965, the CIA had created a series of task reports on the feasibility of automatic target recognition.[308] This chapter demonstrates that a lack of clarity regarding the subject of vision—both as a philosophical question and an institutional condition—has gone hand in hand with technical and political pursuits of perceptual expediency. In military contexts, it has proven to be politically powerful. Murray's mid-century, cybernetics-inflected research community took the implicit stance that human phenomenal

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[304] Albert E. Murray, "Perceptron Applications in Photo Interpretation," *Photogrammetric Engineering* 27, no. 4 (1961): 627.

[305] Murray, 628.

[306] Murray, 628. For a thorough analysis of the computer vision field at mid-century, see James Dobson, *The Birth of Computer Vision* (Minneapolis: University of Minnesota Press, 2023). Dobson examines how Murray's description of Perceptron techniques would later be used in Vietnam War targeting (82–89).

[307] The CIA's photo interpretation division held many different names. For clarity, I refer to it as the "CIA Photo Division." As of 1952 it was formalized and named the CIA Photographic Intelligence Division; in 1958 it became the Photographic Interpretation Center,= and in 1961 became the National Photographic Interpretation Center. See CIA Historical Staff, *National Photographic Interpretation Center*, vol. 1, *Antecedents and Early Years, 1952–56* (CIA Internal Use) (Langley, VA: CIA, 1972), declassified 2012, https://www.cia.gov/readingroom/document/cia-rdp04t00184r000400070001-5.

[308] CIA Staff, "Automatic Target Recognition," 1965, in Dino Brugioni Collection, Box 13, Item 702, NASM.2012.0004, National Air and Space Museum (NASM), Smithsonian Institution (SI).

perception, computational processing, and sociocultural practices of signification exist in a fungible relation.

What follows is, to some extent, an examination of the emergence of "the operational image," a term filmmaker Harun Farocki devised to describe the machinic vision that undergirds automatic military targeting amid the proliferation of drones at the dawn of the twenty-first century.[309] Operational images do not simply re-present things in the world, they do the work of perception writ large, yoking it to decision-making and tactical action. In Farocki's *Eye/Machine* (2000–2003), clips of military control rooms depict the human beings as diminutive button pushers, when they are present at all. Some have argued that operational images, because they do not need human eyes to do their work, imply the total excision of the human from the so-called loop.[310] But the operational image became thinkable before computers were employed for military labor and, crucially, on the basis of principles about the very workings of the human form—as a nervous system, as a rigid body in physical space, as an affective subject. Pattern recognition programs such as Rosenblatt's perceptron, and the deep learning models of the 2010s, for which Rosenblatt has been deemed a "forefather," are not only extra-perceptual translations of bits, as the operational-image discourse accounts for them.[311] They are also models of human perception and analytical labor, making them elusive as objects of humanistic inquiry. Murray's mid-twentieth-century moment reveals how human visual experience became technical infrastructure, and vice versa, and how images enabled the transformations.

Automated target recognition originated because of the reorganization of human perception necessitated by the U.S. proclivity to accelerate (the possibility of) military action. This story begins with James J. Gibson, a prominent psychologist and mentor of Rosenblatt whose studies of perception in WWII both developed a militarily useful concept of a target and, contradictorily, would serve as a precedent for his subsequent ecological theory of vision. In both contexts, Gibson embraced the notion that recognition of an object was contingent on one's sense of relation to it in physical space and affective register. A target, then, was an entity whose meaning—its adversarial resonance—had been institutionally determined in advance and imposed upon embodied acts of recognition so they could be coupled with action in an automatic, unconscious way. In the 1950s and 1960s, the CIA would take up these perceptual techniques in its MARK I Perceptron tests and its parallel activities of human photo interpretation (specifically, object detection) in the lead-up to the Cuban Missile Crisis. Despite the staggering U.S. investment in global surveillance technology, this era was characterized by "photo gap" periods, which fed a paranoia that the country was becoming physically reachable by the weapons of an adversary it could not perceive. Defense institutions' sense of geopolitical uncertainty prompted a preemptive posture. What may have appeared as an "age of the world

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[309] Harun Farocki, *Eye/Machine I–III* (2001–2003). See also Harun Farocki, "Phantom Images," trans. Brian Poole, *Public*, no. 29 (2004), 13–22, https://public.journals.yorku.ca/index.php/public/article/view/30354; Volker Pantenburg, "Working Images: Harun Farocki and the Operational Image," in *Image Operations: Visual Media and Political Conflict*, ed. Jens Eder and Charlotte Klonk (Manchester, UK: Manchester University Press, 2017), 50–62; and Jussi Parikka, *Operational Images: From the Visual to the Invisual* (Minneapolis: University of Minnesota Press, 2023).

[310] See Trevor Paglen, "Operational Images," *e-flex journal* 59 (November 2019), www.e-flux. com/journal/59/61130/operational- images.

[311] Charles C. Tappert, "Who Is the Father of Deep Learning?," in *2019 International Conference on Computational Science and Computational Intelligence* (New York, NY: IEEE, 2019), 343–348.

picture" was in fact an age of the pictorial target list *as* world, which enabled a collapse of the temporal gap between recognition and response.[312]

RECOGNITION SPEED

In 1940, as England was anticipating an air raid by German forces, the British government oversaw a mass media effort to recruit civilians in the reconnaissance activity of aircraft recognition. Packs of pictorial flashcards, training booklets, and a monthly periodical titled *Aircraft Recognition Magazine* circulated throughout the nation, serving dually as propaganda and an earnest means for generating the earliest possible sighting of an oncoming attack.[313] The representational form of these image collections gestured at nineteenth-century government programs that established the photograph as germane to government bureaucracy.[314] If read reflexively, they are also examples of what Walter Benjamin termed an *Übungsatlas*, a neologism referring to a collection of photographs through which the viewer subversively can train her perception and, in doing so, situate herself within modernity's flux of people and objects.[315] The *Übungsatlas* stabilizes, gives a static form to, otherwise destabilized and chaotically changing relations across modern European society. In this regard, the aircraft recognition cards served as a visual encyclopedia for the acquisition of politically expedient knowledge for the everyday citizen, in line with the Enlightenment tradition informing Benjamin but shot through with an industrialist impulse to impose perceptual standardization.[316] And yet the cardpacks are also something of a proto image dataset, like those used to train contemporary AI, and as such are an example of an originary cybernetic object.[317] By *cybernetic*, I refer to the field's origins in physiological research positioning the biological nervous system as a mediator between subject and environment and between perception and action.[318] As such, the picture

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[312] Martin Heidegger, "Age of the World Picture" (1938), in *The Question Concerning Technology and Other Essays* (New York: Garland, 1977), 115–154.

[313] See Dino Brugioni Collection, Box 3, Book No. 35 Miscellaneous Airplane and Ship Photos, Special Documents, 20–28, NASM, SI.

[314] See John Tagg, *The Burden of Representation: Essays on Photographies and Histories* (New York: Palgrave, 1988).

[315] See Walter Benjamin, "Kleine Geschichte der Photographie," in *Walter Benjamin Gesammelte Schriften*, ed. Rolf Tiedemann et al. (Berlin: Suhrkamp Verlag, 1977), 381. In the translated version of the essay—"Little History of Photography," in *Walter Benjamin: Selected Writings*, vol. 2, *1927–1934*, ed. Michael W. Jennings et al., trans. Rodney Livingstone et al. (Cambridge: Belknap Press of Harvard University Press, 1999)—*Übungsatlas* is translated as "training manual" (520). Benjamin creates this term to describe the photographic collections of August Sander, within which Benjamin recognized a latent social and political function of photographic education. On Sander, he cites critic Alfred Döblin: "'Just as there is comparative anatomy, which helps us to understand the nature and history of organs, so this photographer is doing comparative photography, adopting a scientific standpoint superior to that of the photographer of detail'" (520). Benjamin (citing Goethe) then endorses this "'delicate empiricism'" (520).

[316] For an analysis of the Enlightenment origins of the encyclopedia, see Daniel Brewer, *The Discourse of Enlightenment in Eighteenth-Century France: Diderot and the Art of Philosophizing* (Cambridge, UK: Cambridge University Press, 1993). Denis Diderot and Jean le Rond d'Alembert's *Encyclopédie* (France, 1751–1772) features nearly three-thousand image plates and was fundamentally pictorial in its taxonomic organization. According to Brewer, the volume was to mirror the authors' conception of the mind's structural order, expressing an Enlightenment stance of "knowledge as representation" (17–18).

[317] For an analysis of contemporary datasets, see Emily Denton et al., "On the Genealogy of Machine Learning Datasets: A Critical History of ImageNet," *Big Data and Society* 8, no. 2 (2021), https://doi.org/10.1177/20539517211035955.

[318] See Stefanos Geroulanos and Todd Meyers, *The Human Body in the Age of Catastrophe: Brittleness, Integration, Science, and the Great War* (Chicago: University of Chicago Press, 2018). Geroulanos and Meyers demonstrate the

collection is conceived to be not so much a site of cultural signification as it is a series of signals regarding an object's capacity to produce feedback, to alter or be altered by oneself and one's environment. In referencing warplane pictures, British civilians were implicitly referencing the wartime condition of existing as a target. The two-dimensional, pictorial Luftwaffe fleet simultaneously registered the timescales of their potential action, implicating the civilian in the adversary's imminent advance.



Figure 11: British aircraft recognition chart, 1943. Source: National Archives, College Park-Still Pictures.

The optical activity of aircraft recognition materialized the notion that visual perception is an *act*, situated in physical space, delimited in duration, and entangled with the phenomenon of being perceived by others. The notion was being developed simultaneously with the British campaign by psychologist James J. Gibson, then at the Army-Airforce Aviation Psychology Program. Gibson undertook empirical research and formalized a perception training program for combat pilots that included aircraft recognition techniques.[319] Aviation posed a challenge for

implicit and explicit ties between physiologist Walter Cannon's concept of homeostasis and Norbert Wiener's cybernetics (145–146).

[319] See James J. Gibson, ed., *Motion Picture Testing and Research*, Army Air Forces Aviation Psychology Program Research Reports, Report No. 7 (Fort Belvoir, VA: Defense Technical Information Center, 1947), https://apps.dtic.mil/sti/citations/AD0651783.

Gibson's research, as it required the pilot to apprehend optical information at a timescale not previously considered by scientific studies of the human perception system.[320] Becoming visually oriented while in midair had a unique set of requirements, especially when landing a warplane (often in unfamiliar geographic locations and onto unpredictable surfaces) and judging one's spatial relationship with another plane. Combat pilots had to sense unpredictable and continual environmental change and produce instantaneous decisions and near automatic motor responses.

In his 1950 book *The Perception of the Visual World*, Gibson explains that these WWII empirical problems revealed a gap in preexisting knowledge about visual perception. The Western philosophy canon and modern perception science, Gibson concluded, offered only "air theories."[321] From the abstract space of Euclidian geometry and the Cartesian coordinates that served it up to algebraic calculation, to Hermann von Helmholtz's nineteenth-century experiments with abstract points of light—these frameworks all focused on the open space through which light travels, but in doing so they presupposed that a ground simply existed. Even the Gestalt psychologists' ideas about figure/ground distinctions had undervalued what it actually meant to *be in* (a) space. Gibson's conceit was that the vertically inclined twentieth century needed a "ground theory." His wartime research revealed that, paradoxically, "the airplane's space is determined by the ground and the horizon, not by the air through which he [*sic*] flies."[322] While the Cartesian tradition conceived of distance in positive terms, as an object's *distance-from* a subject, Gibson positioned it in negative terms, as a *closeness-to*. When landing a plane and rapidly approaching the earth's surface, for example, "such distance judgments always involve the 'here' position of the observer at one end of the distance to be judged." Gibson called this "the phenomenal ego."[323] With this conceptual inversion, Gibson expanded the perceptual environment to include the sensing subject.[324]

Combat pilots' perceptual-cognitive task, as Gibson saw it, was to correlate one's optical apprehension of a landing surface or another in-flight airplane with those forms' capacity to affect or be affected by the pilot. The Gestalt psychologist Kurt Koffka, also Gibson's colleague at Smith College before the war, called this scope of actability the "behavioral environment." Koffka articulates two distinct yet interconnected conceptions of environment—a geographic one and a behavioral one. The former pertains to the physical organization of space, independent of one's perception of it. A purely geographical environment would be a mountainscape in which a mountaineer loses her footing and has no capacity to act upon her surroundings. A single geographic environment may engender many behavioral ones. Koffka offers as an example how one subject might use a tree stump as a seat and another might use it as a ladder. In each case, the

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[320] In an obituary for Gibson in *American Psychologist*, his colleague Ulric Neisser writes, "Born in 1904 just a few months after Orville and Wilbur Wright had flown at Kitty Hawk, James Jerome Gibson was an exact contemporary of the airplane." Ulric Neisser, "Obituary: James J. Gibson (1904–1979)," in *American Psychologist* 36, no. 2 (1981): 214.

[321] James J. Gibson, *The Perception of the Visual World* (Westport, CT: Greenwood Press Publishers, 1950), 6.

[322] Gibson, *Perception*, 6. Gibson writes reflexively with respect to his historical moment and the impending space race, where one would have to be oriented in "a series of more and more inclusive spaces of which the most general is the astronomical universe" (230).

[323] Gibson, *Perception*, 230. Gibson draws on Ernst Mach's theory of the "phenomenal ego."

[324] See James J. Gibson, *The Senses Considered as Perceptual Systems* (Boston: Houghton Mifflin, 1966); and James J. Gibson, *The Ecological Approach to Visual Perception* (Boston: Houghton Mifflin, 1978). See also Martin Jay, *Downcast Eyes: The Denigration of Vision in Twentieth Century French Thought* (Berkeley and Los Angeles: University of California Press, 1994), 4.

subject materially changes the geographic environment.[325] The two realms inform one another, and the subject generally brings them into alignment. But the pilot's conditions created a discrepancy between sensation and action. WWII prostheses for remote aggression—combat aircrafts and artillery—upset the alignment. One could effect destruction beyond the scope of one's perceptual range and also, crucially, be the site of destruction when an adversary was beyond the range of perceivability.

The Air Force's training solution addressed this spatial disparity by reworking recognition as a temporalization of space.[326] Gibson's 1947 ex post facto report explains that "[aircraft] identification was necessary primarily because decisions had to be made to fire or to withhold fire at other planes [and] . . . in air combat the size of the airplane which is to be fired at must be known in order to determine its [firing] range."[327] Level of lethality was based not solely on firing range as an abstract number; it was instead relational, based on the physical distance between planes at any moment. Gibson's team discussed whether to deprioritize identification in favor of analyzing a planes' behavior to predict imminence of attack. This behavior-recognition strategy was central to Norbert Wiener's on-the-ground automatic anti-aircraft weapons research, which Peter Galison positions as the origin of cybernetics and its foundational making of "a mechanized Enemy Other."[328] Gibson's ultimate embrace of form recognition tells us an alternative story, one that demonstrates the imperative to protect the physical body of the U.S. pilot by articulating its entanglement with the machinery of war. Unlike Wiener's machinic offensive guns, these pilots were existential subjects, simultaneously offensive and defensive. Gibson's empirical tests found that behavior recognition took longer than aircraft-object recognition, endangering the pilot. His strategy accounted for artillery maximum distance with optical speed:

> The time for recognition is not during an attack, when it is already too late, but before the attack begins when the airplane in question is still out of range, i.e., at more than 1,000 yards. Recognition at that time permits the gunner to make preparations and plan his fire beforehand. . . . There was some discussion of what recognition range was, but it was unquestionably greater than the firing range.[329]

Gibson's training exercises sought to extend combat pilots' perceptual range through the embodiment of a predictive posture.

The goal of the program was to disassemble the process of seeing, to account for as many interpretive components as possible in the training itself so that, when two combat pilots locked eyes and reticles in the sky, the duration between identification and behavioral response contracted. Thus emerged a form of automatic target recognition that was noncomputational but

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[325] Kurk Koffka, *The Principles of Gestalt Psychology* (London: Harcourt, Brace, 1936), 27–39.

[326] Not all aerial targeting emphasized such object-based precision and emphasis on speed; this is a particularly defensive posture. Aerial bombardment, as it was planned, actualized, and imagined with respect to nuclear weapons, was conceived according to a different logic, one of imprecision, widespread destruction, and the limits of habitable space. See Peter Galison, "War against the Center," *Grey Room* 4 (2001): 5–33; John Harwood, "The Other End of the Trajectory: Danger Zone," *Grey Room* 54 (Winter 2014): 80–106; and Lucia Allais, "Unwitting City Planning," in *Designs of Destruction: The Making of Monuments in the Twentieth Century* (Chicago: University of Chicago Press, 2018).

[327] Gibson, *Motion Picture Testing*, 118.

[328] Peter Galison, "The Ontology of the Enemy: Norbert Wiener and the Cybernetic Vision," *Critical Inquiry* 21, no. 1 (1994), 231.

[329] Gibson, *Motion Picture Testing*, 118–119.

that established the conditions for its computerized form. *Automatic* here refers not to the replacement of person with technical device but rather to the proclivity to act with reflex.

This exercise in habituating bodily automaticity was possible only because the Air Force was pursuing a finite list of mechanically reproduced target objects. Gibson's aircraft recognition training focused on eight American, eight British, six German, and three Japanese planes—the total number of models in the Allied and Axis combined fleets.[330] This determinative object list stripped the combat environment of its exorbitant uncertainty. Unlike in Wiener's paradigm, here the mere presence of the object itself—not the object's behavioral indicators of intention to attack—constituted the decision to fire. Aviation's supposed expanded view-from-above coincided with a visual mode of target-recognition in which a handful of discrete aircraft types were understood to make up the totality of the perceptual field.[331] That Gibson oversaw a program premised on the extractability of sensory objects in optical processes seems to contradict his professional upbringing in the Gestaltist tradition of psychology, which holds that an object's perceptual meaning is conditioned as much by its relation to a background as by its own intrinsic form. Nonetheless, the assumed necessities of the wartime paradigm compelled Gibson to focus pilots' attention on the discrete aircraft list exclusively and to part with background context. Other object relations gained urgency—between Allied pilot and Axis plane/pilot, between the subject and the immediate geographic features of their proximate landing site. The quality of remoteness as achieved through WWII aerial flight and military-trained visual acuity paradoxically indexed the state of zeroing in and of always being inside the perception-action system.

IMAGES AND 'AS IF' RELATIONS

Another kind of remoteness was also at play. The pilots in Gibson's studio could not experience the flight combat conditions firsthand, and like the British civilians they would learn aircraft recognition using still and moving images. This added layer of representational abstraction prompted more basic considerations about phenomenal perception: where does vision "happen" if people can have individuated visual experiences yet tend also to experience the same spatial reality? On this topic, Gibson was departing from, for example, von Helmholtz, who had conceived of perception as involving the active engagement of the imagination.[332] Gibson would also distance himself from the behaviorist conceit that animals (including human beings) visually apprehend elements of their external environment on the primary basis of those percepts' relation to rewards and punishments.[333] He instead centered the observation that in everyday situations human beings and animals do not collide with things because their visual sensing agrees with the measurable dimensions and deformations of concrete space, a phenomenon he would later term "direct realism."[334] Sharpening the pilots' attention to the latent spatial information available in their sense impressions of specific aircraft types was thus a matter of survival. Images, Gibson's postwar Air Force report found, were surprisingly effective at eliciting pilots' perceptual clarity.

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[330] Gibson, *Motion Picture Testing*, 199.

[331] For an analysis of the aerial view outside a military context, see Patrick Ellis, *Aeroscopics: Media of the Bird's-Eye View* (Berkeley and Los Angeles: University of California Press, 2021).

[332] Gibson, *The Senses*, 228. Gibson argues that, instead of the imagination being involved in perception, it is attention.

[333] Gibson, *The Senses*, 282.

[334] See Gibson, *Ecological Approach to Visual Perception*.

Later he theorized this finding. In his 1971 essay "The Information Available in Pictures," Gibson characterizes photographic images as having an "as if" relationship to their physical referents, offering reliable measurement information and capable of achieving a direct realism effect.[335]

Within Gibson's empirical project, any photographic representation seems to be what Allan Sekula, writing in 1975, critiqued as the "instrumental image." Commenting on Edward Steichen's aerial photographs from the First World War, Sekula asserts that such images served institutional aims because of their perceived "ability to testify to a *present* state of affairs."[336] A classical conception of the photograph as the "pencil of nature" combined with the suggestion of a totalizing view from the sky and the newfound immediacy of image production and dissemination across military divisions.[337] As signifiers of that which is merely present, instrumental images deny their own status as mediated objects. The things they signify are also emptied of their culturally determined and discursive meaning. Borrowing terms from Roland Barthes, Sekula argues that this pictorial form artificially separates the *connotative* from the *denotative* level of the image and champions the latter. Instrumental images simply answer the question "'Is that a machine gun or a stump?' In other words, interpreting the photograph demanded that it be treated as an ensemble of 'univalent' . . . signs that could only carry one meaning, that could only point to one object."[338] Sekula calls this condition "the triumph of applied realism," whereby institutions' assumption of fidelity in photographic representation permits the image's imbrication with intelligence, training, and tactical protocols.[339]

Instrumental as they were, images in Gibson's Air Force training did not so neatly fit within the linguistic realm assumed by Sekula in his invocation of Barthes's structuralist frame. And though Gibson's later writing positioning perception as an embodied and *ecological* phenomenon departs significantly from the military focus of his WWII work, it both echoes and reinforces his Air Force–era stance that the image is, at once, a site of socially constructed, functional meaning and of neural-activating sensation. Attending to Gibson on his own terms—terms that were explicitly and implicitly integrated into the scientific and military-industrial milieu of the latter half of the twentieth century—helps us understand how photographic apparatuses moved from being *instruments* that simply point to objects and narrowly circumscribe their meanings to *operations*, through which human beings and machines (in manifold combinations) automatically both apprehend and act upon those objects in real time.

Significantly for Gibson's pilots, the imperative was to recognize aircrafts on the basis of their forms and those forms' resonance as either ally or enemy. Only secondarily was recognition by name considered necessary. Gibson's pedagogy sought to instill a direct-realism matching between external form and internal visual phenomenon.[340] It would be an exercise in the mass habituation of form perception among trainees, treating all pilots as one indistinguishable group

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[335] James J. Gibson, "The Information Available in Pictures," *Leonardo* 4, no. 1 (1971): 27–34. For a discussion of how Gibson's work informed the development of computer graphics, see Jacob Gaboury, *Image Objects* (Cambridge: MIT Press, 2021).

[336] Allan Sekula, "The Instrumental Image: Steichen at War," *Artforum* 14, no. 4 (1975): 29.

[337] See William Henry Fox Talbot, *The Pencil of Nature* (1844; Chicago: KWS Publishers, 2011).

[338] Sekula, "The Instrumental Image," 30. See also Allan Sekula, "On the Invention of Photographic Meaning," *Artforum* 13, no. 5 (1975): 36–45.

[339] Sekula, "The Instrumental Image," 31.

[340] Gibson, *Motion Picture Testing,* 199.

and overhauling the nuances of individual experience. Aiding in the production of a shared perceptual world for these cadets was the exceptionally narrow set of objects of perceptual attention: the twenty-five types of planes in the Allied and Axis fleets. Discrete as the collection was, the training itself would require extensive exposure so that trainees could move recognition capacity from particular to general; from *this* view of a German Avia B-534 to *any* German Avia B-534 observed from any perspective. Gibson's team used 35mm clips from the Air Force Motion Picture Unit film library, selecting shots that "show[ed] the plane in a continuously changing aspect, i.e., in transitions between head-on, passing, and plan views," to aid with generalization aptitude.[341] The time-based nature of the film also aligned with Gibson's understanding that perceptual acts happened in time. To cultivate pilots' visual memory, Gibson used a process called "differential reinforcement":

> The more similar the forms, the more difficult is the learning. . . . confusions occur, i.e., the misnaming of forms which look alike. . . . As these errors are corrected and the correct responses are reinforced, the errors drop out and the responses become differentiated. . . . As differentiation of the naming responses progresses, it must be supposed that visual memory images develop of the forms. . . . [The student's] perceptions may be assumed to acquire meaning and the shapes will become . . . fully organized or precise. They are also, surely, unitary perceptions, i.e., planes, and in that sense are seen and learned as "total forms."[342]

Following the training, pilots demonstrated their mastery by drawing the planes' distinctive silhouettes. Meaning here referred to trainees' acquisition of forms *as* forms, irrespective of their names. The act of identifying aircraft by linguistic descriptor would take too much time. Nonetheless, making binary distinctions of present/not present and enemy/ally was paramount; the instinct to do so was to be perceptually innervated so that the recognition process could effectively bypass time-intensive cognitive processes such as word association and directly instigate affectively charged responsive action.

The differential reinforcement exercise concretized a premise for Gibson that he would later develop on theoretical grounds. In his 1966 monograph *The Senses Considered as Perceptual Systems*, Gibson distinguishes perceptual meaning from verbal meaning and notes the ambiguous position of the image within this scheme. Unlike a symbol or a word, which "is related to its referent by social convention," the phenomenally apprehended stimulus object "is related to its source in the world by the laws of ecological physics."[343] The former involves "the process by which a human individual is *made* aware of things outside his immediate environment" and is what Gibson calls "mediated perception," or adopting the sense-making of another person, institution, human-made instrument, or some combination of these. It traffics in secondhand knowledge, or knowledge *about*.[344] The latter affords firsthand knowledge, or knowledge *of*. The photograph is peculiar. It is not inhabitable yet "consists of the variables of structure [of the external world] in its optic array," and adheres to physical laws.[345] Thus "the

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[341] Gibson, *Motion Picture Testing,* 100.

[342] Gibson, *Motion Picture Testing,* 120. This use of the term *reinforcement* calls to mind behaviorism. However, Gibson challenged the mechanistic conception of the human proposed by Edward Thorndike and B.F. Skinner. He did study under Edwin Holt, whose philosophical ideas share some common themes with behaviorism.

[343] Gibson, *The Senses*, 244.

[344] Gibson, *The Senses*, 234.

[345] Gibson, *The Senses*, 233–234.

virtue" and also the dubiousness "of images . . . seems to be that they permit socialized knowledge to be closer to immediate apprehension, i.e., closer to knowledge by direct acquaintance."[346] If we take this as an empirical-theoretical conceit that we can incorporate into a critical-theoretical frame, Gibson gives us a new critical perspective on the image as dually instrumental and operational. In the earlier Air Force training, for example, the meanings associated with aircraft recognitions were a matter of social significance: the military had designated them targets, and pilots were to interpret them as such too. The training images' realist presentation simultaneously erased this socially constructed meaning and naturalized target-worthiness. But here the conceit was not just that the image indexed a reality; it was to materially alter pilots' central and peripheral nervous organization, not only producing measurably accurate percepts but instigating specific motor responses. Meaning here meant the incorporation of an image's affective adjuncts—or what Gibson called "psychic resonances"—appetition and repulsion, pursuit and retreat, fire or withhold fire.[347]

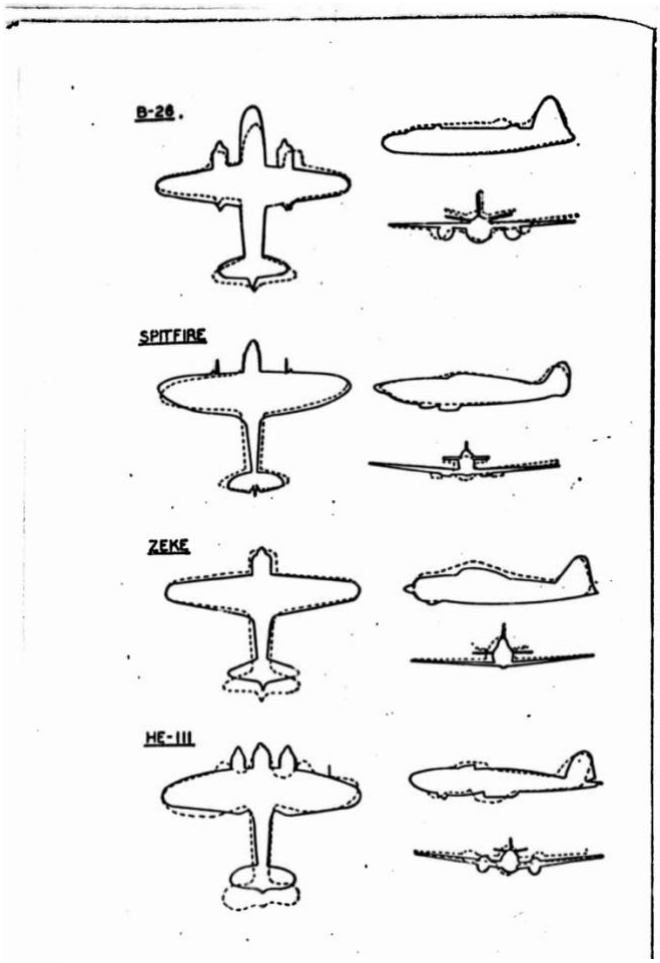


Figure 12: Composites of drawings of planes made by Gibson's trainees to demonstrate their learning of "differential" features.

Gibson's philosophy of direct realism and its approximation in the image is perplexing because it seemingly both derives from and conceptually feeds back into military-specific applications. Paradoxically, it also forms the basis for Gibson's 1960s and 1970s work on ecological perception, which contradicts military logic. The latter posits that the world as it is available to human perception is far more complex than a percept and its conventional association or psychological resonance can contain. For the most part, human beings see *things* as they are, not as they imagine or wish them to be (as with Helmholtz or the behaviorists respectively). But as people are always situated in *environments*, they must make unconscious and conscious perceptual selections—choices as to where to look—that best suit their needs and proclivities. These subject-object linkages have an ecological constitution. Just as they are a primary site for generating meaning, such determinations always also point to that which they fail to grasp. Here, Sekula and Gibson would likely agree. That which *exceeds* the representational frame or the image-word association fundamentally characterizes phenomenal and linguistic experience alike.

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[346] Gibson, *The Senses*, 235.

[347] Gibson, *The Senses*, 244.

But Gibson, too, emphasized that human beings—as locomotive mammals—are biologically predisposed to perpetually establish (and reestablish) determinative relations with objects and their affordances, relations with an affective bent. Gibson's theory remained neutral on the principle that social institutions educate their members' perceptual attention. This could just as easily be a function of a liberal education as of a military bootcamp. Nonetheless, the military indeed exploited this capacity. In the case of aircraft recognition, the perceptual selections and their respective meanings had been institutionally fixed in advance and their detection was to incite a behavioral program.

LEARNING, OUTSIDE-IN

Gibson's 1940s experiments in differential learning fit within a mid-century, cybernetics milieu in which visual memory was conceived to be material but framed as having a temporal and not a representational logic. Gibson and his contemporaries in neurophysiology and computing were departing from the Gestaltists and those working in a Kantian tradition and instead aligned with William James, who half a century earlier had articulated perception's neurological foundations.[348] Gibson in *Perception of the Visual World* offered that the optical processes involve a "series of transformations."[349] Perceptual centers transform a spatial composition of the external scene on the subject's retina into layers of nervous excitation that move the stimulus through the hemispheres. Gibson called this the "ordinal network."[350] Within the network, retinal impressions enter through the optic nerve like frames of a film and ultimately become a synthesized percept, a phenomenal object that remains constant ("invariant") in the mind's eye even as the body remains in motion with respect to the environmentally situated thing. Though the synthesized perception is a reliable reference to a concrete, three-dimensional world, it is not, in Gibson's formulation, a projection in the brain of the exterior object but is instead an index of these temporally ordered retinal image-takes.[351]

Gibson, an experimental psychologist, did not pursue research into the specific brain phenomena responsible for transforming sense impressions into neurologically organized visual memory, but that same conceptual problem was the focus of consequential research in early computing. Wiener, in his popular book *Cybernetics* (1948), and neurophysiologists Warren McCulloch and Walter Pitts (in a key 1947 article) were all concerned with how sensory input that is spatial in nature—as visual stimulation is—gives way to the brain's synaptic flows that correlate with the mind's recognition acts.[352] McCulloch and Pitts, in their development of a servo-mechanism brain model that identifies Gestalt basic shapes, found that the "spatio-temporal distribution of excitations [of neuronal chains] which represents a figure need not

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[348] See William James, *Principles of Psychology*, 2 vols. (Garden City, NY: Dover Publications, 1890). James suggests a likeness between "the [brain's] nervous currents [and] electrical currents" (1:20). The brain is largely unstructured, for James, but through habit, "the currents . . . deepen old paths or make[s] new ones" (1:107). James also describes visual memory as nonrepresentational and circuit-like: "the brain reacts by paths which previous experiences have worn, and makes us usually perceive the probable thing" (2:103).

[349] Gibson, *Perception*, 153.

[350] Gibson, *Perception*, 230.

[351] Gibson, *Perception*, 51.

[352] See Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and Machine* (Cambridge: MIT Press, 1948); and Walter Pitts and Warren McCulloch, "How We Know Universals: The Perception of Auditory and Visual Forms," *Bulletin of Mathematical Biophysics* 9 (1947): 127–147.

resemble it in any simple way."[353] This point was "to be taken against the Gestalt psychologists who . . . conceive a figure . . . by depicting it topographically on neuronal mosaics."[354] Instead, McCulloch and Pitts incorporated time as a variable and presented the model as an example of the "systematic use of the principle of the exchangeability of time and space."[355] They were looking to develop an approximation of the eye-brain in the computer. In doing so, they were confining their understanding of these biological organs to terms that were specifically relay-based and numerical. Further, they were devising a scheme whereby *an image*, a physical thing—a projected basic shape, in their model—materially transforms to be *an operation.*

The term *operation*, in the context of cybernetics and early artificial intelligence models, had a dual meaning. On the one hand, the researchers intended to simulate human perception, as a biological function, by focusing on its processual quality. Gibson's WWII efforts to improve combat pilots' recognition speed resonated with scientific observations of neurological activations and computational capabilities: in every case a primary dimension was time. On the other hand, Gibson's nuanced empiricist-philosophical conclusion that embodied seeing is purposive even when perception is considered in its ecological and nonmilitary contexts—the notion that human beings see, first and foremost, so as to get by in a complex world—was too easily collapsible with the utilitarian aspect of computing culture and its institutional applications.

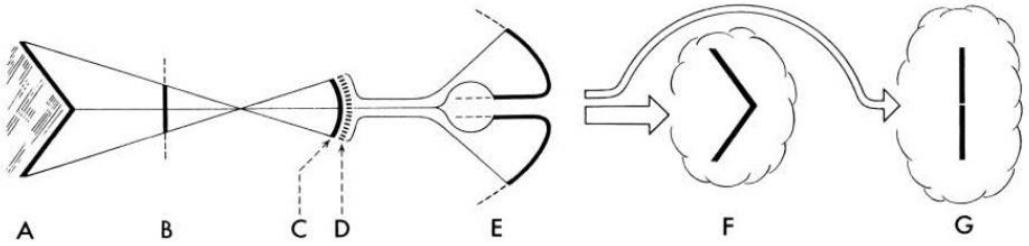


Figure 13: Gibson's "Series of Transformations in the Process of Visual Perception." Source: Cornell Library James J. Gibson Collection.

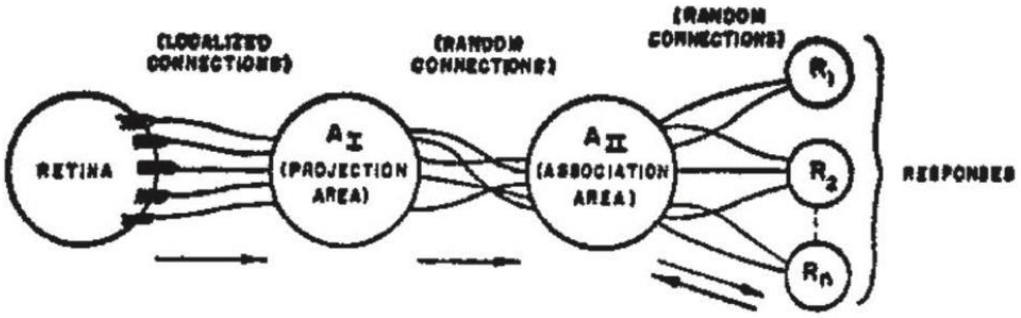


Figure 14: Rosenblatt's "Organization of a perceptron." Source: Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," 389.

[353] Pitts and McCulloch, "How We Know Universals," 136.

[354] Pitts and McCulloch, "How We Know Universals," 137.

[355] Pitts and McCulloch, "How We Know Universals," 146.

Neuropsychologist Frank Rosenblatt captured this duality of operational visioning with his neural network conceptual model and its instantiation in a militarily applicable physical machine—the perceptron and the MARK I Perceptron respectively.[356] Rosenblatt had been a mentee of Gibson at Cornell, and the two coauthored a paper in 1955.[357] Given this association, Rosenblatt unsurprisingly adopted a "direct realism" approach to his computational model of a perceiving agent. Echoing Gibson, Rosenblatt in his foundational text *Principles of Neurodynamics* (1961) opens with the assertion that "the theory of the perceptron shows how . . . knowledge . . . of the physical world . . . depends upon the organization of the environment, as well as on the [organization of the] perceiving system."[358] The two realms were to be connected by a machinic retina that would take visually arrayed inputs. As in the McCulloch and Pitts shape-recognition model, the sense impression was integrated with visual memory not by creating a representational double but through a translation of the retinal image into neurological traces. And yet Rosenblatt's perceptron was not prestructured to recognize basic shapes alone, as was the program of McCulloch and Pitts. Instead, whatever visual data entered the perceptron system would impose its structure on the synaptic form of the brain model. The computer-brain learned to perceive through sensory encounters with the external environment.

Of central concern for Rosenblatt, then, was how to model the brain's quality of plasticity. This was a problem that Rosenblatt thought his contemporaries had not pursued to a satisfactory degree. McCulloch and Pitts, in a different experiment in 1943, had developed an artificial neuron; it was a two-state logical calculating machine that, according to Rosenblatt, had limited learning capacities because of its high degree of initial structure.[359] Donald Hebb's "fire together, wire together" theory of brain organization allowed for more adaptation, as it was amenable to probabilistic calculation, but Rosenblatt argued that it was "still too programmatic" and lacked the degree of openness found in the human brain.[360] Rosenblatt, too, employed probability theory to account for uncertainty within the system's operations, but to build in the capacity to engage with external contingency he endowed the perceptron with an artificial retina.[361] Following in the British empiricist and Jamesian tradition of neural trace theory, Rosenblatt's program would have minimal "innate knowledge."[362] In his scheme, at the get-go "the organization of the network is specified only in part, by constraints and probability

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[356] Rosenblatt's and Murray's writing explains why they preferred to keep these terms separate. The "perceptron" was the conceptual model, the class of systems with perception-brain properties; "Perceptron" referred to the machine.

[357] See J.J. Gibson, P. Olum, and F. Rosenblatt, "Parallax and Perspective during Aircraft Landings," *American Journal of Psychology* 68, no. 3 (1955): 372–385.

[358] Frank Rosenblatt, *Principles of Neurodynamics: Perceptrons and the Theory of Brain Mechanisms* (Ithaca, NY: Cornell Aeronautical Laboratory, 1961), 3; originally classified.

[359] Warren McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," *Bulletin of Mathematical Biology* 52, no. 1–2 (1943): 99–115.

[360] Rosenblatt, *Principles of Neurodynamics*, 23. See also Donald Hebb, *The Organization of Behavior* (New York: John Wiley and Sons, 1949).

[361] Rosenblatt first published on the perceptron model in 1957 in a report for the Office of Naval Research titled *The Perceptron: A Perceiving and Recognizing Automaton*, Report No. 85-460-1 (Ithaca, NY: Cornell Aeronautical Laboratory, 1957).

[362] See Frank Rosenblatt, "The Perceptron: A Probabilistic Model for Information Storage and Organization in the Brain," *Psychological Review* 65, no. 6 (1958): 386.

distributions which generate a *class* of systems rather than a specific design."[363] Rosenblatt's model would thus require repetitive exposure to visual forms, which would directly alter its temporally ordered neural traces. Through repetition, certain imagistic impressions would compound, making the brain model more determinate in its material organization and, in effect, less plastic. The stronger the network links between nodes, the more probable that this pathway would be traversed in the future and the more likely the network was to correctly recognize an object.[364] Plasticity, as a property of the brain, here has a similar paradoxical quality to Gibson's ecological quality of vision: its openness to complexity and uncertainty necessitated its subsequent acquisition of a fixed structure and narrowing of perceptual meaning.

Rosenblatt's perceptron conceptual model simultaneously synthesized contemporary scientific assumptions about biological perception and cognition, as well as his presumptions about what could be approximated in the computer given its servomechanism logic. In this respect, the perceptron indexed an emerging ontology of vision for the Information Age. But as the concept took material form in Rosenblatt's MARK I Perceptron machine, funded by U.S. defense agencies, it was also imbricated in an institutional framework that had for decades been understanding optics according to the principles of scientific management.[365] Accordingly, the MARK I, as a perceptual "agent" that would have to fit within the optical workflows considered militarily useful, would *see* in order to *do*. This casts certain perceptron concepts in a new light. Like the combat pilots in Gibson's training, Rosenblatt's neural network positioned perception as a space-time transformation, whereby the time of recognition was specified as a metric of tactical success or failure. Perceptual learning would result in increasing organization of neural traces and, by extension, achievement of operational efficiency and exactitude. Visual experience involved the negotiation of (un)certainty and, paradoxically, the binary logic of identification—a plane was either present or not, ally or enemy. Gibson's and Rosenblatt's work together shows how the perceptual apparatus of the body or computer alike was thought to be accessible by an unpredictable outside and thus profoundly unstable. Its inherent indeterminacy was conditioned by the determinateness of its environmental features. In institutional settings, the "environment" for cadets and perceptions alike was artificially produced. Instead of having the plenitude of ecological experience, perceptual training was achieved through extensive exposure to a finite, discrete list of objects. Learning in this institutional setting thus demanded dispensing with sensorial and symbolic complexity and seeing a target for a target for a target.

CRATOLOGY

Murray's public introduction to the MARK I Perceptron at the 1961 engineering conference naturalized the qualities of target worthiness when he detailed exactly what the neural network machine would do in its photo-interpretation role: "A simple . . . automation goal would be the ability to scan large quantities of mostly uninteresting photographic material in search of only one kind . . . of object or feature. . . . The ability to recognize simple target forms in relatively

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[363] Rosenblatt, *Principles of Neurodynamics*, 19–20.

[364] Rosenblatt, "The Perceptron," 386. See also Hebb, *The Organization of Behavior*.

[365] For an examination of the emergence of scientific management's imbrication with perceptual training, see chapter one; see also Julia A. Irwin, "Exhibition Ergonomics: The Interactive Film and Media Theory of Lillian Moller Gilbreth," *Film History* 35, no. 1 (2023): 1–30.

featureless environments . . . is a capability which should be inherent" to the Perceptron.[366] Meanwhile, this visual task of detecting militarily interesting structures in photographs was the workaday practice of CIA human photo interpreters. According to the extensive documentation of senior interpreter Dino Brugioni, their techniques followed suit with Murray's described method of featureless/feature discernment and object classification.[367] They would employ it when scanning "intriguing" U-2 photography of Cuba in October 1962.[368] In images of the landscape just outside Los Palacios, interpreters noted "six long canvas-covered objects," determined them to be more than sixty feet long, and thus identified them as medium-range ballistic missiles capable of reaching the continental United States.[369] This photographic identification event marked the onset of the Cuban Missile Crisis, in which the U.S. pursuit of a frictionless visual perception apparatus was interrupted by the profound uncertainty of geopolitical activity and the condition of being geographically reachable as a target.

These object-based interpretive practices had emerged in the preceding decades, originally within intelligence divisions of the military in WWII and, as of 1952, within the CIA's new Photo Division. A recently declassified internal historical survey of the division, written by CIA staff, describes how its identity formed in contrast to intelligence agencies' WWII photo-interpretation methods. While the usefulness of aerial photography for military reconnaissance and targeting had been enduringly secured by U.S. Strategic Bomb Survey's postwar reports, in the early Cold War a "technological explosion [was] generated by crash efforts to apply scientific knowledge to the . . . evaluation of information."[370] This embrace of new devices to aid in performing intelligence work exemplifies what Kristie Macrakis calls the CIA's "technophilic hubris."[371] It was accompanied by the agency modifying the scope of an otherwise complex and discursive professional field. This is reflected in the history's attention to terminological specificity: WWII aerial-image analysts had engaged in *photo intelligence* in which they associated photographic information with other human-derived information on the subject. CIA Photo Division staff engaged in the narrower and more automatic activity of *photo interpretation*, which, as Murray's comments convey, was synonymous with object recognition.[372]

The Photo Division's moves fit within the broader apparatus of U.S. efforts in the 1950s to achieve reconnaissance prowess during a period of Iron-Curtain-clad opacity. These years (especially those prior to the U-2 spy plane's regular deployment at the end of the decade) were characterized by "photo gap" periods in which the CIA received little to no up-to-date photography of strategic locations.[373] The exposing and destabilizing effects of visual perception

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[366] Murray, 628.

[367] See Dino Brugioni Collection, NASM, SI; and Dino Brugioni, *Eyeball to Eyeball: The Inside Story of the Cuban Missile Crisis*, ed. Robert F. McCort (New York: Random House, 1990).

[368] Brugioni, *Eyeball to Eyeball*, 195.

[369] Brugioni, *Eyeball to Eyeball*, 197.

[370] CIA Historical Staff, ii, 2.

[371] Kristie Macrakis, "Technophilic Hubris and Espionage Styles during the Cold War," *ISIS* 101, no. 2 (June 2010): 378–385.

[372] CIA Historical Staff, 8.

[373] For an analysis of the photo gap periods, see CIA Historical Staff; and Brugioni, *Eyeball to Eyeball*. See also Katherine Chandler, *Unmanning: How Humans, Machines and Media Perform Drone Warfare* (New Brunswick, NJ: Rutgers University Press, 2020). Chandler argues that the history of unmanned aerial vehicles is marked by networks of human

as conceived by Gibson and Rosenblatt aligned with the paranoid style of American government agencies.[374] Permeating U.S. defense institutions was a fear of being targeted from a direction and with weapons it could not perceive.[375] They thus pursued an impossible goal of obtaining perceptual proximity to the entire globe, and they did so by developing alternative interpretive methods that could skirt the inadequate photographic means.

The changing formal construction of photo-training encyclopedias within intelligence contexts exemplifies the shift toward a technocratic approach and an impulse to do more with less photographic material. WWII image intelligence analysts had organized these booklets by pairing photographic examples of industrial installations (e.g., oil refining) or specific objects (e.g., aircrafts) with thick descriptions of their contents and contexts.[376] In the 1950s the Photo Division interpreters, deprived of current images, mined these troves of WWII-era aerial photography and training encyclopedias and cropped out and extracted specific objects that were likely still in use by the Soviets: airplanes, ships, missile launchers, military installation parts. Meanwhile, the CIA built up prefabricated targeting lists that assigned determinate and binary political meanings to these object types.[377] In images from a 1954 tactical guide developed for the U.S. Army with input from the CIA Photo Division, physical structures and material things have been removed from their geographic and cultural context.[378] The guide opens with a description of its interpretive philosophy:

> Photo interpretation is . . . a process of elimination. As the primary interest is in the military installation or object, the interpreter separates the natural features in the photo from the manmade and eliminates the natural. . . . Distinguishing . . . is a simple matter. . . . Nature works without pattern; man works in straight lines, sweeping curves, and angles.[379]

Accompanying the graphically rendered objects are checklists of shape-based "indicators," specifying features of a particular object within its larger class of "signatures."[380] Photo

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and nonhuman actors mediating technical and political failures. The Photo Division undertook frequent analysis of satellite photography artifacts and (un)usability. See National Archives, Cartographic Records, Record Group 263, Records of the Central Intelligence Agency, 1894–2002, "Photographic Evaluation Reports, 1/1963–1/1972."

[374] This phrase originates with Richard Hofstadter, "The Paranoid Style of American Politics," in *The Paranoid Style of American Politics and Other Essays* (Cambridge: Harvard University Press, 1963), 3–40.

[375] U.S. paranoia about its exposure and reachability goes hand in hand with what Paul Edward theorizes as its "closed world" Cold War discourse and technical practices. See Paul Edwards, *The Closed World: Computers and the Politics of Discourse in Cold War America* (Cambridge: MIT Press, 1996).

[376] Dino Brugioni's archive includes the WWII photo interpretation manuals that the CIA photo division used for reference. See Dino Brugioni Collection, Box 23, NASM, SI. They are also housed at the National Archives, College Park, Maryland, and take up more than eight hundred boxes. See National Archives Textual Records, Record Group 341: Records of Headquarters U.S. Air Force, 1934–2004, Series: Military Intelligence Photographic Interpretation (MIPI) Reports, 1942–1956.

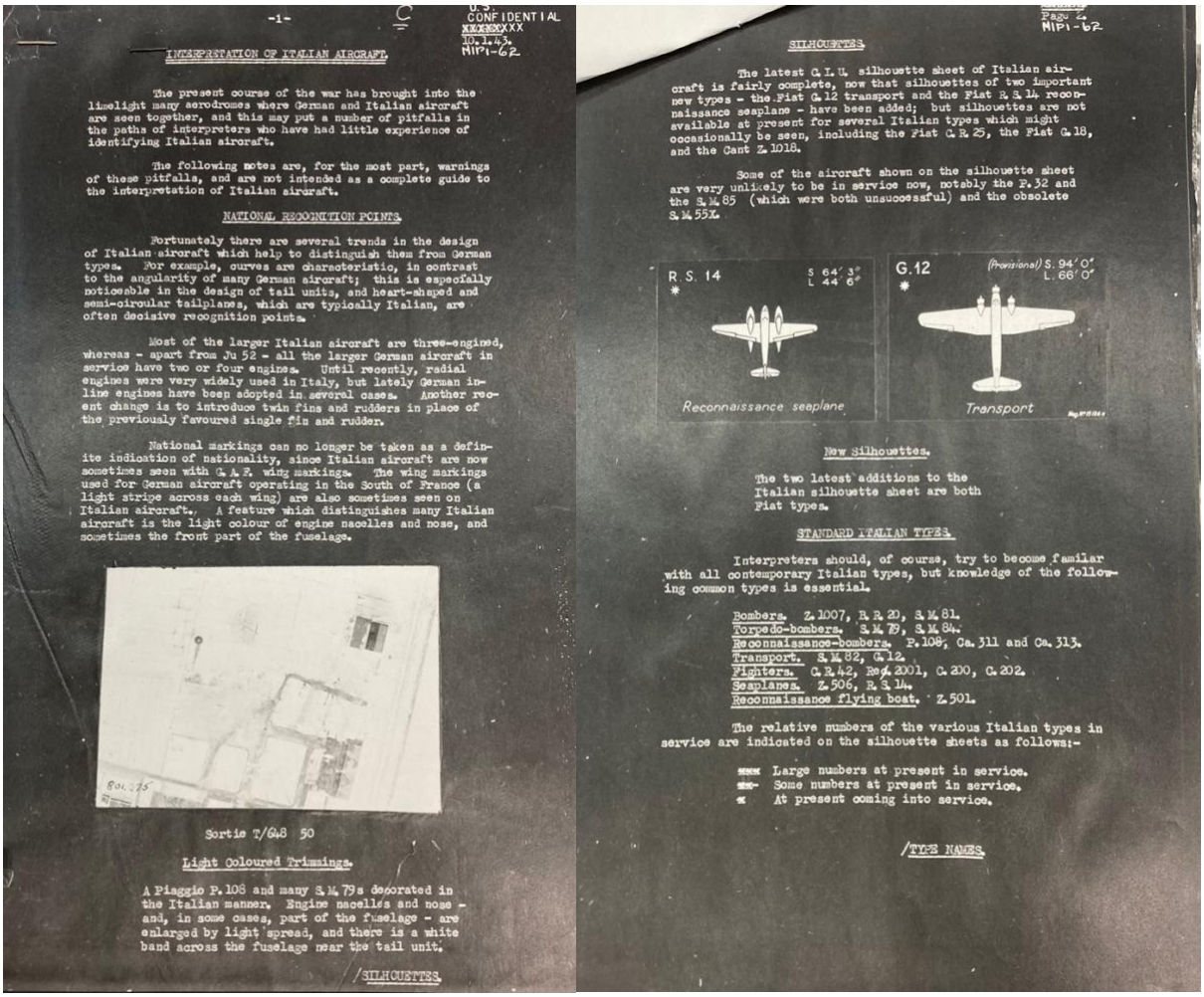
[377] This top secret target list project is discussed in "Report on Perceptron [Redacted] Concerning Automated Image Recognition," April 1963, 4, in CREST Database, NGA Records, FOIA Number: CIA-RDP78B04770A002300030029-4.

[378] CIA Historical Staff, 26. Though this manual was produced for the Army, CIA interpreters helped develop the document. Photo interpretation reports produced for the CIA during this period, using WWII photography, remain largely classified.

[379] Department of the Army, *Tactical Interpretation of Photos*, Department of the Army Technical Manual TM 30-246 (Washington, DC: Department of the Army, February 1954), 5, in San Francisco Maritime National Park Association Archive, https://maritime.org/doc/photo-interp/index.php; see also Appendix, figs. 2–7.

[380] Department of the Army. See also Brugioni, *Eyeball to Eyeball*, 196.

interpreter Brugioni encouraged colleagues to visually memorize specific objects (e.g., a Soviet ship model) for easy recognition upon presence in any of the scant new photography. If they could trace new locations of already known Soviet objects, Brugioni thought, they could determine emerging geopolitical alliances.[381] Modernity's standardization of the built environment and manufactured goods had conflicting perceptual effects. On one hand, it enabled U.S. object recognition at an institutional scale. On the other, it aided the USSR in circulating goods to solidify emerging alliances with nations at the margins of the U.S.'s perceptual scope.



-1-

CONFIDENTIAL

MIPI-62

INTERPRETATION OF ITALIAN AIRCRAFT.

The present course of the war has brought into the limelight many aerodromes where German and Italian aircraft are seen together, and this may put a number of pitfalls in the paths of interpreters who have had little experience of identifying Italian aircraft.

The following notes are, for the most part, warnings of these pitfalls, and are not intended as a complete guide to the interpretation of Italian aircraft.

NATIONAL RECOGNITION POINTS.

Fortunately there are several trends in the design of Italian aircraft which help to distinguish them from German types. For example, curves are characteristic, in contrast to the angularity of many German aircraft; this is especially noticeable in the design of tail units, and heart-shaped and semi-circular tailplanes, which are typically Italian, are often decisive recognition points.

Most of the larger Italian aircraft are three-engined, whereas - apart from Ju 52 - all the larger German aircraft in service have two or four engines. Until recently, radial engines were very widely used in Italy, but lately German in-line engines have been adopted in several cases. Another recent change is to introduce twin fins and rudders in place of the previously favoured single fin and rudder.

National markings can no longer be taken as a definite indication of nationality, since Italian aircraft are now sometimes seen with G.A.F. wing markings. The wing markings used for German aircraft operating in the South of France (a light stripe across each wing) are also sometimes seen on Italian aircraft. A feature which distinguishes many Italian aircraft is the light colour of engine nacelles and nose, and sometimes the front part of the fuselage.

Sortie T/648 50

Light Coloured Trimmings.

A Piaggio P.108 and many S.M.79s decorated in the Italian manner. Engine nacelles and nose - and, in some cases, part of the fuselage - are enlarged by light spread, and there is a white band across the fuselage near the tail unit.

/SILHOUETTES.

Page 4

MIPI-62

SILHOUETTES.

The latest C.I.U. silhouette sheet of Italian aircraft is fairly complete, now that silhouettes of two important new types - the Fiat G.12 transport and the Fiat R.S.14 reconnaissance seaplane - have been added; but silhouettes are not available at present for several Italian types which might occasionally be seen, including the Fiat C.R.25, the Fiat G.18, and the Cant Z.1018.

Some of the aircraft shown on the silhouette sheet are very unlikely to be in service now, notably the P.32 and the S.M.85 (which were both unsuccessful) and the obsolete S.M.55X.

R.S. 14 S 64' 3" L 44' 6"

Reconnaissance seaplane

G.12 (Provisional) S. 94' 0" L. 66' 0"

Transport

New Silhouettes.

The two latest additions to the Italian silhouette sheet are both Fiat types.

STANDARD ITALIAN TYPES.

Interpreters should, of course, try to become familar with all contemporary Italian types, but knowledge of the following common types is essential.

Bombers. Z.1007, R.R.20, S.M.81.
Torpedo-bombers. S.M.79, S.M.84.
Reconnaissance-bombers. P.108, Ca.311 and Ca.313.
Transport. S.M.82, G.12.
Fighters. C.R.42, Reg.2001, C.200, C.202.
Seaplanes. Z.506, R.S.14.
Reconnaissance flying boat. Z.501.

The relative numbers of the various Italian types in service are indicated on the silhouette sheets as follows:-

xxxx Large numbers at present in service.
xx- Some numbers at present in service.
x At present coming into service.

/TYPE NAMES.

Figure 15: Example of a WWII photo interpretation report.

[381] See Dino Brugioni Collection, NASM, SI; Brugioni, *Eyeball to Eyeball*; and Dino Brugioni, *Eyes in the Sky* (Annapolis: Naval Institute Press, 2010). The CIA Historical Staff report on the *National Photographic Interpretation Center* also describes these activities.

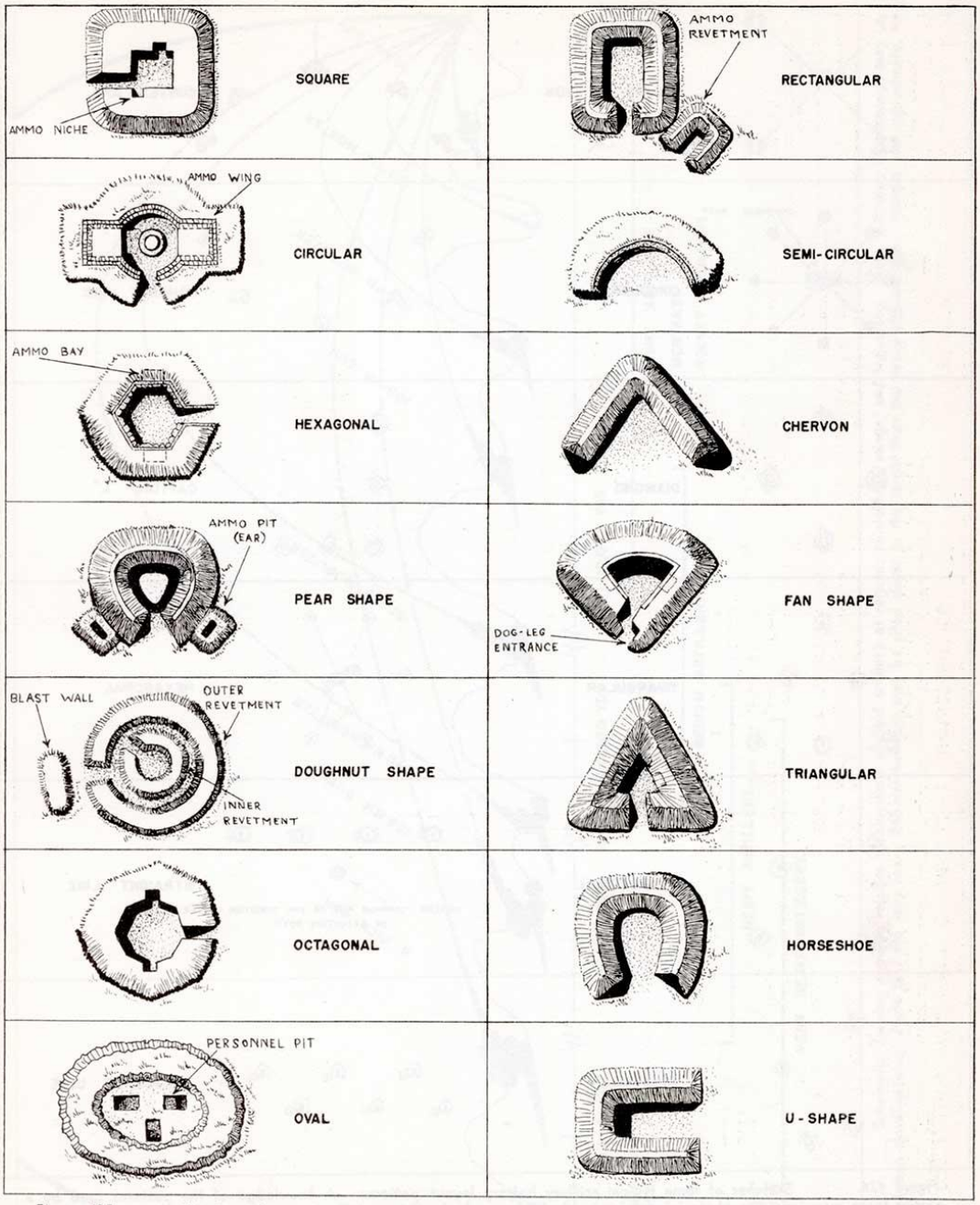


Figure 425. Sketches of some basic types of artillery emplacements. The photo interpreter will find many variations of these basic types, depending on the teachings and ingenuity of hostile artillery.

Figure 16: Graphics from the 1954 Army Tactical Photo Interpretation Handbook.

Nonetheless, the CIA's methodology traded discursive understanding for the near automatic activity of pattern matching. The interpreters' encyclopedic object-network picture collections derived their meaning from a binary interpretive logic: presence/absence. Objects' significance was determined in advance of their selection. Despite the supposed noncombat intentions of the U.S. defense apparatus in the 1950s, its photo interpretations, like those of Gibson's combat pilots, took the posture of active targeting.

Through the late 1950s and early 1960s an existential feedback loop conditioned photo interpretation. Hellbent on determining the scope of Soviet missile capabilities so as to *avoid being attacked*, the United States had to acquire more reconnaissance photographs to analyze. But to obtain the images, U.S. aircrafts had to fly over Soviet or Soviet-affiliated territories fortified with surface-to-air defense missiles that could be aimed at them. That is, the United States had to *risk being attacked* to gain the very images it needed to avoid being attacked. In these calculated and often unsuccessful missions, the ranges of Soviet missiles were faced off against the altitude capacities of U.S. spy planes and the focal lengths of their on-board cameras.[382] This exercise replicated the paranoia that Soviet weapons could travel to terrestrial locations from which the continental United States would be in firing range. Missile scalar dimensions correlated directly with their respective detonation ranges; therefore, the CIA's object-recognition practices attended most acutely to weapon identification. Photo Division staff even joked that their job was to "answer the size question."[383]



Figure 17: Photograph used in the NPIC's cratology practices. Source: National Security Archive, George Washington University.

[382] CIA Historical Staff, 3; Dino Brugioni Collection, NASM, SI; Brugioni, *Eyes in the Sky*; Brugioni, *Eyeball to Eyeball*; and Chandler, *Unmanning*.

[383] Ralph Pearse, "What Size Is It?: The Evolution of Photogrammetry within the CIA," *Studies in Intelligence* 15 (1971): 53.

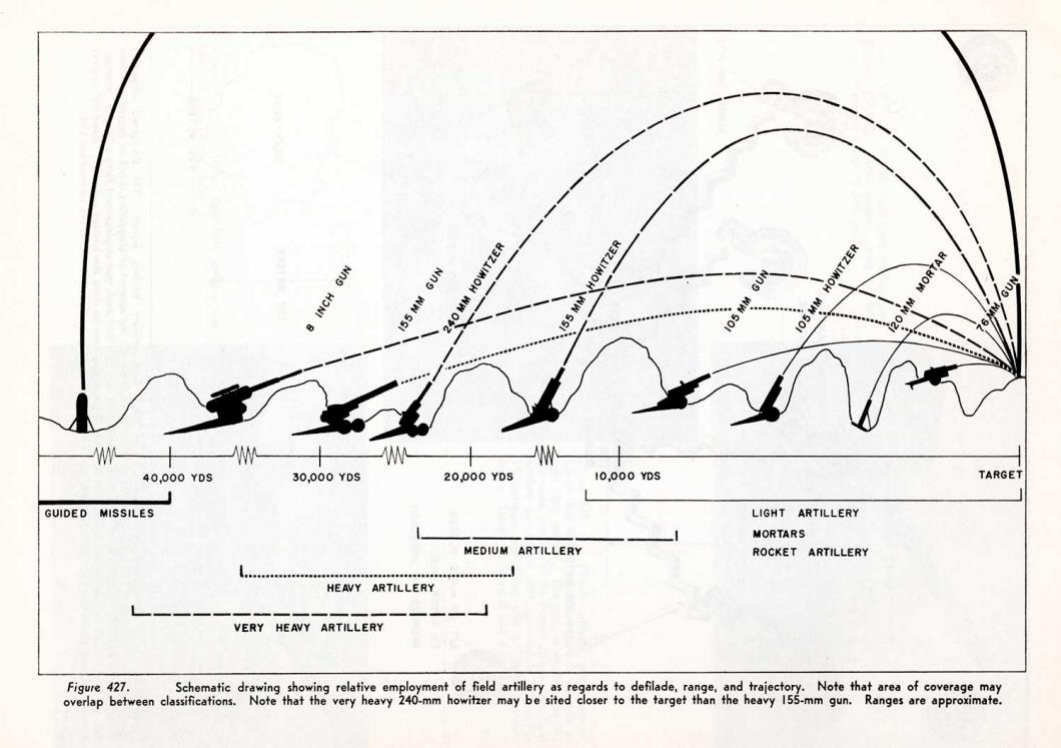


Figure 18: Graphical demonstration of the relationship between object and range detection. Source: 1954 Army Tactical Photo Interpretation manual.

What aerial reconnaissance did take place in the 1950s before the advent of the U-2 era produced photographs of activity on the open oceans because they were not fortified with the same closed-border defense systems found on Soviet territory and because armaments would primarily be globally dispersed as cargo. Aerial representations of ships provided little straightforward information regarding their cargo, however. Brugioni describes a practice the Photo Division staff devised to overcome this opacity:

> When the Soviets first began sending armaments abroad, it was frequently carried as deck cargo on merchant vessels. . . . [They] covered the weapons with packing crates. . . . [Photo Division Director Arthur] Lundahl asked that the crates and containers be carefully analyzed and measured using photogrammetric means. He labeled the science of measuring, identifying, and cataloguing the crates and their contents *cratology*. By the time of the Cuban missile crisis, cratology was firmly established as an intelligence technique.[384]

The crates epitomized the object-recognition spirit. Their bright canvases announced their presence and measurability against the dark, superfluous features of the transport vessel and surrounding ocean. But cratology, like Gibson's aircraft recognition, necessitated perceiving not just objects but object relations.

Fashioning an analogical relationship between a missile container's imagistic representation and physical reality was achieved using the mensuration technique of photogrammetry. Devised in the nineteenth century to survey land, photogrammetry involves comparing multiple photographs with overlapping features to obtain the real-world size of

[384] Brugioni, *Eyeball to Eyeball*, 73.

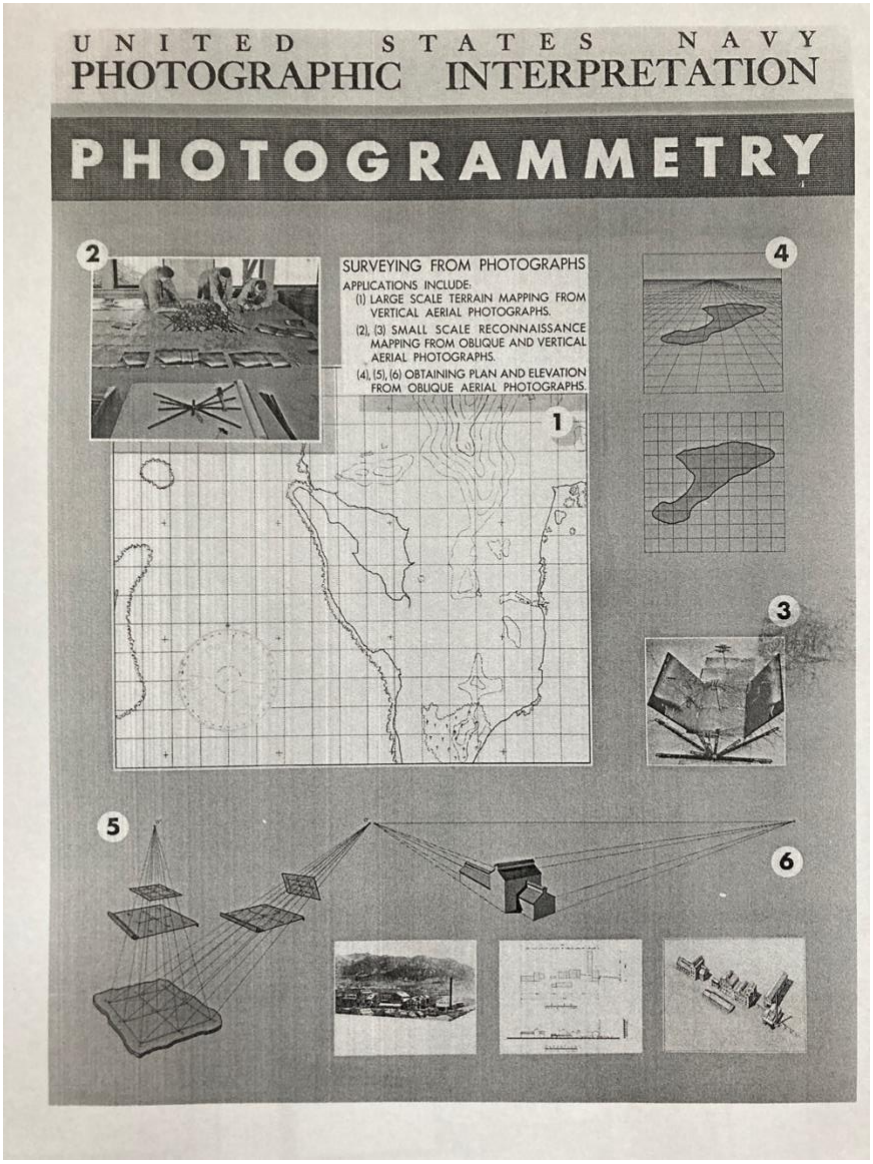


Figure 19: WWII photogrammetry poster. Source: Dino Brugioni Collection.

objects in three dimensions.[385] A photogrammetric procedure requires two input categories: first, several fiducials, or markings on the earth's surface whose relative position can be tracked across images; second, camera focal length at image capture, a measurement that also correlates with the aircraft's altitude.[386] The reflexive operation of measuring the proximity of camera to missile, self to other, reiterates the WWII combat pilot position in that the act of perception coincides with the condition of being a target. Just as the CIA's interpretive techniques explicitly embraced a technocratic ethos, these efforts also registered the visual ego of the U.S. government and its sense of susceptibility to the Soviet behavioral environment. While these latter factors expose those elements of perception conceptually tied to political ambiguity, the visual interpretive method that placed knowing before seeing effectively made this precomputer, human form of vision automatic.

PERCEPTRON AND DECISION

By the start of the Cuban Missile Crisis in October 1962, the CIA Photo Division had already, for two years, been testing Rosenblatt's MARK I Perceptron for the possible computer-automation

[385] See Francis H. Moffitt, *Photogrammetry,* 3rd ed. (New York: Harper and Row, 1980). See also Brooke Belisle, *Depth Effects* (Berkeley and Los Angeles: University of California Press, 2023).

[386] Pearse, "What Size Is It?"

of photo-interpretation tasks.[387] A 1963 report summarizes the tests' rationale and status: "There is ample evidence to support the conjecture that simple objects, and even some complex objects, in aerial photographs might be isolated and classified automatically. . . . It is possible that [redacted] and other organizations of this type and caliber will produce the first practical devices for *automated target recognition*."[388]

Automatic classification of forms required extensive preorganizational work before the machine could read images, but this procedural feature was far from technologically determined. The selection and signification of object types *as* targets in advance of recognition had similarly conditioned Gibson's training and the CIA Photo Division's work of the 1950s.[389] The 1963 report even echoes the 1954 interpretation manual:

> Objects of interest have been categorized in two different ways. First, *simple objects*, such as buildings, aircraft, ships, and tanks have been distinguished from *complexes*, or *complex* objects. Second, *simple* objects have been categorized, according to their length-to-width ratios, as being either blobs (aircraft, storage tanks, buildings, runways) or ribbons (roads, rivers, railroad tracks). . . . The detection of simple objects is accomplished separately for ribbons and for blobs.[390]

Once preclassification was completed, the MARK I Perceptron executed object recognition. The process conceptually follows suit with both Gibson's differential reinforcement perceptual learning and Rosenblatt's original probabilistic brain model diagram:

> Recognition of simple binary images, after detection, isolation, and standardization, will be accomplished by . . . comparing the weighted sum of a set of property values to a threshold. The weights used are determined by exhibiting a sequence of patterns whose classification is known and adjusting the weights when classification is incorrect, according to prescribed algorithms, until all patterns in the sequence are correctly classified. Thus, the device is "adaptive" and "learns."[391]

As of mid-1962, engineers had "established [the] capability of a 500-unit perceptron to recognize noisy, militarily interesting objects."[392] This description involves a notable slippage. The machine is not recognizing the quality of "militarily interesting" in the object; instead, it is matching this newly encountered form with a class of forms stored in memory that some external entity has in advance determined to be meaningful in an affective (ally/enemy) register.

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[387] This test did not result in full implementation of the Perceptron but initiated an automatic target-recognition program that defense departments have maintained ever since. See Jack O'Connor, "Undercover Algorithm: A Secret Chapter in the Early History of Artificial Intelligence and Satellite Imagery," *International Journal of Intelligence and Counterintelligence* 36, no. 4 (2023): 1337–1351, https://doi.org/10.1080/08850607.2022.2073542.

[388] CIA Staff, "Report on Perceptron [Redacted] Concerning Automated Image Recognition," April 1963, in CREST Database, NGA Records, FOIA Number: CIA-RDP78B04770A002300030029-4, 3–4; emphasis added."

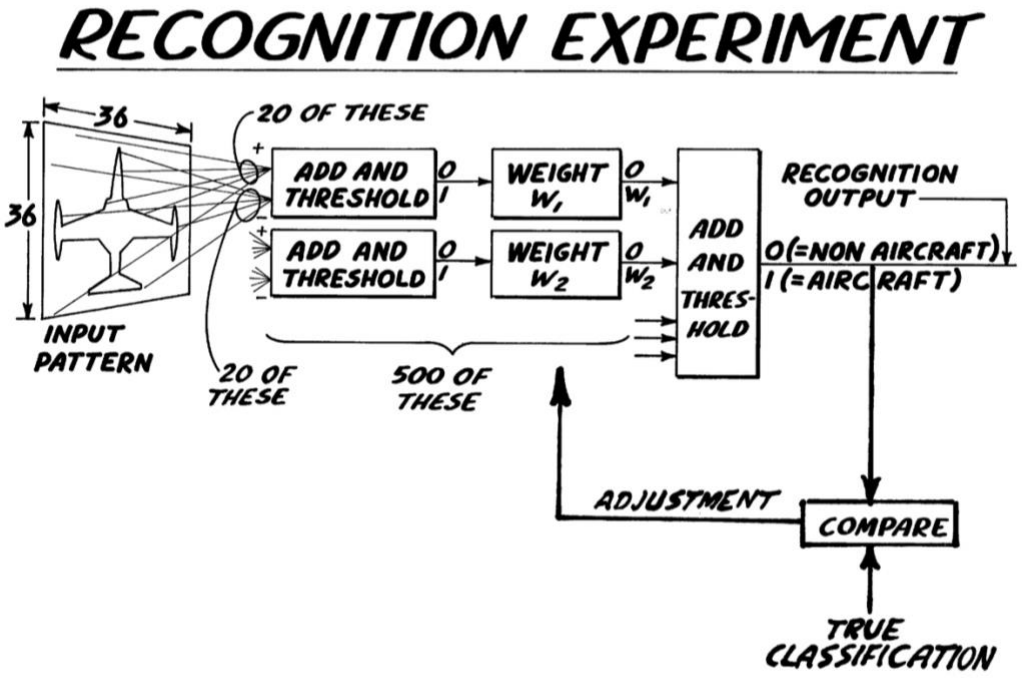
[389] Internal documents indicate that the CIA was receiving a national target list called the "COMOR Report." CIA Staff, "Automatic Target Recognition," 6.

[390] CIA Staff, "Report on Perceptron," 6; emphasis in original.

[391] CIA Staff, "Report on Perceptron," 21–22.

[392] "Contract [Redacted] Perceptron Concepts to Photo-interpretation," July 1963, 19, in CREST Database, NGA Records, FOIA Number: CIA-RDP78B04770A002300030027-6.

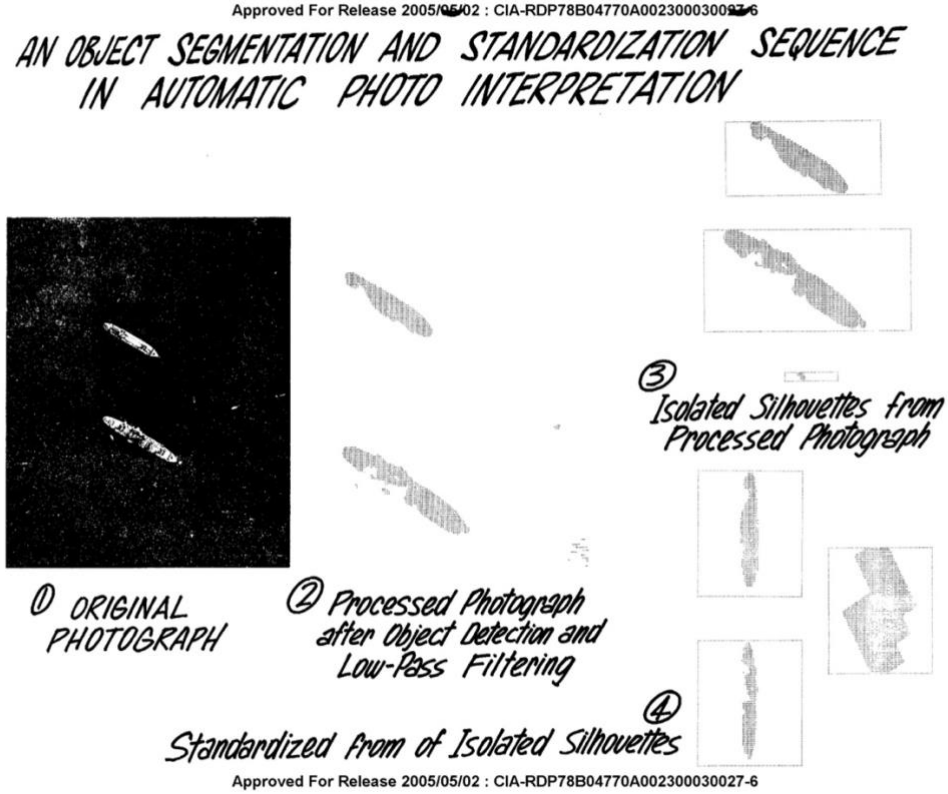
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Figure 20: Explanatory slide from the July 1963 CIA Photo Division Perceptron report. Source: CIA CREST database.

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Figure 21: Explanatory slide from the July 1963 CIA Photo Division Perceptron report. Source: CIA CREST database.

This cybernetic dataset logic enabled the temporal coupling of perception and (classification) decision by excising thinking and discursivity from the loop. It abstracted meaning making and made it precedent to the perceiving entity's moment of recognition. Like plane recognition during WWII, the Perceptron's visual memory—its neural organization—adapted in response to new retinal data. The model's interior lack of "brain" structure encountered the CIA's imposition of a structure via its rendering of a fixed target list. These factors define automatic target recognition, which otherwise manages to exploit the automatic qualities of the human body and the computer alike despite the ontological distinctions between them.

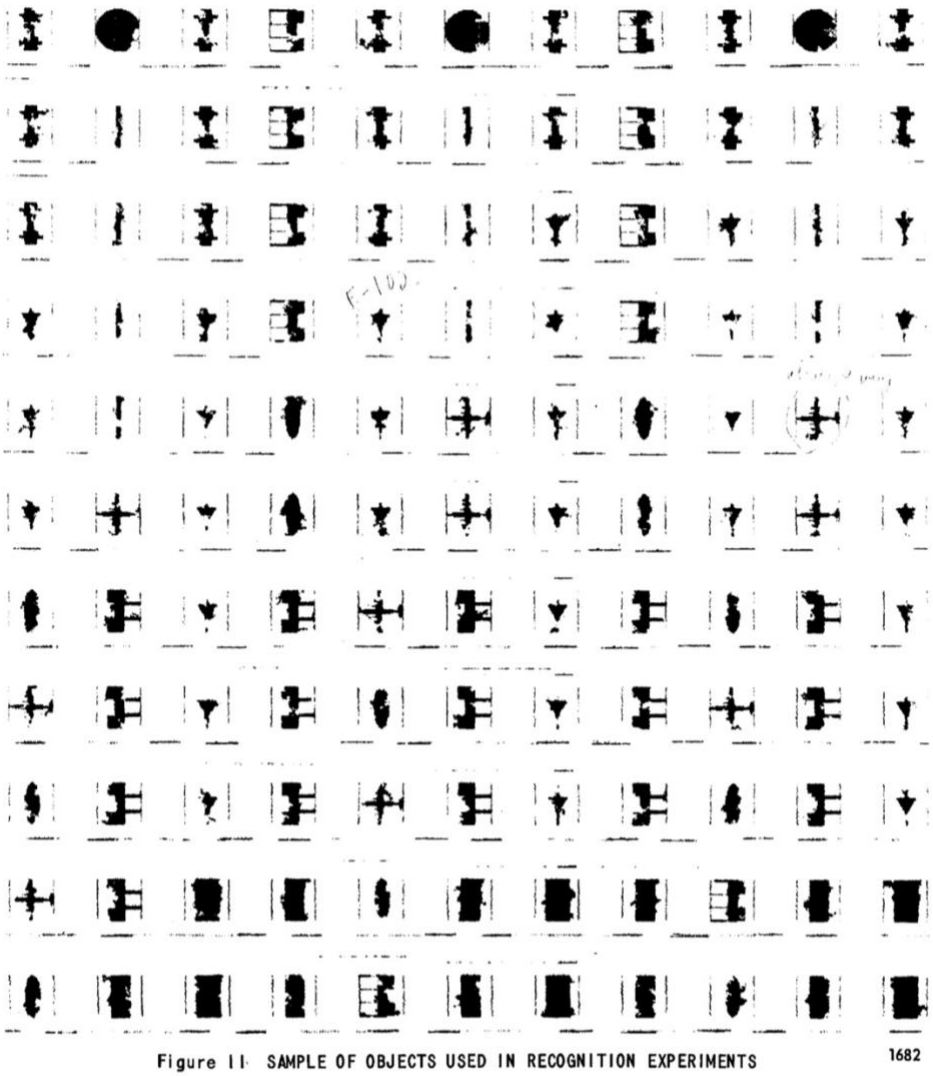


Figure 22: Explanatory slide from the July 1963 CIA Photo Division Perceptron report. Source: CIA CREST database.

But the CIA's pursuit of frictionless binary recognitions encountered the uncertainty of political decision-making when the United States wielded photo interpretation during the Cuban Missile Crisis. Photo interpreter Brugioni's recounting of the conversation that triggered the onset of the Cuban Missile Crisis, on October 16, 1962, centers CIA Photo Division head Arthur C. Lundahl's briefing of President John F. Kennedy on the image intelligence that indicated the presence and "occupied" position of medium-range ballistic missiles: "Lundahl pointed out the missile transporters, the tents, the launcher, erectors. . . . The president took the magnifying glass and studied the photography . . ., turned to his right and, looking Lundahl straight in the eye . . . asked, 'Are you sure?'"[393] Lundahl responded that he was "'as sure of this as a photo interpreter can be sure of anything.'"[394] In a 1996 interview Brugioni recalled how his team, invoking humor, trained the president's perception. Presenting Kennedy with an aerial image of three open-air latrines, CIA Director John A. McCone said, "We have a new site in Cuba with three positions, with one position occupied and the President's jaw dropped. . . . He started laughing and he said, now I understand what occupied, unoccupied is, why didn't I have this primer earlier?"[395]

These anecdotes illustrate a semiotic evacuation and its replacement by a presence/absence interpretive framework. On the one hand, objects are interchangeable—a medium-range ballistic missile, a latrine—and acquire meaning from questions such as: alien object on farmland, or not? occupied latrine or unoccupied latrine? On the other hand, a different current of meaning undergirds the whole operation. Objects' significance is based on their probabilistic likelihood to do harm to the perceiver, based on a variable spatial relation between the two. These scenes between CIA officials and Kennedy betray a profound gap between the procedures of automatic target recognition and the virtues of a discursive mode of decision-making. We might ask, who or what determined the risk to the United States? Kennedy's question— "are you sure?"—is the bastion of "humanness" that keeps recognition technologies from automatically deciding on military action. Still, the skepticism and dialogue it prompts does little to disrupt the fixed data-interpretive structure already put in place by CIA interpreters. Lundahl and his team engaged with the president's questions through dialogic means, but their path to sureness was, in fact, automatic.

NETWORKED OBJECT-VISION

Though the CIA's Perceptron test did not result in its adoption by the Photo Division, its vision for how an individual's neural organization entangles with target recognition techniques established a schematic for institution-wide processes. In 1966, months after the United States had ordered troops to Vietnam, the CIA's Photo Intelligence Division[396] produced a training film

[393] Brugioni, *Eyeball to Eyeball*, 230.

[394] Brugioni, *Eyeball to Eyeball*, 230.

[395] Dino Brugioni, "CNN's The Cold War Series: Interview with Dino Brugioni," in National Security Archive, George Washington University, https://nsarchive2.gwu.edu/coldwar/interviews/episode-10/brugioni1.html.

[396] This group within the CIA went through several name changes—the Photo Intelligence Division, Project HTAUTOMAT, the Photo Intelligence Center, and the National Photographic Interpretation Center. It also was sometimes jointly managed between the CIA and Department of Defense, though the CIA was its longstanding home in the mid-century. Today the group resides within the National Geospatial-Intelligence Agency, a division within the Department of Defense. For consistency, I will refer to the unit as the Photo Intelligence Division or Photo Division.

for the Navy titled "The Integrated Operational Intelligence System: The Photo Interpretation Station."[397] Much of the film depicts processes that our foregoing historical references have made evident. A recurring image reveals two CIA-employed interpreters at work at a towering electronic viewing unit. Occupying the screens before them are two scaled-up aerial pictures, notable for their bright yellow-green tint that contrasts with the otherwise beige color scheme of the surrounding apparatus, operators, and room. Positioned behind the two men and parallel to the screens that hold their gaze, the camera unwittingly registers the mise en abyme that is photo intelligence work. We punch in, and observe the interpreter watch as his screen's crosshair zooms in on an aerially shot array of circular oil tanks, plotted across a nondescript field. The abstract objects form a network that we seem to be entering as the operator continues to zoom. The interpreters' eyes pierce these depthless projected images as if penetrating the abyss within them. From their modest position engulfed by technology, the men appear to be constructing a world in vain, one that otherwise fails to cohere on the picture plane.

In descriptions of workflows, the film depicts operators and machines searching for (and extracting from photographic frames) oil drums, emitter sites, and military installations, and then establishing the circulatory relations among these discrete objects in disparate locations. The interpreters then correlate those relations with the U.S.'s own reconnaissance flight paths, building out the distributed system map with a reflexive bent. This interpretive project of object recognition both decontextualizes manufactured things from surrounding landmasses and recontextualizes them, building out a remotely-sensed, object-based networked environment. We cut to a close-up, aerial-view shot of an automated digital plotting device marking a map with symbols of objects detected in photographs. The film exposes the conditions that make vision automatable, and therefore that make the perceivable world adhere to an automated way of seeing. The resulting visual patterns officers discern resemble the division's own distributed organization and its interpretive schemes.

Another recurring visual motif is a graphical network diagram that conveys that how neurally inspired sequences for executing photo interpretation had been mapped onto the photo division's distributed web of photo interpreter experts, electronic devices, and magnetic-tape computing programs. A voiceover narrator guides us through these sequences: "[With] automation, this station … helps the operator convert raw data into useful intelligence much more rapidly than he previously could." The film takes a double posture with respect to the roles of humans and machines in the making of image intelligence. On one hand, the expository presentation conveys the immense scope of the division's electronics setup and processing power. Even the converters modulating electrical signals between devices get their time in the

[397] CIA Staff, "Integrated Operational Intelligence System: Photo Interpretation Station," *National Archives Digital Collection*, Record Group 330: "Records of the Office of the Secretary of Defense, 1921–2008," Series: "Motion Picture Films and Video Recordings of Five Decades of U.S. Military Activities Around the World, 1950–2000)," https://catalog.archives.gov/id/733841. Note, the film's title seems to contradict the internal CIA report's explanation that the photo division had by this time changed the description of its activities from "intelligence" to "interpretation." The reason for the use of "intelligence" in the title, we can infer, is that the film was created by the CIA for an external entity, the Navy, and therefore describing the CIA's activities necessitates designating it as such. Internal documents betray political friction between the CIA and branches of the military during this period.

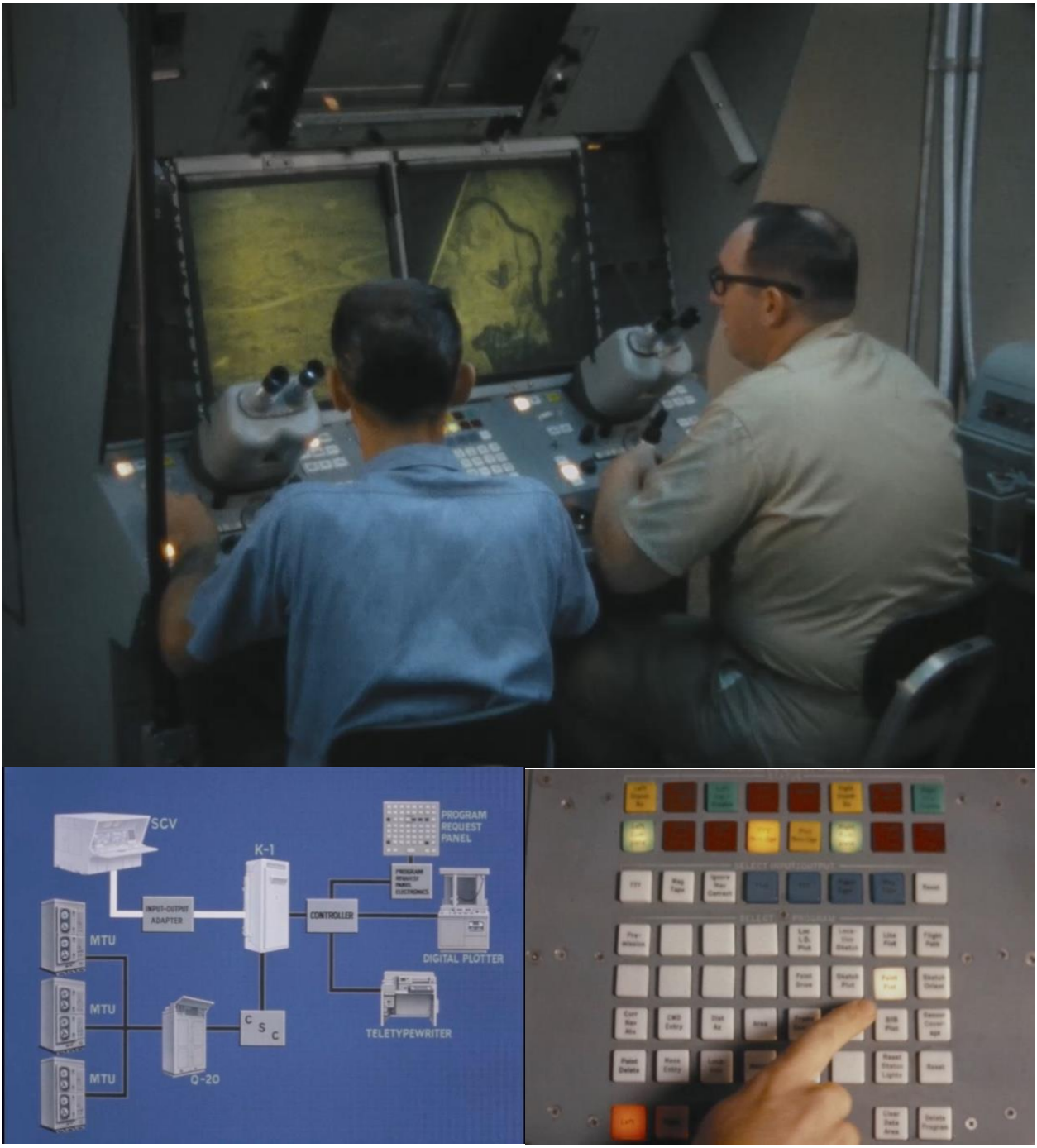


Figure 23: Stills from the CIA Photo Division image-interpretation film, produced for the Navy (1965). Source: National Archives Digital Records.

spotlight. The human operator is but one node in an expansive technical system. On the other hand, the film ends with a statement of overt reassurance to its naval-operative audience regarding the safeguarding of human perceptual and cognitive faculties from machine-replacement: "the computer, of course, can't make decisions," and "those decisions, and utilization of accumulative [interpretive] experience, continue to be the responsibility of the men."[398]

But even as this concluding message promises that human operators are the evaluative engines behind military intelligence, the film lays bare the many ways in which these operators' experiential and evaluative capacities are conditioned by the system, its input/output options, and the bounds of the aerial photographic frame. The film registers the very mechanisms by which the CIA had patterned human visual perception itself and made it into a reliable procedure. The CIA had reorganized vision as such to implicitly pledge that the scope of what could be optically encountered in the future had already been accounted for by the netlike interpretive system itself. It implicitly shows how, in turn, that procedure pre-determined what was and was not perceptible. The movie does not simply show the CIA's "integrated operational intelligence system," but stages the conceptual knots generated by *the integration of human operators into an automated system* for the purposes of producing consequential visual recognitions.

PATTERN OF LIFE, OUT OF CONTEXT

On April 26, 2017, the US Department of Defense publicly announced Project Maven, an initiative to integrate computer vision and other AI technologies into military intelligence and targeting procedures at an unprecedented scale. The Deputy Defense Secretary Bob Work stated in a memo that the objective of Project Maven was "to turn the enormous volume of data available to DoD into actionable intelligence and insights at speed."[399] The first task would be "to field technology to augment or automate Processing, Exploitation, and Dissemination (PED) for tactical Unmanned Aerial System (UAS) and Mid-Altitude Full-Motion Video (FMV) in support of the Defeat-ISIS campaign." PED is a set of rigidly defined steps for turning streams of image-based data into "meaningful" patterns such as identifying a suspicious-seeming object or structure on a landscape. It is a practice traditionally undertaken by the Pentagon and removed from combat targeting cycles, and the DoD memo indicated it had to date been performed by human analysts. In the year 2017, the U.S. military's Central Command collected a record 700,000 hours of full-motion video—or, eighty years—most of it captured by unmanned aircrafts hovering over the Middle East.[400] Project Maven, the memo informed, would "reduce the human factors burden of FMV analysis … and enhance military decision-making."[401] Deputy Work's call to automate video analysis in fact translated to a very specific charge: the DoD was to train

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[398] CIA Staff, "Integrated Operational Intelligence System." Note: This statement is, at best, misleading. The photo division did by the early 1960s employ computers to discriminate patterns in aerial photos and make evaluations.

[399] Bob Work (Deputy Secretary of Defense), "Establishment of an Algorithmic Warfare Cross-Functional Team (Project Maven)," Department of Defense Memorandum, April 26, 2017.

[400] Richard Shultz and Richard Clarke, "Big Data at War: Special Operations Forces, Project Maven, and Twenty-First Century Warfare," Modern War Institute at West Point, https://mwi.usma.edu/big-data-at-war-special-operations-forces-project-maven-and-twenty-first-century-warfare/.

[401] Work, "Establishment…"

computer vision algorithms to recognize "'38 classes of objects that represent the kinds of things the department needs to detect,'"[402] and to produce targeting alerts whenever one of them appears in an aerial vehicle's video feed.

Computer vision systems, the DoD missive claimed, can dramatically diminish the temporal gap between visual sensing and tactical action. The duration of that gap is contingent upon the speed of video analysis and the degree to which PED is more thoroughly integrated with active targeting cycles. Military scholars Richard Schultz and Richard Clarke state that PED had been moving closer to combat activities since the mid-2000s, and that Project Maven would further support real-time targeting.[403] Secretary Work presented the problem as one of scale in data accumulation and of speed, for which the automation of visual analysis was the logical solution. Implicit in the message, however, is a conception of visual perception that is synonymous with pattern recognition—a task-based and repeatable procedure whose utility is determined by its capacity to direct immediate military action. It suggests that humans and machines are interchangeable sensing and processing 'units' imbricated in an increasingly compressed "find, fix, and finish"[404] targeting cycle. Though the Department of Defense had made no comments regarding the extent to which Project Maven's computer vision activities informed the recent strike in Kabul, General McKenzie's statement and the *New York Times* reporting speak the language of object detection and pattern recognition promulgated by the Project Maven public announcement.

On August 29, 2021, two days before the U.S. military was to withdraw troops from Afghanistan, the Pentagon announced that the U.S. had carried out a drone strike in Kabul. According to the U.S. Central Command, as reported by the *New York Times*, "the strike … eliminated an imminent threat to Hamid Karzai International Airport from the Islamic State Khorasan group."[405] In the days that followed, a stream of reports broke that the U.S.'s decision to strike was based on erroneous intelligence and that operatives had misinterpreted the activities of a civilian for those of an ISIS-K suicide bomber. The misidentified target was Zemari Ahmadi, an engineer for a U.S.-based aid organization with no ties to ISIS-K; the blast had killed him and nine civilians, seven of them children. In a showdown of investigative and image forensic analysis between the Pentagon and the *New York Times*, the newspaper eventually reported on September 17 General Kenneth McKenzie's admission that, "'We did not have the luxury to develop pattern of life.'"[406] The U.S. combat team was piecing this evidence together, analyzing video footage, and operating the unmanned aerial vehicle from over 1,000 miles away in the United Arab Emirates. The pattern it did discern: The military mistook the white Toyota Corolla Ahmadi drove for a white Toyota Corolla understood to be in the possession of members of ISIS-

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[402] Cheryl Pellerin, "Project Maven to Deploy Computer Algorithms to War Zone by Year's End," *DoD News*, July 21, 2017, https://www.defense.gov/News/News-Stories/Article/Article/1254719/project-maven-to-deploy-computer-algorithms-to-war-zone-by-years-end/, citing Col. Drew Cukor.

[403] Shultz and Clarke, "Big Data…" Also, see Katherine Chandler, *Unmanning*.

[404] Shultz and Clarke, "Big Data…"

[405] Helene Cooper and Eric Schmitt, "U.S. Strike Explosive-Laden Vehicle in Kabul," *The New York Times,* August 29, 2021, https://www.nytimes.com/2021/08/29/us/politics/us-strike-kabul-airport.html.

[406] Eric Schmitt and Helene Cooper. "Pentagon Acknowledges Aug. 29 drone strike in Afghanistan was a tragic mistake that killed 10 civilians," September 17, 2021, https://www.nytimes.com/2021/09/17/us/politics/pentagon-drone-strike-afghanistan.html.

K. Operatives mistook the residence of Ahmadi's boss, which Ahmadi visited, to be an ISIS-K safehouse which is apparently a few doors away. The large water jugs Ahmadi loaded into his trunk registered to U.S. military analysts as explosive devices. The Pentagon's explanation and the *New York Time*s's reporting detail a number of additional instances of object misidentification and pattern misrecognition.[407] The language of military err mirrors the language of supposed military targeting success. General McKenzie's logic suggests that the egregious killing of Ahmadi and his family was the result of insufficient aerial video data, which spelled but a patchwork pattern. Taken for granted by both the Pentagon and the *New York Times* reporters, pattern recognition in the form of object detection from a bird's eye view is the assumed surefire method for making military intelligence and informing attacks. Their inane, trite question: does this video data bear the "luxury" of pattern of life?

CONCLUSION: ACCELERATING RECOGNITION

In his 2014 memoir, *My Share of the Task*, military general Stanley McChrystal describes a phenomenon called "the 'blink' problem," encountered by his team in the Iraq War.[408] "A blink was anything that slowed or degraded the [targeting] process, which often involved a half dozen or more units . . . working in as many locations," McChrystal explains. "'By the time we're ready to go after another target, . . . it's often days later, the situation has changed, and we're essentially starting from square one.'"[409] The targeting process McChrystal had inherited went like this: the operatives would identify an anomaly in aerial video or photographic footage and pass this information to intelligence groups that would analyze it against existing image intelligence and verify its status as a target; only then would the tactical teams be authorized to act. The term *blink problem*, then, is a misnomer. Given these operational details, the phenomenon figuratively refers not to the autonomic motion of the eyelid that interrupts the temporal flow of visual sensation but to the timescale of the analytical and discursive activity of decision-making. The blink-problem label conveniently covers up this politically fraught part of the process.

Isolating and defining the blink problem as such and characterizing it as an equally organizational and technical issue legitimized the military's subsequent move to, quite momentously, collapse two defense groups—active targeting and intelligence making—that previously were strategically separated in the name of accuracy and prudence. In addition to easing the integration of algorithmic tools into both groups' workflows, this human/machine resource reorganization enabled the reconfiguring of the targeting cycle. This new circuit of operations was termed the "find, fix, finish, exploit, analyze" targeting cycle, or F3EA.[410] Instead of the original perception-analysis-action sequence, defense institutions would embrace a

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[407] Eric Schmitt, "A Botched Drone Strike in Kabul Started With the Wrong Car," *The New York Times*, September 21, 2021, https://www.nytimes.com/2021/09/21/us/politics/drone-strike-kabul.html.

[408] Stanley McChrystal, *My Share of the Task* (New York: Portfolio, 2013), 154.

[409] McChrystal, 154, quoting then-Colonel Bennet Sacolick, with whom McChrystal collaborated on an adaptation of the targeting cycle.

[410] McChrystal, 153–157. See also Richard Shultz and Richard Clarke, "Big Data at War: Special Operations Forces, Project Maven, and Twenty-First Century Warfare," Modern War Institute at West Point, August 25, 2020, https://mwi.westpoint.edu/big-data-at-war-special-operations-forces-project-maven-and-twenty-first-century-warfare/.

perception-action-analysis sequence. No more blinking, just reflection after the targeted attack and future-casting before the next go round.

But what if blinking is a virtue? In Gibson's later theoretical work, the physiological blink is an orienting mechanism just as is the physical horizon line. The horizon mediates between the co-constituting entities of ground and air; the blink mediates between perceptual experience and physical object.[411] In interrupting the sensory flow, the blink enables one to sense the co-constitution and also the difference between the two, denaturalizing its own spatial and temporal rules for perceptual attention. The blink, that is, is the body's way of recognizing recognition itself.

[411] Gibson, *Ecological Approach to Visual Perception*, 216.

—Chapter 04—

Environments: Programmatic Reduction, Sensory Selection, and Recognizing Novelty

In 2014, Tesla introduced its self-driving system, called Autopilot, and as of 2023 it offered a pre-release beta suite of "Full Self Driving" features. The driverless capabilities are enabled by its Tesla Vision system: eight cameras covering 360 degrees and hundreds of meters of visual range as well as a neural-network based system for interpreting and reacting to the visual data in real time.[412] According to the company's website, Tesla Vision "provides a view of the world that a driver alone cannot access, seeing … on wavelengths that go far beyond the human senses." This means that the vehicle can, theoretically, "navigate more complex" roads, parking lots, urban intersections, and freeways, because it "deconstructs the car's environment at greater levels of reliability" than non-AI techniques and people alike.[413] But this picture of machine autonomy is not so seamless. The Tesla user manual outlines a number of conditions that Full Self-Driving is not equipped to handle, from "narrow roads with oncoming cars," "winding roads with sharp curves," and "roads where traffic conditions are constantly changing and where bicycles and pedestrians are present." Lane markings and roads signs must be unambiguous and in clear view.[414] So while the website boasts that the Tesla has access to *more* sensory data than an embodied driver would, the user manual conveys that it in fact can apprehend *fewer*, or a narrower range of, features within its environment. But this is not just a problem of quantity, addressed through the Autopilot neural network's exposure to a greater number of pre-defined objects and events through training. The self-driving apparatus imposes demands on its environments that there be *less ambiguity* within driving conditions than a human driver would safely be able to navigate.

This necessity is latent in the company's response to a 2023 fatal crash involving Autopilot Full Self-Driving, in which CEO Elon Musk stated that, "We test as much as possible in simulation … but reality is much more complex."[415] Within computer science and

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[412] Andrej Karpathy (AI scientist at Tesla), "Workshop on Autonomous Driving," *Conference on Computer Vision and Pattern Recognition* (2021), https://www.youtube.com/watch?v=eOL_rCK59ZI&t=28286s. See also Ben Dickson, "Tesla AI chief explains why self-driving cars don't need lidar," *Tech Talks* (June 28, 2021), https://bdtechtalks.com/2021/06/28/tesla-computer-vision-autonomous-driving/.

[413] *Tesla,* "Future of Driving," https://www.tesla.com/autopilot, accessed July 20, 2024.

[414] *Tesla Model S Owner's Manual 2021+*, https://www.tesla.com/ownersmanual/models/en_us/Owners_Manual.pdf, 129. The manual is also available on the owner's manual website at: https://www.tesla.com/ownersmanual/models/en_us/GUID-E5FF5E84-6AAC-43E6-B7ED-EC1E9AEB17B7.html.

[415] As reported in: Trisha Thadani et al., "Tesla worker killed in fiery crash may be first 'Full Self-Driving' Fatality," *The Washington Post,* February 13, 2024, https://www.washingtonpost.com/technology/interactive/2024/tesla-full-self-driving-fatal-crash/. It is worth noting that complexity has a specific meaning in mathematics that is at odds with the

mathematics, complexity is understood as "a measure of the difficulty of solving a class of problem, as measured by the expected number of computational steps required to do so using an algorithm."[416] According to this logic, the richness of features and events in the natural surroundings needs to be mirrored by the robustness of computing power, neural net connections and layers, and training. A sort of Moore's law problem. Some in the autonomous vehicle (AV) community have argued that driverless cars will be more successful if we route human drivers and AVs along separate roads. After all, people are a big part of what makes roads unpredictable. While this may prove expedient as an industry and infrastructural problem-solving initiative, the broader field of Artificial Intelligence is working from the collective understanding that intelligence *is* the capability to perceive and act, safely and reasonably, in unpredictable situations.[417] Probability theory is developers' means for closing the gap between "perfect rationality" and environmental complexity that would otherwise demand too much computing power to perceive and cognize with absolute certainty.[418] What Tesla Vision seems to alert us to, however, is a sort of incompatibility between pure rationality and non-simulated situations. Human drivers tend to not have total perceptual certainty about their surroundings, and they need not have it to exhibit what cognitive scientists call commonsense reasoning. But the machine must close the gap, to bring the so-called environment into its rationalizing fold. AI systems, no doubt running highly sophisticated programs, therefore produce remarkably deficient conceptions of an *environment*. This is a problem outside the realm of Moore's law, and therefore outside a teleological understanding of technical and historical development. Nonetheless, it is a conceptual issue that animates the history of artificial intelligence.

These considerations fit within a broader debate among philosophers and historians of technology today that, in approaching the problems raised by artificial intelligence, emphasizes a dialectic between the realms of experience, on one hand, and mathematical rationality, on the other.[419] This theoretical stance, too, has a history that is itself entwined with the field of AI. In

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notion of environmental complexity Musk refers to here, which really implies unpredictability. OED for "computational complexity" (an addition made in 1997): ""A measure of the difficulty of solving a class of problem, as measured by the expected number of computational steps required to do so using an algorithm," https://www.oed.com/dictionary/complexity_n?tab=meaning_and_use#8836124.

[416] Oxford English Dictionary, "complexity": https://www.oed.com/dictionary/complexity_n?tab=meaning_and_use#8836124

[417] See Stuart Russell and Peter Norvig, *Artificial Intelligence: A Modern Approach, Fourth Edition* (Hoboken, NJ: Pearson, 2021), 37. There is a shift in emphasis between this textbook's first edition, published in 1995, and this most recent edition. The overall structure of the textbook has changed to add emphasis to the (complexity of) the task environment and the uncertainty therein.

[418] Russell and Norvig, *Artificial Intelligence,* 38.

[419] See [419] Orit Halpern, *Beautiful Data* (Durham, NC: Duke, 2014); Orit Halpern, Patrick Jagoda, Jeffrey West Kirkwood, and Lief Weatherby, "Surplus Data: An Introduction," *Critical Inquiry* 48, no. 2 (Winter 2022): 197–210; Orit Halpern, "The Future Will Not Be Calculated: Neural Nets, Neoliberalism, and Reactionary Politics," *Critical Inquiry* 48, no. 2 (Winter 2022): 334–359, 335; Adrian Mackenzie and Anna Munster, "Platform Seeing: Image Ensembles and Their Invisualities," *Theory, Culture & Society* 36, no. 5 (June 2019), https://doi-org.libproxy.berkeley.edu/10.1177/0263276419847508; Xiaochang Li, "The Measure of Meaning: Automatic Speech Recognition and the Human-Computer Imagination," in *Abstractions and Embodiments: New Histories of Computing and Society* (Baltimore, MD: Johns Hopkins University Press, 2022): 341–359. See also works that discuss the materiality of information, such as: N. Katherine Hayles, *How We Became Posthuman* (Chicago, U Chicago Press, 1999), Tiziana Terranova, *Network Culture* (London: Pluto Press, 2004). And finally, more recent works on the phenomenological discordances with digital media: Shane Denson, *Discorrelated Images* (Durham, NC: Duke, 2020); Mark B.N. Hansen,

1972 philosopher Hubert Dreyfus in *What Computers Can't Do* issued a phenomenology-informed polemic on AI researchers for operating under the assumption that "all knowledge and beliefs of an adult human being can be made explicit" by way of a "formal representation" in a computer model.[420] This approach, Dreyfus explained, operates according to the ultra-rigid—all or nothing—properties of the computer just as it, paradoxically, pursues the "flexible" quality of the human mind. The text ultimately argues that it is only "by virtue of having bodies" that are thoroughly embedded in sensorially rich environments, and that have a great degree of "ambiguity tolerance" in perceiving and making sense of those surroundings, that humans acquire understanding. And understanding is precedent to intelligence.[421]

And yet the neural network, unpopular at the time of Dreyfus's writing and therefore not much at issue in his critique, seems like it could pose a solution to this problem.[422] Instead of being primarily concerned with logic problems, like many early AI programs, the neural network acquired its capacity to make decisions through a process that approximated human perceptual experience. Not only does the neural net fundamentally assume environmental uncertainty, handling it through the use of probability theory, a model's initially indeterminate and open formal arrangement, which acquires structure as a result of its incorporating data, mimics the ambiguous and flexibly qualities of the human brain and, some argue, mind.[423] And yet moving about dynamic environments without needing to have determined absolute certainty about all of their contents (e.g., exhibiting ambiguity tolerance or commonsense reasoning), remains problematic—existentially so—for today's machines but is quite intuitive for people. In other words, humans, and perhaps other organic creatures, appear to largely *exist in the gap* between perfect rationality and a form of environmental complexity that is unruly, resistant to total mathematical rationalization. What do embodied perception and the thought it affords do, if not close this gap?

I would like to address this question—a philosophical, humanistic one—by digging into debates within the history of AI itself, before the discipline knew explicitly what it was trying to solve for and before its technical experimentations had an immediately obvious and useful application. It was within this intellectual milieu, in the later 1950s and early 1960s, that computer scientist Oliver Selfridge and cognitive psychologist Ulric Neisser developed the Pandemonium computer architecture, a model approximating visual interpretation and pattern

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Feed Forward: On the Future of twenty-first-century media (Chicago: U Chicago Press, 2015); and N. Katherine Hayles, *Unthought: The Power of the Cognitive Nonconscious* (Chicago: U Chicago Press, 2017.

[420] Hubert Dreyfus, *What Computers Still Can't Do: A Critique of Artificial Reason* (Cambridge, MA: MIT Press, 1992). In these quotes, Dreyfus is synthesizing his argument from the 1972 edition of the book.

[421] Hubert Dreyfus, *What Computers Can't Do* (New York: Harper & Row, 1972, 19.

[422] A primary target of Dreyfus's book is Marvin Minsky, who in 1968 authored, with Seymor Papert, a consequential critique of Frank Rosenblatt's Perceptron for its incapacity to thoroughly make conceptual generalizations from sensor-based input data. Marvin Minsky and Seymour Papert, *Perceptrons* (Cambridge, MA: MIT Press, 2017 [1969]).

[423] Underlying many of the currents in artificial general intelligence research is the neuroscience "digital brain" movement. See "The coming decade of digital brain research: A vision for neuroscience at the intersection of technology and computing," in *Imagine Neuroscience* 2 (2024), 1–35. For a critique of conceptions of a "digital brain," see David W. Bates, *An Artificial History of Natural Intelligence: Thinking with Machines from Descartes to the Digital Age* (Chicago: U Chicago Press, 2024).

recognition.[424] The underlying conceit behind the work was that, in everyday situations, "ill-defined categories" of visual stimulation "are the rule, not the exception."[425] In this sense, the Pandemonium was addressing something of an aporia. On one hand, this "brain" model presumably needs to have some precedent ability to recognize *some* patterns, but it is inconceivable that it can be pre-programmed with every possible shape or object variation. What degree of "innate" structure does the central processing unit have? On the other hand, if the "brain" has no initial structure and acquires it entirely through sense impressions, as does a neural net model, where does the capacity to generalize perceptual information come from? Neural network theory might address it with the presumption that the model needs more training, more encounters with X object, and more layers. Neisser was dissatisfied with this answer, on empirical grounds. In everyday situations, we witness a strong distinction between how short- and long-term memory are exercised. Commonsense reasoning may involve some trafficking between the two but arises largely from the former, responding to in-the-moment sensory experience and feeding back into immediate motor behavior like changing retinal focus or moving the head and one's frame of reference. Counterintuitively, one crucial premise for the Pandemonium architecture was that a model's higher-order conceptual activity is contingent on having perceptual access—via these sensorimotor activities—to environmental phenomena it cannot conceive of in advance. And yet it also had to have *enough* initial structure to mediate, back and forth, between the realms of the superfluous and the finite. According to Neisser's thinking, if a model only moved in one direction, from excess to parsed, it would increasingly lose the capacity to encounter something unexpected and to recognize it as such. It would lose access to novelty.

When one perceives something unfamiliar, or has a creative idea or makes a discovery, there are two things going on, in my reading of Neisser. There is the intrinsic content of the percept or concept, on one hand, and then there is the necessary step of identifying it to be truly singular, standing apart from that which has been sensed or cognized before. A great deal of perception research informing early computing research had in fact dealt with the opposite issue—the Gestalt psychology occupation with the phenomenon of perceptual constancy.[426]

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[424] See a description of the pandemonium architecture in Oliver Selfridge and Ulric Neisser, "Pattern Recognition by Machine," in *Computers and Thought*, edited by Edward Feigenbaum and Julian Feldman (Malabar, FL: Robert Krieger Publishing, 1961): 237–250.

[425] Neisser, *Cognitive Psychology*, 58. In 1961 Marvin Minsky coined the term "well-defined problems," as the necessity for artificial intelligence successes. This was a consequential concept, as it contributed to the turn away from "perceptron" neural networks and toward expert systems with more narrowly defined goals and cognitive models. Several contemporaries of Minsky in AI, and in particular in pattern recognition research, took an interest in explicitly "ill-defined" problems, systems, perceptual and conceptual means of categorization, etc. This was concurrent with the rise of fuzzy logic in mathematics (conceived by Lofti A. Zadeh; see Daniel McNeill and Paul Freiberger, *Fuzzy Logic: The Discovery of a Revolutionary Computer Technology—And How It Is Changing Our World* (New York: Simon & Schuster, 1993), which took an approach distinct from probabilistic reasoning (according to which artificial neural networks are based; a probabilistic approach to AI based on Bayesian networks (belief propagation) was introduced by Judea Pearl, profiled by the A.M. Turing Awards, https://amturing.acm.org/award_winners/pearl_2658896.cfm). The underlying assumption of probability theory is that uncertainty is a property of the reasoning agent, whereas in fuzzy logic the assumption is that uncertainty is inherent in the environment itself (on this topic, see Stuart Russell and Peter Norvig, *Artificial Intelligence*, 116). Neisser's cognitive psychology, based in empirical and phenomenological principles and not exclusively mathematics, sought out the relationship between perceptual selection and environmental complexity (or uncertainty).

[426] See in particular Max Wertheimer's "Experimental Studies on Motion Vision" (1912). In the next generation, James J. Gibson would take up the issue of perceptual constancy in *Perception of the Visual World* (1950)—for an analysis of

Humans, and other animals with complex vision systems, perceive while in constant motion. A single, unmoving external object nonetheless gets apprehended by way of sequential sensory impressions on the subject's eye, each retinal "snapshot" is different (or, in a way, novel), as a factor of movements of the eye, the head, and the body. How, then, do we generalize—or, translate superfluous sense data into determinate, structural percepts and their respective concepts? The assumption here is that the charge of the brain and the mind is to take the ambiguous, the superfluous, and *reduce* it to produce perceptual clarity and well-reasoned thought. Much of the early work in computational pattern recognition, by Norbert Wiener, Warren McCulloch, and Walter Pitts, follows within this conceptual framework. And if we read the Pandemonium architecture exclusively through the lens of Oliver Selfridge's conceptual approach, we too find that making sense of an environment means a process of environmental complexity reduction. What remained unsatisfied by these approaches, with respect to the realm of the ambiguous pattern, was how something could be identified *as* as-yet unseen or unknown.

In what follows, I trace Ulric Neisser's alternative vision for the Pandemonium, which I show for him served as a heuristic for in fact theorizing about aspects of human vision and memory that were fundamentally not amenable to computer modeling. The Pandemonium was particularly suited for handling ambiguous and multiplicitous visual inputs, and for doing so via parallel processing—what for Neisser was a nod toward people's seeming ability to see and think more than one thing at once, if not everything to the same degree of focus. He took an interest in empirical work on ambiguous figures, such as the famed Gestalt Peter-Paul Goblet, and in this way was drawing on a different, even oppositional, aspect of Gestalt psychology.[427] How is it that one visual pattern, perceived by one single subject who stands still before it, thus maintaining a relatively static perspective, can at one moment see a face and the next see a goblet? This phenomenon, for Neisser, opened out onto a number of scenarios that involved much more than a binary choice. But the point here is that for Neisser perception and thought must include a way of going from one to many, from finite to indefinite, from certain to ambiguous and back again. In other words, of facilitating between perfect rationality to contextual complexity. If a fundamental pattern-recognition activity was, for Selfridge and neurophysiologist and computer scientist colleagues, *reduction*, for Neisser, as his 1960s and 1970s work shows, it was *selection.*

In 1963, Selfridge and Neisser co-authored a paper that appears to introduce the germ of Neisser's later research, and in fact departure from Selfridge's realm. In "Pattern Recognition by Machine," the two write that "machines are not well equipped to *select* from their environments the things, or the relations, they are going to think about."[428] This statement invites the inquiry, how do people make these selections? The very notion of perceptual selection has many implications. First, that there is some active step—the motor activity of *looking at*—that is precedent or primordial to a process of figure-ground, or object-based, segmentation and

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Gibson's empirical studies and theoretical explanations on this topic, see Chapter 3 of this dissertation, "Objects: Nonhuman Targeting, Perceptrons, and Ecological Perception."

[427] Also called Rubin's vase, developed by Danish psychologist Edgar Rubin. The Gestalt psychologist's took up this figure as an exemplar of the principle of figure/ground. See: Max Wertheimer, *On Perceived Motion and Figural Organization* (Cambrdige, MA: MIT Press, 2012) (features "Experimental Studies on Seeing Motion" (1912); Wolfgang Köhler, *Gestalt Psychology* (New York: New American Library, 1947 [1929]); Kurt Koffka, *Principles of Gestalt Psychology* (New York: Harcourt Brace Janovich, 1935).

[428] Neisser and Selfridge, "Pattern Recognition by Machine," in *Computers and Thought*, 237, my emphasis. "Very often the basis of classification is unknown, even to [the individual]," 237.

therefore apprehension of that object. Second, it suggests that the perceiver already understands that there is more, or different, information that could alternatively be the object of attention. In other words, she is aware of the possibility of *looking elsewhere*; she could potentially see that the ground could be the figure and the figure could be the ground and therefore could, simultaneously, unfix otherwise determinate perceptual categories. Third, it points to a paradoxical quality of the process of selection, as it factors in the time-based act of perception. Selection must happen before the "recognizing" of an object, and therefore close—in time and space—to the sensorial plane, often conceived as an autonomic (and somewhat automatic) process. And yet, selection is also an act of reason, will, or desire—those processes tending to draw a great deal of input from memory and therefore with great remove from sensation. This suggests that, within Neisser's frame, the capacity to apprehend environmental complexity—or those activities handled by the preattentive processes—is closely linked with an ability to think and act with complexity.

In what follows I read these many attempts at solving for perceptual and ideational novelty—as a means for handling environmental uncertainty, and thus the capacity for creativity, discovery, and everyday commonsense reasoning that its apprehension makes possible. My examination of Neisser's empirically grounded philosophical claims, which offer a studied critique of neural network theories, is not an evaluation or endorsement of his work on scientific grounds. Rather, I see Neisser's research endeavors, which spanned decades and evolved in their own right, as identifying some of the most essential conceptual problems for which AI computer models were designed to solve and which they were instead missing. In this very gap is revealed certain exceptions of biological, and socially and aesthetically situated, perception and cognition. A Dreyfus approach to the contemporary technical condition would prompt us to evaluate *what today's AI's still can't do*. But that question in itself involves a gross assumption—we might instead ask, *what is the "what" we even should be talking about?* In a technical culture launching toward "AGI" and increasingly "autonomous" nonhuman systems, we are prompted to articulate the complexity of this question with newfound urgency. A purposeful journey through Neisser's research helps us address the inquiry with attention to a dialectic between clarity and that which resists rational definition, and with an appreciation for the intellectual resources afforded by sensory abundance and perceptual ambiguity.

WEINER AND ASSOCIATIONISM

In his final chapter of his 1967 monograph *Cognitive Psychology*, Niesser proposes a theory of human memory and thought. He says, "given the fact that information about the past is somehow preserved, it is important to ask what aspects of experience are stored, how the stored information is organized, how and why it is recovered, and by whom."[429] Neisser's choice of metaphors is quite overtly informed by computer technology, but I offer that he was far less interested in subsuming human memory to a machine program and most interested in dispelling a common existing metaphor—the trace, or association. Established by the British empiricist philosophers, such as John Locke and Stuart Mill, associationism had been embraced by cyberneticist Norbert Wiener as a basis for formal modeling.

Within this tradition, there is a direct relationship between past sensations and present ideas. According to Wiener's reading of Locke,

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[429] Ulric Neisser, *Cognitive Psychology* (Englewood Cliffs, NJ: Prentice Hall, 1967), 281.

> the content of the mind was considered to be made up of certain entities known … as ideas…. The simple ideas or impressions were supposed to exist in a purely *passive* mind, as free from influence on the ideas it contained as a clean blackboard is on the symbols which may be written on it. By some sort of inner activity, hardly worthy to be called a force, these ideas were supposed to unite themselves into bundles, according to the principles of similarity, contiguity, and cause and effect.[430]

This associative understanding of mental organization informs Wiener's approach to formally modeling intelligent activities in the computer. And in particular, he draws on Locke's notion of similarity for processes of perception. Locke's principle of similarity, on Wiener's reading, describes the process through which one connects a stimulus impression of a form with a conceptual category. In Locke's realm, these associations are not subject to the physical laws of time and space; by making them so, Wiener hypothesizes, he could account for the *dynamic* qualities of perception of thought. Therefore, Wiener sought both to materialize Locke's philosophical framework and, in producing a computer model, in fact update that very philosophy of mind to better align with twenty-first-century physics, neurophysiology, and electrical engineering.

Neisser identifies a fundamental problem here. Given his psychology bent, we might assume Neisser would directly critique the computational nature of Wiener here. It is in fact the underlying associationism philosophy—or what he calls the "Reappearance Hypothesis"—to which Neisser takes issue:

> This assumption is so ingrained in our thinking that we rarely notice how poorly it fits experience. If Reappearance were really the governing principle of mental life, repetition of earlier acts or thoughts should be the natural thing, and variation the exception. In fact, the opposite is true. Precise repetition of any movement, any spoken sentence, or any sequence of thought is extremely difficult to achieve. When repetition does occur, as in dramatic acting … or a compulsive sequence of actions, we ascribe it either to long, highly motivated practice or to neurotic defensiveness.
>
> What *is* natural, on the contrary, is adaptive variation.[431]

In Neisser's view, adapting based on experience is contingent on constantly changing internal and external conditions. There can be no learning without circumstances that afford selection in both perception and thought.

NEUROPHYSIOLOGY AND SEQUENTIAL PERCEPTION

One of the most significant contributions of the Pandemonium architecture, with respect to pattern recognition, was its use of parallel processing, or multiple sub-programs that ran at once (see Figure 1). Neisser understood this qualitatively to mean that visual cognition involves processes that are spatially multiple, operationally multiple, and simultaneous. He would go on to test these hypotheses with human subjects in and out of the lab. The Pandemonium model, for him, was a formalized approximation in that it was a formalized hypothesis of perceptual

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[430] Norbert Wiener, *Cybernetics: Or Control and Communication in the Animal and the Machine* (Cambrdige, MA: MIT Press, 2019 [1948]), 174, my emphasis.

[431] Neisser, Cognitive Psychology, 282.

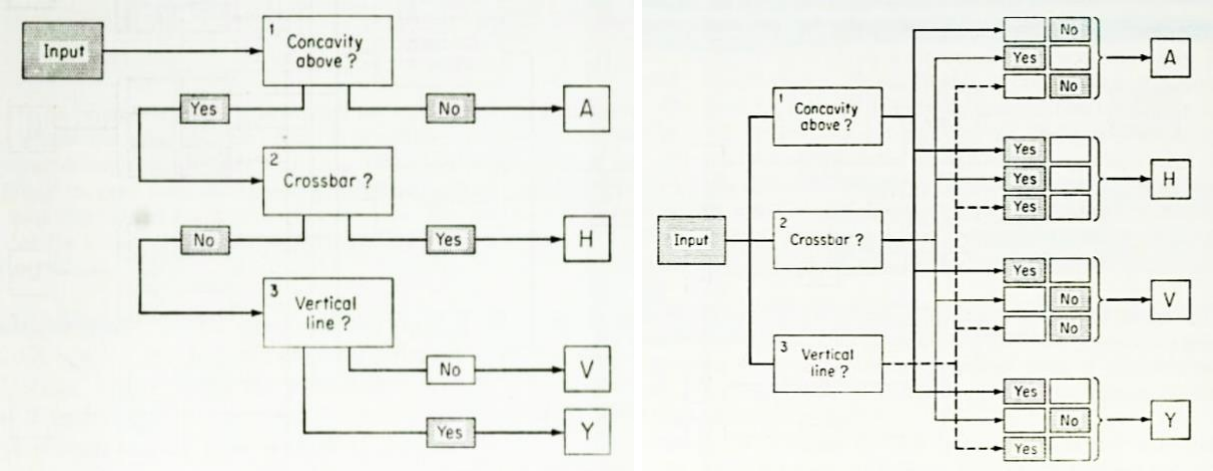


Figure 24: Left: Example of a sequential-processing program. Right: Example of the Pandemonium's parallel-processing program architecture. Source: Selfridge and Neisser, "Pattern Recognition by Machine," 245–246.

selection and, paradoxically, pointed toward the mind's non-automatable perceptual processes. Selfridge, on the other hand, saw his Pandemonium project existing within the lineage of the neurophysiology of Warren McCulloch and Walter Pitts, his colleagues at MIT. He understood models as approximations strictly because they could not reach the visual cortex's level of complexity in quantitative terms—the brain simply has so many neurons.[432] Within this view, Selfridge's addition of parallel processes follows in step with McCulloch and Pitts's original contribution, in their 1947 paper "How We Know Universals," of conceiving of perception as a time-based process through which *similarity* between an input form and a memory form could be recognized. They, along with Wiener, imagined this to be a sequential process.[433] Neisser would later critique the approach because of its conflation of processes of environmental selection and processes of similarity determination.

The Warren McCulloch and Walter Pitts model, discussed in the 1947 paper, was to perceive basic visual forms, or "useful common characters."[434] As the article title implies, the intention here was to focus on few forms with a high degree of categorical specificity. A square differs significantly from a triangle, which differs significantly from a circle. Like the duo's much cited 1943 paper, "A Logical Calculus of the Ideas Immanent in Nervous Activity," and its originary neural network model, "Universals" incorporated insights from information theory about mathematical operations for signal transformation with theories about the brain's neural connectivity and activity.[435] But much of the perceptual problem the model was solving came

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[432] See Oliver Selfridge, "An Interview with Oliver Selfridge," in *The Mechanical Mind in History* (MIT Press, 2008)

[433] Walter Pitts and Warren McCulloch, "How We Know Universals: The Perception of Auditory and Visual Forms," in *Bulletin of Mathematical Biophysics* 9 (1947): 127–147.

[434] Pitts and McCulloch, "How We Know Universals," 127.

[435] For the earlier paper, see: Warren McCulloch and Walter Pitts, "A Logical Calculus of the Ideas Immanent in Nervous Activity," Bulletin of Mathematical Biology 52, no. 1–2 (1943): 99–115. For an information theory reference, see: Claude Shannon, "A Mathematical Theory of Communication," *Bell System Technical Journal* (1948) and Norbert Wiener, *Cybernetics*. For a brain science reference, see: Ramón y Cajal, *Histologie du Système Nerveux* (1911) and *Die Sehrinde* (1900).

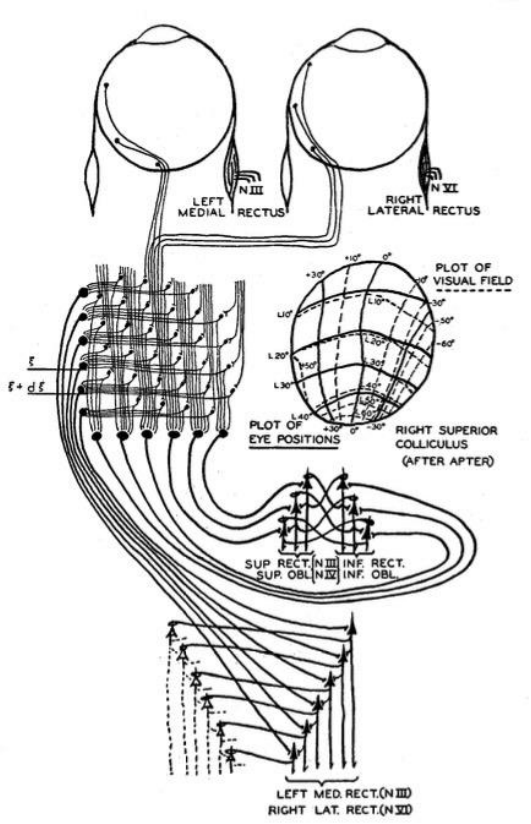


Figure 25: Pitts and McCulloch diagram of the occular flows that informed their computer model. Source: "How We Know Universals," p141.

from Gestalt psychology and its discussion of figural similarity. Unlike the Lockean concept, at issue here had much less to do with memory of long ago experiences and everything to do with how we perceive a form from split second to second. This localization of the problem, nonetheless, makes explicit some assumptions within the former. For example, how does a square continue to appear as a square to us, even as its size, rotation, orientation, or position within the retinal image changes quite significantly with the move of the head, body, object or any of the three. This is also known as the problem of perceptual constancy. The Gestalt psychologists used the "similarity" hypothesis, and McCulloch and Pitts adopted this assumption. But in order to model it they would need some sort of mathematical transformation of the retinal impression without changing the form so significantly that it no longer matched its shape category, or maintained its invariance.[436]

McCulloch and Pitts developed a model based on this assumption of "similarity."[437] Yet they were dubious about the Gestaltists' notion of "a figure being known" on account of "depicting it topographically on neuronal mosaics."[438] They argue that the mechanism of form perception is *not* represented spatially, as a copy, as the Gestaltists had presumed.[439] Instead, it is based on a series of mathematical operations that transform the shape, a retinal impression with *particular* spatial qualities and measurements, into a processual structure that matches a generalized template. That is, "the group-invariant spatio-temporal distribution of excitations which represents a figure need not resemble it in any simple way."[440] To model this, McCulloch and Pitts compute various properties of a given form as averages that could be both scalable and invariant (a square is still a square regardless of its size or orientation), a process called normalization. Further, they use the cybernetics principle of negative feedback, or of servo-mechanism, to perform a space-time transformation apt for

[436] Pitts and McCulloch, "How We Know Universals," 127. See also Neisser, *Cognitive Psychology*, 61–62.

[437] Neisser calls this "template matching." in *Cognitive Psychology*; Wiener, in *Cybernetics*, bases his notion of similarity on the Lockean principle of association.

[438] Pitts and McCulloch, "How We Know Universals," 137. See also the authors' explanation of "*the exchangeability of time and space*" on page 130.

[439] They also argue that the mechanism of form perception is not linguistic, as was assumed by the nineteenth-century empirical neurologists, such as John Hughlings Jackson. Pitts and McCulloch, "How We Know Universals," 137.

[440] Pitts and McCulloch, "How We Know Universals," 136.

translating a shape-based percept into a neural trace. They conceive of this process as analogical to motor processes and term it "reflex mechanisms":

> Consider the reflex-arc from the eyes through the tectum to the oculomotor nuclei and so to the muscles which direct the gaze. We propose that the superior colliculus computes by double integration the lateral and vertical coordinates of the 'center of gravity of the distribution of brightness' referred to the point of fixation as origin… As the center of gravity approaches the origin, its ordinate and abscissa diminish, slowing the eyes and finally stopping them when the visual axes point at the 'center of brightness.' This provides the invariants of translation. If a square should appear anywhere in the field, the eyes turn until it is centered, and what they see is the same, whatever the initial position of the square.[441]

Because what is remembered as a universal form is not a representational copy of the square inside the visual cortex, visual memory and therefore the capacity to identify similarity in visual forms is associated with the time-based trace itself. The memory is not the form but the *structure of the process* of recognizing a square as a square: "These procedures are a systematic development of the conception of reverberating neuronal chains, which themselves, in preserving the sequence of events while forgetting their time of happening, are abstracted universals of a kind."[442]

In *Cognitive Psychology*, Neisser is dubious of this, what he calls "template theory," because even as it conceives of perception as time-based, it tends of conflate steps in the process that to him seem distinct.[443] Building Neisser's critique of associationism, we can question that in the McCulloch and Pitts model there seems to be no difference between perceptual constancy through reflex motions, a very localized time period, and fixed long-term memory within which "universals" remain through extended periods of time. Another way to say this is that the model collapses visual normalization and visual memory. In other words, it collapses an activity metaphorically associated with the reflex motion of the head and eye muscles with a supposedly mind- or brain-based activity of recalling past experience. Even while it is a notably active process compared to something like that of Locke, the perceptual process elaborated by Pitts and McCulloch nonetheless conceptualizes higher levels of visual understanding as having the same reflex-based response to an environment.[444] The model seeks out the "'center of gravity of the distribution of brightness,'" but it does so blindly. In doing so, it elides Neisser's important step of perceptual selection.[445]

Norbert Wiener would take this assumption as the foundation for his own theorization of form perception as an informatic process in *Cybernetics*, published a year later. Wiener drew from McCulloch and Pitts the importance of the space-time transformation and of normalization

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[441] Pitts and McCulloch, "How We Know Universals," 137. See also, Wiener, *Cybernetics*: "the eye-muscle feedback in man" (184–185).

[442] Pitts and McCulloch, "How We Know Universals," 146.

[443] Neisser, *Cognitive Psychology,* 63, 61–70.

[444] See also Michael Arbib's 1964 analysis of the McCulloch and Pitts universals model in *Brain, Machines and Mathematics* (New York: McGraw-Hill, 1964), in the section "Gestalt and Universals": 108–113.. Neisser also cites Arbib's review of McCulloch and Pitts on universals, in *Cognitive Psychology,* 63.

[445] Pitts and McCulloch, "How We Know Universals," 137.

in perception.[446] As the book's forward notes, Wiener insists that "the process of recognition of an object needs to be invariant under an appropriate group of transformations."[447] Wiener explicitly calls this "selective reading."[448] We will go on to see this is a misnomer and would be better described according to what, following Edward Feigenbaum and Julian Feldman in their comments on pattern recognition, we can call automatic information reduction.[449] By automatic, I mean having a passive quality of nonawareness. Wiener was looking to update Locke's theory in order to explicitly make it dynamic, but his assumes a similar quality of givenness to the perceptual field.[450] Discussing normalization, Wiener states that "we center our images around the focus of *attention* and reduce them more or less to outlines."[451] Because people encounter such forms in a variety of possible perspectival views, Wiener proposes, "the different aspects of the same object are often to be seen in *those processes which bring it to the focus of attention*, and of other motions which lead us to see it, now at one distance and now at another, now from one angle and now from a distinct one."[452] Such is a process of "scanning" the environmental scene, which Wiener likens to a television screen scanning system surveying the image plane one point at a time. Here, scanning takes a similar form to McCulloch and Pitts's reflex-mechanisms, and attention is nonetheless quite automatic.

In Wiener's approach, these individual impressions then undergo a process that, following the Lockean theory of association, can "compare them with one another, or at any rate with a standard stored in memory, such as 'circle' or 'square.'"[453] Wiener calls this group scanning:

> Now, just as a region in the ordinary two-dimensional plane is covered by the process of scanning known to the television engineer, by which a nearly uniformly distributed set of sample positions in that region is taken to represent the whole, so every region in a group-space, including the whole of such a space, can be represented by a process of *group scanning*. In such a process, which is by no means confined to a space of three-dimensions, a net of positions in the space is traversed in a one-dimensional sequence, and this net of positions is so distributed that it comes near to every position in the region, in some appropriately defined sense. It will thus contain positions as near to any we wish as may be desired. If their 'positions,' or sets of parameters, are actually used to generate the appropriate transformations, it means that the results of transforming a given figure by these transformations will come as near as we will to any given transformation of the figure by a transformation operator lying in the region desired…. If at any stage of the scanning of the group of transformations the image of the region to be compared under

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[446] Wiener, *Cybernetics*, 20–21: "They [Pitts and McCulloch] added elements which were not prominent in Shannon's earlier work, although they are certainly suggested by the ideas of Turing: the use of the time as a parameter, the consideration of nets as containing cycles, and of synaptic and other delays."

[447] Wiener, *Cybernetics*, xxxiii.

[448] Wiener, *Cybernetics*, 33.

[449] In the first published volume on the subject of artificial intelligence, the 1963 *Computers and Thought*, editors Edward A. Feigenbaum and Julian Feldman, 235.

[450] Wiener, *Cybernetics*, 184.

[451] Wiener, *Cybernetics*, 187.

[452] Wiener, *Cybernetics*, 187–188, my emphasis.

[453] Wiener, *Cybernetics*, 187

> some one of the transformations scanned coincides more perfectly with the fixed pattern than a given tolerance allows, this is recorded, and the two regions are said to be alike. If this happens at no stage of the scanning process, they are said to be unlike. This process is perfectly adapted to mechanization, and serves as a method to identify the shape of a figure independently of its size or its orientation or of whatever transformations may be included in the group-region to be scanned.[454]

Neisser rightly identifies a gross oversight within Wiener's neural perception model, however: In Wiener's neural scanning, the contents of perception collapse with the form, or process, of perception. Neisser further details that Wiener's

> intended analogy is genuinely spatial searches, as when the sky is scanned with a radar beam in search of aircraft. But the search for a fitting template [in memory] is not carried out through a real space, unless, as seems unlikely, the several templates are neatly laid out in different parts of the brain. Used in this way, the metaphor leads to confusion between a possibly sequential consideration of alternatives, on the one hand, and several genuinely spatial scans on the other. One kind of real 'scanning' occurs when we examine a scene, or a list, by moving our eyes across it…. These … must be distinguished from the sequential conduct of a series of different *operations*, like a number of template comparisons.[455]

Wiener's approach conflates sensory input with processes of conceptualization, or generalization. Neisser, too, would in *Cognitive Psychology* put great emphasis on the intelligence at work in sensory experience, with the concept of preattentive processes. However, his theory distinguishes them, quite distinctly, from the thinking-heavy aspects of recognizing forms, though the two co-determine one another and thus both are necessary components of perception.

Wiener's model, as well as McCulloch and Pitts's, acquires a degree of physical dynamism that distinguishes it from earlier trace theories, and yet they are still passive. While they both consider the importance of perceptual attention as a necessary means of getting sensorial inputs and normalizing contents, both overlook the basic principle of *where—upon what*—one focuses the eyes, and *why there*. This would then preclude access to understanding and adapting the criteria forming the basis for these perceptual, and motor, decisions—the criteria for perceptual selection.

PANDEMONIUM, PARALLEL COMPUTERS, AND THE MULTIPLICITY OF HUMAN VISION

As a follow on to the work of McCulloch and Pitts, the Pandemonium was structured such that it could recognize not only a greater variety of potential forms but also could operate under conditions in which the form categories were *ill-defined*. In the case of the Gestalt basic shapes, the basis for both the McCulloch and Pitts and the Wiener models, the categories could be accounted for, and template-matched, based on the total forms.[456] But this approach could not

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[454] Wiener, *Cybernetics,* 190–191.

[455] Neisser, *Cognitive Psychology,* 65.

[456] Later we will see that this approach was not universally accepted. Donald Hebb, for example, denigrated this assumption and instead focused on parts of shapes (corners and high-contrast edges) that add up to totals.

account for more complex pattern forms that "cannot be described merely as shapes."[457] Selfridge and Neisser experimented with the characters of the English language which, they argue, are to be "specified only in terms of a preponderance of certain *features*. Thus A tends to be thinner at the top than at the bottom; it is roughly concave at the bottom; it usually has two main strokes more vertical than horizontal, one more horizontal than vertical, and so on."[458] Or, for example, "the difference between a *Q* and an *O* is minute compared with the shape differences between *O*s [of different fonts or handwritten script], but it is decisive."[459] Worth noting here is their consideration of pattern complexity not as a factor of individual parts to be added up to a whole. In a sense following the Gestalt conception that we perceive forms as wholes, the Selfridge and Neisser feature descriptions are of qualities, not of parts. Further, other of Selfridge's and Neisser's experiments account for something that the earlier neurophysiological models overlooked yet are a basic aspect of Gestalt-informed pattern recognition: the activity of distinguishing between figure and ground. This principle overlaps with an analogous notion in information theory: the process of discerning pattern from noise. In their MAUDE experiment, for example, Selfridge and Neisser used the Pandemonium architecture to recognize handwritten Morse code and were concerned with a peculiar quality of handwriting: "the distinction between dots and dashes is far from clear…. It frequently turns out that some dots are longer than some dashes."[460] Complexity of percept was not just a factor of spatial arrangement but of the relationship between form and context among other forms (background). Whereas the earlier work on normalization had turned form-perception from a process of precise, absolute measure (particular size and orientation on the "retina") into a relational one with respect to templates *in memory*, for MAUDE, significance thus emerged from this foreground/background contextual relationship. It was this inclusion of the background in the analytical method that enabled MAUDE to account for ill-defined percepts.

One of the promising features the Pitts and McCulloch, and Wiener, had introduced with their normalization experiments was a layer of "preprocessing," or "a level of analysis *between* the input and the shape template."[461] In Wiener's scanning process, the television-style spatial scan collapses with the template-matching process. In the psychological terms of Neisser, this is like assuming that the sensory and the cognitive aspects of perception were one in the same. Wiener arrived at this collapse through his adoption of the associationist principles and its contention that ideas are based on copies of sensory impressions, and his use of a sequential computational architecture in which one step in the perceptual process takes place at a given time and gives way to the next. As Wiener's neurophysiologist colleagues would soon discover, and as Neisser would find from the cognitive psychology side, the distinction between sensation and cognition in acts of perception was not so clearly defined—yet this wasn't because of a collapse of content and processual form of perception.

With the Pandemonium, Selfridge and Neisser avoided such a collapse by introducing the feature of parallel processing, with respect to the computational architecture. Both the spatial scanning of an image, along with the cognitive search for various features within it, would take

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[457] Selfridge and Neisser, "Pattern Rec by Machine," 244.

[458] Selfridge and Neisser, "Pattern Rec by Machine," 244.

[459] Neisser, *Cognitive Psychology,* 64.

[460] Selfridge and Neisser, "Pattern Rec by Machine," 238–239.

[461] Neisser, *Cognitive Psychology,* 42.

place by way of a complex of semi-independent processes. Only after these initial scanning and searching activities would the program incorporate sequential processing. That is, the single image input would be fed into several sub-programs (conceptually related to what Wiener called sub-assemblies) that would run simultaneously. Each sub-program would be looking for one feature and would output, to the next phase of the program, the probabilistic likelihood of the presence of that feature (e.g., "concavity"). Each sub-assembly looks for its pre-programmed feature exclusively, and the programs themselves—each of which correspond to the features for which they are to detect—are put into the system ahead of time and are to be devised by a human programmer. In other words, the machine could perceive increasingly complex shapes—set off in obvious ways from a background, with binary distinctions between figure and ground—but could not devise or, on its own, update the rules by which it analyzed, or the things it was looking for.[462]

The capability for a pattern-recognition program to recognize or generate its own rules was not simply an issue that could be overcome by incorporating a more sophisticated learning process. In fact, at this time, there seemed to be an inverse relationship between a computational system's learning capacity, on one hand, and its ability to handle environmental (sensory input) indefiniteness. For example, Leonard Uhr and Charles Vossler created a pattern recognition computer program specifically with the ability to generate, from scratch, its own operators for analyzing patterns, based on the inputs provided. It differed from a neural network program, like that of Rosenblatt's Perceptron, in that it wasn't totally random. The latter program, they and other colleagues in this cognitivist camp argued, would require too much training to acquire meaningful identification ability. The Uhr-Vossler program was endowed more initial structure, whereby

> the memory of the program exists in at least three different places: (1) in the lists of characteristics in memory [to be used like feature templates against which new inputs would be matched], (2) in the settings of the various amplifiers, and (3) in the set of operators in use by the program. While the lists of characteristics bear some direct relationship to the individual patterns processed by the program, the values of the amplifiers and the set of operators in use by the program depend in a more complex way on the whole set of patterns processed by the program, and on the program's success or failure in recognizing these patterns. The learning in this case, which involves simply storing characteristics in memory, is merely 'memorization' or 'learning by rote.' In the second case, the learning is more subtle for it involves the program's own analysis of its ability to deal with its environment, and its attempt to improve this ability.[463]

But, the list of characteristics for which the program is looking is input ahead of time. And, in the case of the Uhr-Vossler program, the *number* of different characteristics was inversely related to the degree of variability within each category. Similar to the Selfridge's vision for the Pandemonium program and those others in discussion here, the Uhr-Vossler program treats complexity of both perceptual environment as well as interior processing as a combinatorial problem, a matter of the number of features, the number of sub-programs, and of their

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[462] For descriptions of the Pandemonium architecture, see: Oliver Selfridge, "Pandemonium: A paradigm for learning," in *The mechanization of thought processes: Proceedings of a Symposium Held at the National Physics Laboratory on 24th–27th November 1958* (Her majesty's stationary office): 1:513–526; Selfridge and Neisser, "Pattern Recognition by Machine;" and Neisser, *Cognitive Psychology,* 74–79.

[463] Leonard Uhr and Charles Vossler, "A Pattern-Recognition Program That Generates, Evaluates, and Adjusts Its Own Operators," in *Computers and Thought,* 251–268.

integration. There is an underlying assumption about a direct relationship between increased number of operators and an increased ability to reduce environmental complexity. But the reduction was already completed by the human programmer, and therefore, like the Feigenbaum and Feldman description, reduction is an automatic process, lacking awareness of environmental complexity.

The implications of environmental complexity being treated as an exclusively combinatorial problem are not just a matter of comparing a mathematical rationalization approach with an embodied subjective perceptual encounter. We can understand this by returning to the question of the relationship between reduction and selection in perception that started off this section. The Pandemonium and the Uhr-Vossler program represent something of a middle ground between the two. Unlike the McCulloch and Pitts, and the Wiener, models they handle issues of ill-defined percepts, and they do so not just through multiple (parallel) means of reduction. In one respect the Pandemonium's feature-detecting sub-programs, and their subsequent parallel cognitive processing, are selectors—they are respectively *looking for* something. But the subject of their search is in-put into the system in the form of the list of, in the experiments' example, a total and finite number of letters in the English language. Finitude in the set need not be limited to something like an alphabet, but it is always finite, determinate, and anticipatory in a binary way.

But what about the more indeterminate aspects of human perception, as had been elaborated by centuries of philosophical inquiry and modern scientific practice, as well as being a central subject of twentieth-century Gestalt psychology that formed the undercurrent of much computer pattern-recognition work? With his 1972 *What Computers Can't Do*, Hubert Dreyfus would critique Selfridge's and Neisser's pandemonium proposal on these grounds, and use it as an example of the fundamental flaws in artificial-intelligence research in general. Dreyfus uses the example of phenomenology and Gestaltist considerations of the "Peter-Paul Goblet" experiment as part of his building argument for embodiment as a key missing component of contemporary AI designs. But we can appropriate the question this example raises for our discussion not of embodiment per se but of reduction versus selection. According to Dreyfus, distinguishing figure from ground involves the direct interplay of determinate pattern against indeterminate background. "This background, which need never have been made determinate, affects the appearance of what is determinate by letting it appear as a unified, bounded figure."[464] The line of contour of the Peter-Paul Goblet "'"belongs" to the figure only and [phenomenally] changes its shape radically if a figure-ground reversal occurs.'"[465] Alternatively, Dreyfus argues, "for a computer, which must take up every bit of information explicitly or not at all, there could be no such outer horizon," or indeterminate background context.[466]

We may take this example in order to do our own thought experiment. If the Pandemonium architecture were to be loaded with sub-programs for detecting the features of both Peter-Paul, on one hand, and sub-programs for detecting features of a goblet, on the other, when it came time to *decide* what pattern the program recognized, it would get caught in a logic loop, with the two perpetually cancelling one another out.[467] Neisser is concerned with a similar

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[464] Dreyfus, *What Computers Can't Do,* 152.

[465] Dreyfus, *What Computers Can't Do,* 152.

[466] Dreyfus, *What Computers Can't Do,* 153.

[467] Computer scientists and cognitive scientists in Japan recently took on this very exercise. See: Daiki Matsumoto, Hanwen Xu, and Junichi Takeno, "Simulation of the Cognitive Process in Looking at Rubin's Vase," in *Proceedings from*

problem of simultaneity of significance. Of parallel models such as the Pandemonium, and of neural network models, too, Neisser asserts that these models "[do] not explain the perception of [for example] a pair of triangles presented together, and indeed it is difficult to do so without an additional assumption. If the many assemblies sensitive to angles or to triangles all lead to the same central result, two triangles should produce the same result as one."[468] For Neisser, this issue of spatial multiplicity and temporal simultaneity became the point at which he departed from the Pandemonium, and from computational modeling altogether. But before moving to focus on Neisser, we will continue to trace the neurophysiological conceptual thread, because subsequent research would add for additional basis for Neisser's eventual critique.

BUG DETECTORS, DEMAND CHARACTERISTICS, NOVELTY

Selfridge's early Pandemonium architecture, as it had been proposed in 1958, would go on to inform McCulloch and Pitts's later work with Jerome Lettvin, in 1959.[469] The Pandemonium's parallel feature-detecting processing formed the basis for their hypothesis about biological vision, and also about the question of *where* in the temporal flow of the perceptual process apprehension of (certain) forms takes place.[470] Lettvin, McCulloch, and Pitts tracked the activity of individual fibers in a frog's optic nerves as it was presented with various visual stimuli in a laboratory setting. They determined that these individual fibers were, respectively, responsible for identifying the presence of certain, specific, environmental features. They thus resembled the sub-programs of feature detectors in Selfridge's Pandemonium, Lettvin and colleagues explain: "These findings … establish that optic nerve fibers (the axons of the ganglion cells) do not transmit information only about light intensity at single points in the retina. Rather, each fiber measures a certain feature of the whole distribution of light in an area of the receptive field."[471] Each fiber, they found, was *looking for*, so to speak, a certain particular feature (object or event) and, if found within the retinal field, would communicate the stimulus event to the brain. Lettvin et al. identified four feature-activated fibers: a contrast detector, a movement detector, a dimming detector, and a convexity detector—or, as the researchers are inclined to conclude them to be, "'bug perceivers' … [which respond] best when a dark object, smaller than a receptive field, enters that field, stops, and moves about intermittently after."[472] The alignment of these findings with the Pandemonium architecture goes beyond the principle of feature-detection to the principles of communication between different hierarchical regions of the perceptual process: "What, then, does a particular fiber in the optic nerve measure? We have considered it to be how much there is in a stimulus of that quality which excites the fiber maximally, naming that

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the 8th Annual International Conference on Biologically Inspired Cognitive Architectures (BICA 2017), Procedia Computer Science 123 (2018): 265–270.

[468] Neisser, *Cognitive Science,* 86–87.

[469] This research resulted in the following publication: Lettvin, Maturana, McCulloch, and Pitts, "What the Frog's Eye Tells the Frog's Brain," in *The Mind: Biological Approaches to its Functions,* edited by William Corning and Martin Balaban (1968): 233–258.

[470] On the influence of the Pandemonium architecture on Lettvin et al.'s work, "What the Frog's Eye Tells the Frog's Brain" acknowledgements, page 258. See also Selfridge, "An Interview with Oliver Selfridge," and Neisser, *Cognitive Psychology*, 82.

[471] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 238.

[472] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 252

quality."[473] The logic of communication, the researchers imply, follows a probabilistic logic utilized by the Pandemonium, whereby the fiber with the highest degree of certainty about the presence of its feature will "shout" the loudest, which will activate the subsequent cognitive and decision-making processes associated with perception.[474]

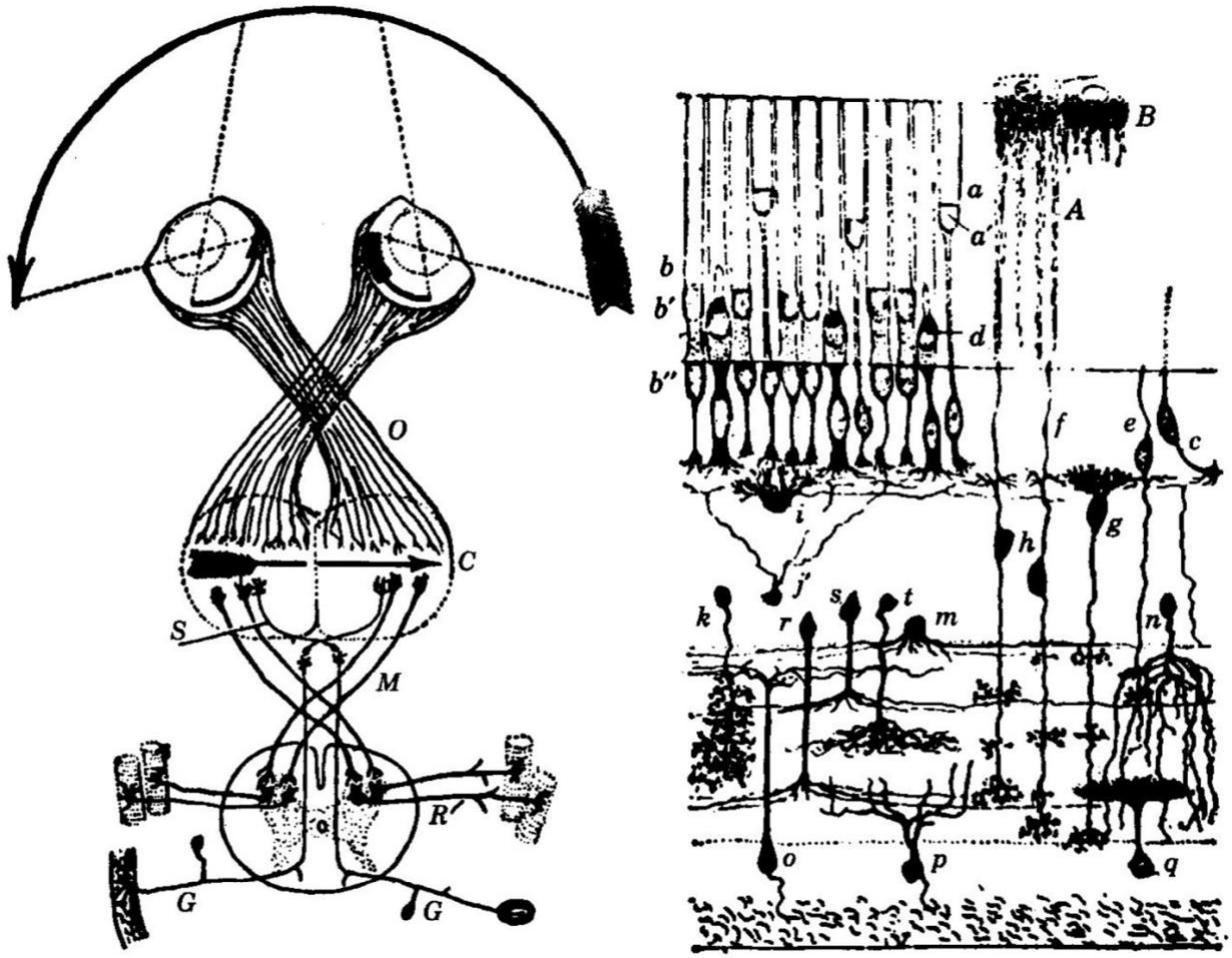


Figure 26: Diagrams of the frog optic nerve (left) and retina (right), created by Pedro Cajal in the late nineteenth century, referenced by Lettvin et al. and published in their 1968 paper.

[473] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 255

[474] The authors explain that this process is not one-directional: "A significant efferent outflow goes to the retina from the brain…. Such axons enter the retina, and we think some effects of their activity on the sensitivity of ganglion cells are noticeable" (256)—but they do not expand upon the implications of this finding. It does seem to suggest that they see some element of negative feedback in the frog's perceptual organization.

One of the most consequential elements of this paper, for our purposes, is the way a process of sensory-data reduction is commingled with a conception of interpretation. A principle of reduction in the sense that Wiener had espoused would assume a one-to-one relationship between an area of the retina or sensory plane and a fiber attached to that area. And in Wiener's scheme, the reduction would equate to a simplification of the spatially arranged contents of perception (e.g., transmitting the outline of a form only). The Lettvin study, alternatively, finds that "the eye [of the frog] speaks to the brain in a language already highly organized and interpreted."[475] This site of visual stimulation, the eye, performs activities that "have much more the flavor of perception than of sensation, if that distinction has any meaning now."[476] The authors initially hypothesized that reduction of sensory data, handled by the retina and the optic nerve, precedes interpretation, handled by the brain. Instead the findings suggested that, for the frog, reduction and interpretation happen in the same region of the perceptual system and during the same step of the process.[477]

This poses something of a paradox. On one hand, the frog's eye undertakes "complex abstractions from the visual image," which can thus provide enough visual discrimination to stimulate an immediate, possibly complex, motor response. The 'bug perceivers' can direct, or elicit, the frog's catching and eating the bug. On the other hand, as Neisser says of this study, "experience is not likely to modify the retina of the frog."[478] The frog's eye is thus not as plastic as our understanding of its brain, certainly of the human brain. If not amenable to processes of learning, then, the feature-detecting element seems to be most associated with immediate and, importantly, repetitive motors acts. Further, despite the intermingling of pattern-recognition processes of reduction and somewhat complex interpretation, these models discussed thus far do not get us any closer to addressing the problem of selection. That is, reduction of environmental complexity is still a process that is undertaken *without* awareness of that complexity. Instead, feature-detectors are automatically looking for the features for which they have, in advance, been charged with searching. In this respect, despite the complexity of the frog's retina, its modes of perceptual attention are directly determined by each fiber's associated feature. Feature-detectors, then, may have the capacity for handling ill-defined perceptual objects—an indication of interior complexity—and yet are still highly lacking in the awareness of environmental complexity associated with the principal of selection, for which Neisser would come to be principally concerned. And if those neurological features reduce interpretable sense data before that data enters thinking activity, consciousness of the exterior contextual complexity, at this later stage of the perceptual process, would not be possible. And this inhibitive condition runs counter to everyday human experience.

This starts to get to the question which is implicit in Neisser's post-Pandemonium cognitive psychology research: *How do humans know what to look for without, or before, we know what we are looking at?* This is a question that is unanswerable by way of the neurophysiological approach to pattern-recognition modeling pursued by Selfridge, and Lettvin, McCulloch, and Pitts, which instead implies pattern recognition to be a matter of quantity of

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[475] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 255.

[476] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 257.

[477] Lettvin et al., "What the Frog's Eye Tells the Frog's Brain," 238–239.

[478] Neisser, *Cognitive Psychology*, 83.

fibers and therefore feature-detecting capabilities.[479] Nonetheless, in Neisser's early-1960s research on human perception in visual search he takes an approach that appears to, conceptually, follow on from the Lettvin findings without much friction, despite utilizing quite distinct empirical methods from psychology instead of neurophysiology. At this point in time, Neisser was interested in pursuing the Pandemonium hypothesis of parallel-processing, or of the multiplicity and simultaneity of human perceptual experience. But his empirical work did elicit some findings that start to depart significantly from Selfridge and that he considered to elude the possibility for computational modeling.

In 1963 and 1964, Neisser published a number of papers on the topic of visual search, based on empirical studies, the theoretical findings of which supported the quality of parallel process in human perception—or, as I prefer to call it, multiplicity—and of their implications for perceptual selection. Similar to Wiener, the starting assumption of this research had to do with the factor of time in the recognition of forms. Neisser's hypothesis contends directly with what he saw as a problem in Wiener's scanning concept, however: "On the sequential theory, one would expect longer decision times with more alternatives."[480] The research used the experimental conditions of scanning visual text, letters in the English language, and it built upon an initial study of Neisser's indicating that subjects' scans "can be consistently interpreted as a measure of the time which these operations [of visual processing] require."[481] When identifying printed letters, the studies in this paper found, "several distinct processes of recognition can function simultaneously in the analysis of a single stimulus-configuration," of an arrayed list of printed letters so long as the elements of the stimulus are spatially contiguous, or perceived as sharing the same context.[482] Put another way, the studies found that "it appears consistently possible to be on the lookout for several things at once."[483] A subsequent experiment elicited the conclusion by Neisser and colleagues that "searching for any of 10 targets [such as 10 specific letters embedded in an arrayed list of letters] is not only as fast but also at least as accurate as searching for only one."[484] From these studies, Neisser theorizes that human perception is, like the Pandemonium's parallel processing architecture, simultaneous and multiplicitous.

Also, not unlike the findings from the Lettvin, McCulloch, and Pitts work with the frog's visual cortex, Neisser finds these rapid feature-recognition processes in humans to be, largely, pre cognitive, or operating without much input from the inner workings of memory and concept formation. But unlike the frog, whose perceptual proclivities align pretty directly, and narrowly, with its life-sustaining motor behavior (e.g., bug catching) that is driven by the reflexes and is innately inscribed. Human sensory organs, reasoning, and even motor behavior contain an excess of possibility, and therefore complexity. At least this was a leading principle within the discipline

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[479] See Selfridge, "An Interview with Oliver Selfridge," in *The Mechanical Mind in History* (MIT Press, 2008); see also the proceedings from Selfridge's 1981 NATO conference, Oliver Selfridge, Edwina Rissland, and Michael Airbib, *Adaptive Control of Ill-Defined Systems* (UMass Press, 1981).

[480] Neisser, *Cognitive Psychology*, 66.

[481] Neisser, Robert Novick, and Robert Lazar, "Searching for Ten Targets Simultaneously," *Perceptual and Motor Skills* 17 (1963): 955–961, 955. Here the authors are citing the 1963 study titled "Decision-Time without Reaction-Time: Experiments in Visual Scanning," *The American Journal of Psychology* 76, no. 3 (September 1963): 376–385.

[482] Neisser, "Decision-Time …," 385. Neisser also states: "No such simultaneity appears in the analysis of *spatially distinct* parts of the input, even after extended practice," 385.

[483] Neisser, "Decision-Time …," 384

[484] Neisser et al., "Searching for Ten Targets Simultaneously," 961.

of psychology at the time, among those who were taking a stand against the behaviorist assumptions about stimulus-response circuits in human behavior, among which Neisser and his colleagues in cognitive psychology very much were. The conceit had originated with William James, who had founded the discipline of psychology on the basis of such excess of possibility. In his magnum opus, *The Principles of Psychology*, James had asserted, "what are our very senses themselves but organs of selection?"[485] He went on: "The selection of several 'normal' appearances from out of the jungle of our optical experiences, to serve as the real sights of which we shall thing, is psychologically a parallel phenomenon to the habit of thinking in words…. Both are substitutions of terms few and fixed for terms manifold and vague."[486] Indeed, understanding the mechanisms of such a process provided the grounds for much of Neisser's cognitive-psychology project. Triangulating James with contemporary neurophysiology work, Neisser took the position that pre-cognitive feature-detectors were not innate organizations of feature-receptive nerve fibers in the human but were more open to the variability of experience and learning.

And yet, in the instance of visual search, the targets for which the subjects were to search *were* established in advance of their searching. Additionally, the "environment" they were visually scanning was, to a great extent, static and fixed. Neisser's later engagements with James J. Gibson's and Eleanor Gibson's ecological perception, which I discuss in the last section, will show his admission of the limitations of these types of experiments for eliciting general theoretical principles. However, for now my point is that the experimental conditions imposed on the subject—e.g., look for a *K*, look for these ten letters—also impose the criteria for selection onto the subject *a priori*. Following Martin Orne, Neisser calls these *demand characteristics*: the phenomenon that "all [experimental] subjects try to figure out what is expected of them, and most subjects try to behave accordingly."[487] The generalizable theoretical idea here is that "the effect of intention on the perception of ambiguous figures it very great. Merely by 'trying' we can affect the way [particular ambiguous figures] appear to us."[488] Demand characteristics in an experiment, like intentions or values in daily life more broadly, thus operate as something of a pseudo-innate program, or perceptual filter, akin to the frog retina's or the Pandemonium computer's feature-analyzers. The difference is that the human can alter these "programs" as different personal or externally imposed intentions and values get incorporated and win others out, or, as an unexpected environmental event or object disrupts one's perceptual flow.

Neisser's recognition experiments were, indeed, measuring the time of one's *reduction of environmental information*, yet the conclusion of the parallel nature of perception suggests that such a practice of removal nonetheless involves a superfluity of sub-processes. Neisser explains that these rapid, early stages of form recognition, "like all parallel processes[, … are] inherently 'wasteful.'"[489] Such "redundance [and] wastefulness" are understood to correlate with a "freedom from gross misrepresentation."[490] The simultaneous and multivocal nature of parallel

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[485] William James, *The Principles of Psychology* (Minneapolis, MN: U of Minnesota Press, 1952 [1890]), 184.

[486] William James, *The Principles of Psychology* (Minneapolis, MN: U of Minnesota Press, 1952 [1890]), 608.

[487] Neisser, *Cognitive Psychology*, 80–81. He is citing Martin Orne, "The nature of hypnosis: Artifact and essence," *Journal of Abnormal Psychology* 58 (1959): 277–299 and "On the social psychology of the psychological experiment: with particular reference to the demand characteristics and their implications," *American Psychologist* (1962): 776–783.

[488] Neisser, *Cognitive Psychology*, 81.

[489] Neisser, *Cognitive Psychology*, 301.

[490] Neisser, *Cognitive Psychology*, 74.

perceptual activity, then, seems to be the body's crude system of checks and balances, of allowing what is really on the page or in the environment to be brought forth phenomenally with some degree of measurable accuracy. This aligns with what James J. Gibson would later term "direct perception."[491] And yet, these preliminary phases of the perceptual process that afford rapid response, like other parallel processes, "resist introspection, since so much unrelated activity is going on simultaneously."[492] Therefore, they can be considered a somewhat automatic, or autonomic, bodily phenomenon.

Neisser's isolation of the pre-attentive processes that discriminate sensory information seems to introduce a contradiction to his very inquiry into the autonomous aspects of perceptual experience that leave the human organism open to its environment's superfluous features. In the essay he had co-authored with Selfridge, "Pattern Recognition by Machine," Neisser had articulated the selection (versus reduction) principle to be a distinguishing feature of human vision: people have the capacity "to select from their environment the things, or the relations, they are going to think about."[493] The authors explain that, not only is this selection capacity possibly outside the realm of relay-based computer processing altogether, formally modeling the criteria by which humans classify the objects and events they encounter is challenging because, for people, "very often the basis of classification is unknown, even to [themselves]."[494] But, I suggested at the beginning of this section that perceptual selection, as a particular—and particularly phenomenal—form of reduction of environmental information, involves some conscious awareness of the environment's broader complexity and richness, beyond the current set of objects being visually apprehended. By a transitive principle, this phenomenon suggests that there is some awareness that one *could select otherwise*, that based on conscious or unconscious activity one could perceive the background as the foreground and vice versa. This persistent phenomenal possibility suggests that deciding to X and not Y would both prompt and require some awareness of one's own interior processes for sense-making, or to put it in pattern-recognition terms, one's criteria and parameters for classification.

Such a seeming paradox guided Neisser's other prominent experiments at this time, on visual search for *novel* targets. Subjects were asked to detect—to (re-)cognize—a nonsense printed symbol, for which they had no familiarity, amid an array of other printed English-language letters. The theoretical question guiding the study was, "Can one expect the unexpected?"[495] Neisser and his research partner Robert Lazar began with the assumption that detecting novelty is a normal part of everyday experience, from monitoring a scene for unusual activity, troubleshooting a technical problem, or proofreading a text. They hypothesized and tested three working definitions of novelty. The first is in step with the Lettvin et al. principle and suggests that novel forms stand out amid a complex background specifically because they are unfamiliar. This assumes that, in human perception, "novelty … [functions] as an intrinsic and

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[491] See James J. Gibson, "The Information Available in Pictures," Leonardo 4, no. 1 (1971): 27–34 and Gibson, *Ecological Approach to Visual Percpetion* (Boston: Houghton Mifflin, 1978). For an analysis of direct perception, see Chapter 3 of this dissertation. See also Julia A. Irwin, "Artificial Worlds and Perceptronic Objects: The CIA's Midcentury Automatic Target Recognition," *Grey Room* 97 (Fall 2024): 6–36.

Note the connection between Gibson and Neisser.

[492] Neisser, *Cognitive Psychology,* 74.

[493] Selfridge and Neisser, "Pattern Recognition by Machine," 237.

[494] Selfridge and Neisser, "Pattern Recognition by Machine," 238.

[495] Neisser and Robert Lazar, "Searching for Novel Targets," *Perceptual and Motor Skills* 19 (1964): 427–432, 427.

compelling property of stimuli," and that we have some retina-level, pre-cognitive feature-detector specifically for unexpected forms (like a negative feature-detector, which identifies anything for which there is *no* existing feature-detector).[496] Second, the authors put forward a more rote cognitive concept of novelty-detection, whereby an atypical symbol gets cognitively compared with "a set of standards" in one's memory and then, as a final step, one "reacts to [the comparison's] failure" to positively detect the novel figure.[497] The authors reject the first definition through experimental confirmation, and they hold the second to be unlikely in everyday practice, because it is expected that it would take more time than practices like proofreading.

The third hypothesis for phenomenal novelty posits that individuals associate certain contexts with certain possible novel stimuli and "assume (rightly or wrongly) that all novel stimuli" in such a context "will share certain properties" associated with other, familiar classes of characteristics.[498] The authors give the example of one's awareness of a car engine's possibility of unexpected behavior eliciting the individual to "reinterpret the task as the detection of a certain class of sounds that 'mean trouble'" and thus failing to notice a novel smell until it reaches a level of intensity that then demands the driver's attention. The car owner "seems, then, to be responding to 'novelty,'" in the smell but is instead responding to "intensity."[499] This is a sort of pseudo-novelty, then, in which the individual is imposing her own, crude demand characteristics onto the sensory experience *a priori*, only for those anticipatory perceptual frames to be disrupted by new, unexpected sensory information.

Neisser and Lazar do not accept this third hypothesis conclusively but hold its possibility open to further experimentation. They do end with an updated hypothesis: If "early experience in the experiment led [subjects] to conclude that the [novel] targets … would share certain properties[, and] these properties then became the object of their search," then "a much higher error rate would appear on the first occurrences of symbols than on later occurrences: *at least some of the symbols will be novel in unexpected ways*."[500] This distinguishes this concept of novel stimulus from the first two, which would likely generate a lower error rate because, in the first case, they would stand out for their intrinsic properties and, in the second case, they would have been carefully analyzed and compared with memory. The high initial error rate would tell us quite a bit. Though this conclusion is here speculative, it points us toward Neisser's theorizations of what he calls *preattentive processing* and *focal attention*. This pseudo-novelty concept implies that perception takes on something of an interactive cycle between subject and environment, between some *a priori* feature-detectors, which are imposed through a cognitive or affective process of expectation-setting or anticipation. This is analogous to a preemptive setting of one's own "demand characteristics" for the imminent sensory experience. Then, one encounters the novel object, symbol, or event "in unexpected ways," and errs; through one's recognition of one's own error in detecting novelty, the subject then adapts the expectations regarding the (already known) class to which novel characteristics be ascribed.

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[496] Neisser and Lazar, "Searching for Novel Targets," 431.

[497] Neisser and Lazar, "Searching for Novel Targets," 428.

[498] Neisser and Lazar, "Searching for Novel Targets," 428.

[499] Neisser and Lazar, "Searching for Novel Targets," 428.

[500] Neisser and Lazar, "Searching for Novel Targets," 432, my emphasis.

This is essentially a learning process, but it differs significantly from that of the computer programs of Selfridge and Uhr and Vossler, and the neural network model of Donald Hebb, to which we will move next, most significantly because of its effects. In Neisser's experiments, while the subject's orientation toward certain environmental features is established in advance of the perceptual event (mostly unconsciously, but consciously in an experimental situation with demand characteristics), the individual remains open to be surprised by what she sees. The subject's pre-recognition (pre-cognitive) awareness of an unexpected environmental feature prompts the subject into awareness of her own, implicit rules for recognizing a pattern. These very criteria for disambiguating sense data then become the focus of one's cognitive attention; they get reworked and renegotiated as a result of the perceptual encounter and in doing so the subject resets the perceptual goal (i.e., the *looked-for object*).

Unlike in the learning style endorsed by Selfridge, Uhr and Vossler, the novel external item doesn't get subsumed into existing memory structures or merely rejected as "not X," in a binary sense. This unfamiliar datum instead exists wholly outside of memory for the person. For Neisser, human beings have a capacity to recognize the partiality and limitations of their own memory, and to remain open to altogether new sensations and modes of thought. These preliminary steps in the perceptual process, those most closely linked with autonomic sensation—what Neisser calls preattentive processes and focal attention—are in fact the qualities that, for Neisser, afford the highest-order forms of consciousness. That is, one of the most abstract activities of consciousness—the practice of coming into awareness of one's own *ways* of perceiving and thinking—is contingent on continual feedback from these sensorimotor mechanisms that both direct the eyes and are directed by the contents the eyes pick up. This phenomenal feedback enables the subject to learn, which for Neisser means to acquire (again and again) a genuinely novel structure for undertaking pattern recognition and remembering visual experiences.

HEBBIAN LEARNING, FAMILIARITY

Neisser's framing of the co-constitution of learning and novelty was not assumed by those theorizing the neural network, however, who implicitly saw the two phenomena as having an inverse relation. Neurophysiologist Donald Hebb's theory, for example, which was introduced in his 1949 text *The Organization of Behavior* and which informed Frank Rosenblatt's perceptron computer experiments, was notable because of the enormous degree to which perceptual "experience" and learning play a role in the structural organization of the brain.[501] The most oft-cited summation of Hebb's theory is that "neurons that fire together wire together." This principle deserves a bit more relevant context for us before moving into Neisser's implicit and explicit critique of it with his principles of preattentive processes and focal attention. Psychologists like Neisser and those within his milieu, such as James Gibson, sought to understand phenomena of perceptual learning that were not immediately explainable, or that seemed to resist, formal modeling. Committed to empirical practice, they were agnostic to whether and how minded activity interacts with, is embedded within, and can be explained by the physical processes and substance of the brain. Motivating this work was an inquiry into

[501] Donald Hebb, *The Organization of Behavior* (New York: John Wiley & Sons, 1949).

how people experience things that they seem to have no cognitive equipment for, until they encounter the percept and then they do. Hebb, on the contrary, assumed an alternative, contradictory scientific approach, and assumed the physical properties of the brain to stand in as thorough explanations for those of the mind.[502] Hebb establishes that "'mind' can only be regarded, for scientific purposes, as the activity of the brain, and that should be mystery enough for anyone: besides the appalling number of cells (some nine billion…) and even more appalling number of possible connections between them, the matter out of which cells are made is being itself reduced by the physicist."[503]

The work of the behavioral scientist, in Hebb's formulation, is the *willful, reasoned*—not automatic—paring down of complexity. He concedes that his approach involves gross reduction, and that this reduction does have consequences, before taking a defensive posture: "To deal with behavior at present, one must oversimplify. The risk, on the one hand, is of forgetting that one has oversimplified the problem; one may forget or even deny those inconvenient facts that one's theory does not subsume. On the other hand is the risk of accepting the weak-kneed discouragement of the vitalist…. But it is never enough to say, because *we* have not yet found out how to reduce behavior to the control of the brain, that no one in the future will be able to do so."[504] But here Hebb conflates the scientist's choices about methodology, given the constraints of existing scientific knowledge and tools for empirical observation, and the ontology of the brain-mind itself. It is within this presumption that the very notion of qualitative complexity of the mind is quite arbitrarily framed as quantitative complexity, for reasons prompted by expedient empirical, neurophysiological practice. Therefore, Hebb maintains that the quality of multiplicity in perceptual and intelligent behavior is a problem of formalizing the connections in the brain. A model's number of neurons and connections is directly proportional to the compounded *number* of objects that brain could conceivably apprehend.

Following from this premise, Hebb's neural net model assumes a quite rigid relation between perceiver and environment, even with its great deal of emphasis on perceptual experience as a factor of brain development, and of learning. Following the mathematical formulations of the neural net proposed by McCulloch and Pitts in their earliest work. "A Logical Calculus of the Ideas Immanent in Nervous Activity" (1943), Hebb's model has no originary structure, only the potentiality for neural connections to be established through experience. It is through local retinal stimulation that the perceiving entity starts to build up a what Hebb calls the "*primitive unity* of a figure." A figure is thus distinct from ground on account of its suggestion of "boundaries" through its collection of parts, and in particular its elemental forms such as angles and lines, which if in a certain set of relations would suggest the presence of a square.[505] These individual pieces of forms were the discrete bits, the already determinate building blocks of complex forms.

Among researchers of perception in the era, there was a tendency to understand the properties of the external world, as it was available to the perceiving subject, as mirrors of the properties of the brain itself. For example, Gestalt psychologists had theorized that forms are

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[502] Hebb's model represents an overt attempt to physicalize the associationist theories to which Wiener was also attending. Hebb, xi

[503] Hebb, *The Organization of Behavior,* xiv.

[504] Hebb, *The Organization of Behavior,* xiii.

[505] Hebb, *The Organization of Behavior*, 21. See also 83: "Lines and angles, then, can be treated as perceptual elements, not fully innate in perception, but partly so."

apprehended as whole objects that are not reducible to their parts. They understood conceptual generalization, an activity of the mind, as an analog of the phenomenon that subjects understand not only objects but also environments often on account of diffuse, nonspecific visual information. Take, for example, Wolfgang Köhler's and Kurt Koffka's experiments with non-geometrical sensory phenomena, like fog are other environmental elements the produce a "homogeneous proximal stimulation."[506] This presumed non-localization theory of environmental stimulation found its match in Köhler's quite speculative proposition of brain isomorphism, informed by Köhler's interest in field theory, as a way to explain non-locatable activity within the mind in physical terms.[507]

Hebb took an oppositional position, championing discrete localization, but made similar assumptions between how the world looks to the brain and the inner workings of the brain itself. Just as individual nodes and synaptic connections got filled in to make the matter of the brain, individual points of contrast in one's surroundings linked up, forming rectangular or topographic matter. Matter—the earthly objects to be sensed just as the brain itself—is an accretion of parts configured in complex arrangements. The atomistic pieces of perceptual forms, anticipating their vectoral connections, were like neural nodes awaiting their synaptic connections and impending structure.

How, then, do we arrive at the a unified object that can both be apprehended as a generalized concept *and* as something that could potentially evade any existing perceptual categories? In addressing the former conceptual problem, Hebb in fact explains away the second. The filling in of boundaries, of connections between edge pieces, comes not directly from the sense impression itself, but from the imposition of expectancies based on previous experience.[508] Therefore, perception involves two simultaneous processes; in addition to the direct sensory impression, there is the "*non-sensory figure-ground organization,*" or the working of experience *on* the perceptual experience to produce the abstractions necessary to identify an object.[509] This latter process, though it works in parallel to sensory stimulation in any event of perception, also develops directly from it: "The course of perceptual learning in man is gradual, proceeding from a dominance of color, though a period of separate *attention* to each part of a figure, to a gradually arrived at identification of the whole as a whole."[510] In this sense, perception is both simultaneous and summative.[511] Hebb uses these factors in his development of the physically based and statistically oriented theory: "There would thus be some necessity of synchronization [or] … integration…. There would necessarily be a gradual change of the frequency characteristics of the system…. *With perceptual development there would thus be a slow growth in the assembly*, understanding 'growth' not necessarily an [*sic.*] increase in the number of constituent cells, but a change" to the physical structure of the net and the probability that neural traces would be traversed again in the instance of an encounter with the same object (or set of

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[506] Kurt Koffka, *Principles of Gestalt Psychology* (London: Harcourt, Brace, 1936), 111. See also all chapters on "The Environmental Field."

[507] See David W. Bates, "Creating Insight: Gestalt Theory and the Early Computer," in *Genesis Redux: Essays in the History and Philosophy of Artificial Life*, edited by Jessica Riskin (Chicago: University of Chicago Press, 2007): 237–259, 242.

[508] For Hebb's discussion of "Movements During Perceptual Integration," see 84–91.

[509] Hebb, *The Organization of Behavior*, 21.

[510] Hebb, *The Organization of Behavior*, 32, my emphasis.

[511] Hebb, *The Organization of Behavior*, 34.

objects)."[512] Hebb's theory of learning, as it relates to experience, assumes that a subject's perceptual attention works like something of a mechanical scanning device that assembles parts into wholes. Perhaps as a factor of the neurophysiology emphasis of his study, the fact that he was looking almost exclusively at the brain exclusively, Hebb skirts the issue, widely held among psychologists and biologists of the twentieth century, of human visual perceptual abundance. The entire practice of converting excessive environmental information into sense impressions and percepts, as it is undertaken by people with bodies, is elided in Hebb's analysis. Hebb instead focuses on what information he assumes makes its way to the brain, how the organ develops new pathways and reinforces old ones, and how such a structure then operates on future experience by way of what has been encountered in the past. The entire mechanism for perception is a feedback loop that reinforces that which is has been encountered before. It therefore precludes the possibility for novelty, because as one learns, one acquires an increasingly narrow conception of an environment.

Even though Hebb's project here, as established in the introduction to his text, is to solve the problem of the incompatibility between perceptual generalization and neurological localization, or put differently the gap between the mind and the brain, his approach falls short of really accounting for the former.[513] This critique is, after all, the one neural network models encountered from artificial intelligence researchers at the time and the impetus for support for an eventual embrace of expert systems, over perceptually based models, in the late 1960s through the early 1980s.[514] But Neisser offers a more subtle critique that serves to deal with the underlying assumption among Hebb and these other researchers alike that our models can immediately propose methods of perceptual reduction before addressing the human issue of perceptual abundance and the selection it necessitates. Hebb, after all, throws around the notion of "attention" in perception without ever contending with the question of why subjects attend to this and not that. Neisser rests his critique of these neurophysiology informed approaches on the distinction between perceptual reduction and perceptual selection: "If we do not postulate some agent who selects and uses the stored information, we must think of every thought and every response as just the momentary resultant of an interacting system, governed essentially by laissez-faire economics. Indeed, the notion of habit strength and 'response competition' used by the behaviorists are based on exactly this model."[515] For Neisser, a thoroughly analytic notion of perception and intelligent action so reduces the complexity of these activities themselves as to make them seem like automatic mechanisms void of consciousness.

Neisser's critique of Hebb is subtle, however, because Hebb's model isn't exclusively analytic. That is, his neural nets both engage in practices of paring down information but also producing new information. This is precisely how Hebb defines neural familiarity: "There is a clear effect of earlier experience, filling in gaps in the actual perception, so that the end result is either something familiar or a combination of familiar things—a reconstruction on the basis of

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[512] Hebb, *The Organization of Behavior,* 76–77. See also Karl Lashley's hypothesis of interference patterns (cited in Neisser) also cited in Hebb, page 15: "one explicit attempt to solve this difficulty [relation between perception and neural excitation] and to deal adequately with both perception and learning."

[513] Hebb, *The Organization of Behavior*, 88. Hebb says: "The larger number of [perceptual] habits means that each one will be more an abstraction, less a perception of a particular angle (or line) in a particular setting."

[514] See Marvin Minsky and Seymour Papert, *Perceptrons: An Introduction to Computational Geometry* (Cambridge, MA: MIT Press, 1969).

[515] Neisser, *Cognitive Psychology,* 293.

experience."[516] In *Cognitive Psychology*, Neisser casually endorses one aspect of this idea but then refutes it, and therefore his own point, a few pages later. He likens Hebb's perceiver as something of a paleontologist "who carefully extracts a few fragments of what might be bones from a mass of irrelevant rubble and 'reconstructs' the dinosaur."[517] Neisser contrasts this *constructive* notion with the more *analytical* work of, for example the chemist, who scrutinizes "unknown substances to find out what they 'really' are."[518] Neisser almost immediately then refers to Hebb's neural nets as "analytic models."[519] This contradiction in Neisser's framing, which Neisser never directly addresses himself, nonetheless is instructive. For Hebb, there is a clear directionality of brain development, from the "intrinsic organization" of a child brain, that gets impressed upon, through time, by a "frequently repeated, particular stimulation" which forms in the brain as a particular "cell-assembly."[520] Perception and thought occurs as chains of cell-assemblies develop, only to become more determinate with time. These "phase sequences" become the analytic rules of perception for the individual. Whenever, outside of childhood or sleep, one's brain deviates from these established courses, this is thought to produce culturally deviant behavior. Thus there is a clear teleology to brain development and to the clear "direction of thought" it can afford.[521] But how, by way of what conscious or unconscious process and according to what criteria, did the infant determine which "bone fragments" to extract from its sense impressions and the overwhelming amount of potential information in them? Hebb has no answer, and in not having one his theory cannot account for the phenomenon of novelty as anything other than a statistical anomaly, a thorough disturbance to the physical neural structure (unlike the gradual adaptations associated with perceptual learning), and the emotional disturbance (neuroses, antisocial, self-afflicting behavior) it apparently causes.[522] Hebb explains that, in so-called normative circumstances, the neural net develops by way of a synchronicity in the "interaction of sensory and central facilitations" that can be expected in "a thoroughly familiar environment."[523] The assumption of normative behavior is thus correlated with an assumption that the surroundings remain increasingly repeatable and predictable through time.

Hebb's own theory foregrounds the dynamic aspects of perception, mostly on account of interior processes, and yet champions the acquisition of compounding stability in neural organization. He pushes this to the extreme in his notion of interfacilitation, which is a most overt expression of formalizing and physicalizing association theory: "Each grossly different pattern of stimulation, as the object is seen from one side or another, requires the establishment of a separate set of cell-assemblies … [which] would gradually acquire interfacilitation—if sight of the object from one angle is often followed by sight of it from another. Arousing one set would then mean arousing the others, and essentially *the same* total activity would be aroused in

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[516] Hebb, *The Organization of Behavior*, 47.

[517] Neisser, *Cognitive Psychology*, 94.

[518] Neisser, *Cognitive Psychology*, 94.

[519] Neisser, *Cognitive Psychology*, 96.Neisser later builds this argument based on the findings of the Wertheimer (Gestalt) experiment with objects in motion, *Cognitive Psychology*, 144.

[520] Hebb, *The Organization of Behavior*, xix.

[521] Hebb, *The Organization of Behavior*, xix.

[522] See Hebb, *The Organization of Behavior*, 87 and also Chapter 10 "Emotional Disturbances" (235–304).

[523] Hebb, *The Organization of Behavior*, 87.

each case."[524] Neisser rejects the interfacilitation concept outright, because it "does not do justice to our perceptual capabilities," in that it "[does] not account for our understanding of *novel*" perceptual experiences.[525] Neisser was resolute that novelty—or at least its potentiality—is part of everyday perceptual experience. This stance was informed by his early laboratory experiments on visual search and on his later collaborations with James Gibson, who maintained an ecological theory of perception highlighting the richness of humans' perceptual environments. According to Neisser, no environment or environmental experience is thoroughly familiar; there are always new elements or relations between elements whether they be words on a page, pedestrians on the street, or one's own relative body-environment orientation from moment to moment.

The root of the problem in Hebb's approach, Neisser reveals, is that interfacilitation subsumes all perceptual experience to long-term memory, which is itself a compounding of direct experience.[526] An anomalous experience will either slightly alter the average form-generalization or, in the extreme cases, create emotional and behavioral disturbances. Neisser's approach gives no less emphasis to sensory experience and its effects on perceptual learning, but he holds that short-term, schematic visual memory serves as an intermediary. The implications of this are that the perceiver's capacity to handle environmental novelty, and the possibility for a figure-ground reversal, can be explained. We can contrast Hebb's style of perceptual expectancy with Neisser's discussion of a study involving an intentionally ambiguous pattern, the *wife/motion-in-law* figure used by Leeper (1935) and subsequently by Epstein and Rock (1960). By showing biased visual forms in various sequences before the test figure, Epstein and Rock found that there "was a clear victory for recency over expectation."[527] Neisser takes this as an indication of the existence of what he calls "short-term storage of visual information."[528] The most important implication of this feature of the perceptual process, for Neisser, is that this "schematic" of perceptual criteria is, unlike the summative neural net, "readily modified by information from further glances" just as it integrates the visual products of many glances and is therefore synthetic.[529] Schematic visual memory is both closely tied to dynamic encounters with environmental novelty, and has enough structure to endure through time, sometimes enabling its apprehension in thought at a much later time. These "visual images" differ from Hebb's cell-assemblies in that they are not "replicas of isolated stimulus patterns" or accretions of discrete pieces of visual forms.[530] They are mind-constructed scaffolded pictures that themselves create something of a complex interior environment for the subject. The fact that they are superfluous, matching the abundance of information available in any present perceptual environment, creates

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[524] Hebb, *The Organization of Behavior*, 91, my emphasis.

[525] Neisser, *Cognitive Psychology*, 143

[526] In *Cognitive Psychology*, on page 143, Neisser explains: "According to this theory [of Hebb's], the integration of retinal patterns does indeed involve visual memory, but it is not primarily a short-term memory for immediately preceding retinal input. Indeed, a long-term and slow-growing 'snapshots' is held to be responsible. If you see the printed page as a stable and single visual object, it is only because you have often experienced such a succession before. Any one of the present fixations would presumably suffice to arouse the neural system created by these earlier experiences."

[527] Neisser, *Cognitive Psychology*, 142.

[528] Neisser, *Cognitive Psychology*, 142.

[529] Neisser, *Cognitive Psychology*, 145.

[530] Neisser, *Cognitive Psychology*, 145.

the conditions for the experience of novelty—of happening upon some new synthesis of perceptual or cognitive material.

Neisser seems to be proposing more layers of intermediation between sensory experience and activities like thinking and remembering than the model of Hebb, on one hand. And in this respect, we might expect to find that Hebb's model retains some fidelity to the environmental encounter, through its apprehension of concrete perceptual traces, and therefore to environmental novelty. After all, the neural net starts out as a totally *open* and bottom-up type of structure and yet Neisser's model is hierarchical and top-down in its suggested orientation. However, for Neisser this provisional layer of perception that results in the schematic short-term memory is especially sensitive to visual information that is ambiguous, vague, or unfamiliar. Neisser does, however, maintain that sensory experience, perceptual learning, and more abstract mental activity are intimately connected. His argument develops toward an ultimate claim that "*the mechanisms of visual imagination are continuous with those of visual perception*—a fact which strongly implies that all perceiving is a constructive [and not merely an analytic] process."[531] To understand this argument, and its implications for even today's neural networks, we need to return to the problem of selection.

My foregoing discussion of the models to which Neisser was responding and from which his theory departed, including the Pandemonium and his work with Selfridge, has served to evidence that all of them have profoundly overlooked the activity of perceptual selection and its imperative relation not only to pattern recognition but to all intellectual activity. Hebb gestures toward its importance at the very beginning of his monograph, in which he sets up the idea that expectations based on experience play a role in perception: "In the simplest of terms, 'attention' refers to a selectivity of response. Man or animal is constantly responding to some events in the environment, and not to others that could be responded to (or 'noticed') just as well."[532] And yet, Hebb's entire neural network theory takes for granted the primordial perceptual decision (e.g. to look at this and not that; to look at X pattern as a goblet *or* as a face), and the subject's constant negotiation or renegotiation as it moves through any given space. As Neisser puts it, "As far as Hebb is concerned, this elementary figure-ground segregation is simply a fact outside his explanatory system."[533] For Neisser, alternatively to his contemporaries on this subject, there is a form of sensorial attending that the subject undertakes that is *prior to* attention, and that operates at the level of environmental ambiguity and vagueness. He calls it *preattentive processes* and explains that they "delineate units [within the perceptual environment], provide partial cues, and control simple [motor] responses" such as movements of the eyes and head.[534] Yet these are not the "primitive unity" form recognizers of Hebb and instead are much more dynamic and responsive to both the environment and the subject's own conscious and unconscious impositions. These impositions are not the direct and rather affectless expectancies arising teleologically from prior sensory experience. Instead, Neisser borrows a term from his empirical

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[531] Neisser, *Cognitive Psychology*, 95. Neisser also, later, explains that the cognitive approach to recall and problem-solving involves a similar continuity between "higher mental processes" and "skilled motor behavior" (292). "The cognitive approach to memory and thought emphasizes that recall and problem-solving are constructive acts, based on information remaining from earlier acts. That information, in turn, is organized according to the structure of those earlier acts, thought its utilization depends also on present circumstances and present constructive skills. This suggests that the higher mental processes are closely related to skilled motor behavior…" (292).

[532] Hebb, *The Organization of Behavior*, 4.

[533] Neisser, *Cognitive Psychology*, 79.

[534] Neisser, *Cognitive Psychology*, 286.

realm and theoretically applies it to all acts of perception: the autonomous activities driving preattentive processes are an individual's "demand characteristics." [535] Demand characteristics, as a conceptual model, are like the precise (mental and motor) behavioral scripts carrying out one's motivations and purposes. Subtler and more internally attuned than the reward-function scripts of the behaviorist, for Neisser these demand characteristics are based on personally and culturally reinforced modes of thought and action, and in this sense are habituated, but importantly, they are provisional and ready to be rewritten based on a truly new, surprising environmental encounter and an internal spark of creativity it might provoke.

PREATTENTION AND THE PROVISIONALITY OF PERCEPTUAL RULES

Much of Neisser's empirical pursuits and theoretical proposals regarding perception and cognition can be understood on account of their tenuous relationship to the information processing research community. In 1972 Hubert Dreyfus castigates Neisser for his information-processing approach to psychology and its tendencies to treat all of human intelligent activity as arising from formalized and determinate mechanisms in the central nervous system. In my reading of Neisser's work, even that in the early 1950s in the era of the Pandemonium and when he was thoroughly entangled with computer pattern recognition research, he used heuristic concepts like "information process" and "central processing units" as a way to acknowledge the complexity of mental life. After all, cognitive psychology developed as a means of rescuing the discipline from the hold of behaviorists, for whom there were no relevant interior processes. Neisser was interested in the computer model specifically as a gross approximation, that gestured at general elements of cognition, and that grounded thinking about consciousness in a modern frame of reference—as a dynamic and activity oriented phenomenon, not simply as a state. At this stage of his academic career, Neisser did not take issue with the widely held view among engineer colleagues that pattern recognition is, as Edward Feldman and Julian Feigenbaum had put it, "the automatic reduction of complex environments."[536] But unlike his colleagues in computing and the neurophysiology of the cybernetic era, who tended to take this charge at face value, Neisser was most concerned about the underlying grounds for sensory information filtering—why and how a subject sees this feature and not that. But further, there seems to be no limit to the kinds of features one could apprehend, because sense organs are blasted with environmental data and because perceptual criteria is quite plastic.

One of the most promising aspects of the Pandemonium, it seems to have been for Neisser, was that it directed scientific attention to both the indeterminate aspects of pattern recognition—which it exhibited quite prominently—*and* made visible a crucial element of human perception that it simply could not simulate. We have established that Neisser and Selfridge were both dubious about the notion of prior experience assembling into near automatic neurological programs. Alternatively, the Pandemonium's limitation, for Neisser, had been that its feature-detectors were input ahead of time by the programmer, serving as something like the frog's innate perceptual equipment. But it gestured at the importance of multiplicity—of many possible different ways of looking at the same field of sensory information. Neisser seemingly

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[535] See Neisser, *Cognitive Psychology*, 305. This is the last line of the book. The same line of thinking is also in Ulric Neisser, *Cognition and Reality* (San Francisco: W.H. Freeman, 1976), 104.

[536] Edward Feigenbaum and Julian Feldman, "Pattern Recognition: Introduction," in *Computers and Thought*, 235.

uses the Pandemonium's computational constraints as a way to arrive at his resolute proposal about human perception and memory, in *Cognitive Psychology*:

> When we first perceive something, the process of construction is not limited to the object itself. We generally build (or rebuild) a spatial, temporal, and conceptual framework as well…. When you see a friend across the street, you are not seeing only him. He, a person of a particular kind with a particular relevance in your life, is appearing there, a particular place in space, and then, as certain point in time…. These frames of reference can be thought of as [another] level of cognitive construction. The preattentive processes delineate units, provide partial cues, and control simple responses; focal attention builds complexly structured objects or movements, one at a time, on the basis thus provided; the background processes build and maintain schemata to which these objects are referred.[537]

The mental schema that arise from experience are abundant, mirroring the richness of the external environment and excesses of the sensations through which the subject encounters it, according to Neisser. The superfluidity of not only sense based but also cognitive frames of reference is thus *necessary* for problem-solving and other autonomous behavior. Neisser goes so far as to frame reason itself as an "ability to use earlier experience selectively." But again, we must ask about the significance of selection itself: "'An organism has somehow to acquire the ability to turn round upon its own 'schemata' and to construct them afresh.'"[538] In Pandemonium terms, this would be, for one, the capability of the subject to devise her own feature-detectors. With respect to an empirical frame, this phenomenon is like incorporating an entirely new set of demand characteristics and applying them to the same perceptual situation or problem-solving activity.

In terms germane to our contemporary AI environment, one might note that today's programs use techniques like back-propagation to revise and update their own rules for discriminating and analyzing information. Back propagation does appear to solve for the very technical problem Neisser pointed out, related to selection: "One of the most serious inadequacies" of computers is that "the executive routine … must be established by the programmer at the beginning. Although AI programs can easily 'learn' (modify themselves as a result of experience), none so far can make major developmental changes in its own executive routine."[539] In other words, there is no "turning round on its own schemata" or, simply put, recognizing its own "ways of seeing" and thinking and applying them to future perceptual acts and problem-solving endeavors.[540] This is a resolutely qualitative capability of human cognition. And it involves both thinking inside and outside oneself. That is, it means acquiring enough experience and skill to recognize modes of preattentive vision and associative thought other than those currently active—available for selective apprehension either in one's environment at large, or within one's own memory bank of schemata. But the result differs from backpropagation because it is an entirely new or different heuristic for the activity of the mind.

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[537] Neisser, *Cognitive Psychology*, 286.

[538] Neisser, *Cognitive Psychology*, 293.

[539] Neisser, *Cognitive Psychology*, 296.

[540] "Ways of Seeing" refers to John Berger's 1972 television series of the same name, and the related book. The series was a postmodern intervention on art historical renderings of visual perception, and does not cover the subject of computer pattern recognition. Nonetheless, it implicitly gets at the plasticity and culturally shaped aspects of human vision that Neisser is, too, describing.

Perhaps the challenge that arises in distinguishing the two arises from thinking of the brain's physical properties as a direct explanation for the ways of the mind. One someone reinvents one's own cognitive schemata, for example, the functional activity of the mind may take a sharp turn. We might think of the example of a shift in one's theoretical frame from that of classical physics to quantum mechanics, and an activation of one's perceptual anticipations and thinking based on these theoretical principles and assumptions. The cognitive alteration, according to Neisser's position, is not like revising one's experience and quantitatively adjusting the weights of one's neural arrangement to redevelop its synaptic structure, as backpropagation would suggest. Instead, it is a qualitative, and lateral or parallel, paradigm change. The study of subatomic behavior need not cancel out all the principles of Newtonian physics, for example. This aspect of the mind that seems qualitatively distinct from the ontological principles of the computer was nonetheless, for Neisser, supported with neurophysiological evidence: "Shifts of attention" such as focusing on one perceptual object and that enable new criteria for selection "are not reflected in quantitative reductions of the inflow along certain nerves, as was once supposed, but by very general changes in cerebral activity…. This view is confirmed—or at least not contradicted—by recent work in sensory neurophysiology."[541] Thus Neisser saw his cognitive psychology theory as compatible—if not directly amenable to a one-to-one, localized mapping—with the organizational activities of the brain.

Beyond the empirical endeavor to produce such scientific explanation, Neisser was proposing a paradigm shift in his field's understanding of human perception and cognition by highlighting assumptions under which much of psychology and neurophysiology had been operating since the dawn of cybernetics in the 1940s. In his 1976 monograph *Cognition and Reality*, Neisser takes the overt stance that human perception, memory, and cognition, are simply not replicable in the computer. The reason for this, Neisser argues, is in the incompatibility between selection and reduction, as heuristic principles for describing how humans process complex environmental stimulus and formulate new complex ideas. Neisser directs readers' attention to a fundamental assumption among twentieth-century scientists that the brain, and the consciousness it supports, has a fundamentally fixed capacity. Despite the brain having "millions of neurons, in unimaginably subtle relationships with one another," a logical proposition has nonetheless prevailed that, since the it carries and stores information and is itself finite, it is subject to the principles of the mathematical theory of communication. Neisser paraphrases the theorem as such: "when the rate of information input to any finite channel exceeds a certain value (called the channel's capacity) not all of this can be transmitted without error."[542] But we might note, in Neisser's earlier work on novelty, erring is a necessary event in perceptual learning, understood as a practice that enables both maturation (through habituation) and authentic discovery (through the breaking of perceptual and cognitive habits). The principle of information reduction—the practice of separating signal from noise, and rejecting the noise from the channel—implicitly suggests that alternate frames of reference are discarded as well. If the

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[541] Neisser, *Cognition and Reality*, 87. In a note on page 106, Neisser describes this work as follows: "Hernandez-Peon and his colleagues (1956) originally reported that the afferent signals in the cat's auditory nerve produced by a train of clicks were reduced when the cat became interested in a visible mouse. Worden (1966), however, has shown that this result was artifactual. Picton, Hillyard, Galambos, and Schiff (1971) found no change in human auditory-nerve activity as a result of shifts in attention, and their findings have been repeatedly corroborated. A recent review of Hillyard and Picton (in press) shows that selective attention is accompanied by a wide variety of changes in cerebral evoked potentials, but these changes are compatible with many theoretical interpretations."

[542] Neisser, *Cognition and Reality*, 98.

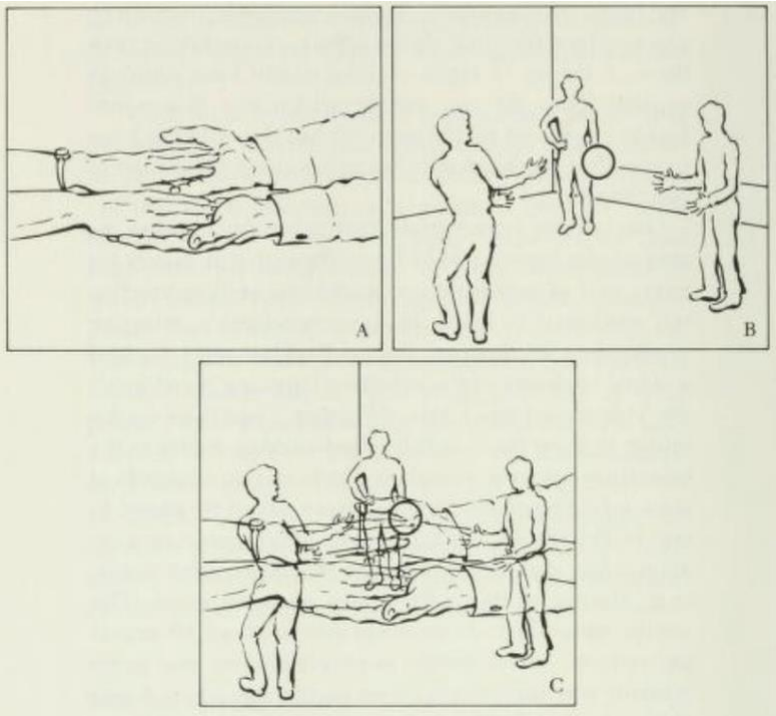


Figure 27: Neisser's "selective looking" experiment, in which subjects switched attention while watching superimposed film footage. Source: Neisser, Cognition and Reality*, 86.*

channel is programmed to recognize the goblet alone, it can never recognize Peter Paul. Neisser asserts that "human abilities do have limitations, but they are not so monolithic or quantitative as such a … filter theory … would suggest. The very concept of 'capacity' seems better suited to a passive vessel into which things are put than to an active and developing structure" as the nervous system and concordant practices of the mind.

Everyday experience and the commonsense reasoning humans engage in goes quite far in demonstrating the point that perceptual selection is unequivocally not reduction, Neisser claims. When one picks an apple from a tree, for example, one need not actively reject all other apples but just work one's way to the apple single that catches the eye and looks appealing. In *Cognition and Reality* Neisser draws on decades of research on human selective attention to formulate a hypothesis, and buttress it with experimental research, that there is in fact no internal mechanism for selection at all. While neurophysiologists and even his own work with Selfridge on the Pandemonium had conflated reduction and selection and attempted to model its switching behavior (e.g., feature pickup as a binary choice), Neisser now was finding that selection does not result from a brain-based logic gate that excises excess sensory information. In an experiment that involved overlaying two independent videos of figures playing different games and playing the overlapping videos simultaneously on one television screen, subjects were asked to attend to one of the games, and then the other, in short sequences. Neisser and his colleagues found that subjects had just as easy a time following a single game when it was superimposed as when it was shown on its own. Demand characteristics, as expected, playing a significant role in directing unconscious preattentive processes and focal attention. But the ease with which subjects selected this and then that perceptual event from within the superfluous mix of visual information gave way to the unanticipated theoretical finding selective attention is exceptionally plastic, even more so than the brain's neural pathways. Therefore, there appears to be no interior selection equipment, so to speak. The mind commands the eye in what to look for, or in other words, "attention is nothing but perception; we choose what we will see by anticipating the structured information it will provide."[543] It then readily adapts its charge based on what appears to be available, or whatever surprises, in the complex environmental field.

[543] Neisser, *Cognition and Reality*, 87.

The dialectic between focus and ambiguous informational flux that is, for Neisser, the stuff of the mind's highest-order perceptual activity and reasoning. It is also a particularly astute argument against a relay-based understanding of the central nervous system, that prompts twenty-first-century humanistic and scientific research into so-called "digital brains," or our assumptions about their ontology, capabilities, and their political implications alike. Despite that much of the philosophical origins on human reason have for centuries encouraged people to "report the singleness of consciousness, … introspection does *not* necessarily show that one is aware of only a single thing at a time."[544] Perception, thought, and motor activity work in concert to navigate through primary focuses and secondary, or "shadow," ones.[545] For example, "skilled pianists can shadow prose while sight-reading music at the piano, and professional typists can type from copy while shadowing or while reciting nursery rhymes from memory."[546] An analogous example of primary and shadow focus would be that which is required of the human driver, who must coordinate responsive action to environmental elements often coming from areas outside of one's focal attention. If we appropriate Neisser's theoretical argument—one that holds philosophical as well as social and political weight—this capability of operating with clarity in scenarios with high degrees of vagueness is perhaps one which we cannot withstand to subsume within the machine, no matter AIs quantitative capacities and sophisticated relay structures in the twenty-first-century. Intertwined with the nuances, multiplicities, and excesses of experience, "consciousness is," in Neisser's words, "an aspect of mental activity, not a switching center on the intrapsychic railway."[547] In other words, when a subject sees and acts consciously, she is engaging in a dynamic activity that is embedded within the noise, interacting with and making provisional selections within the environments qualitative complexity.

[544] Neisser, *Cognition and Reality*, 104.

[545] Neisser, *Cognition and Reality*, 86.

[546] Neisser, *Cognition and Reality*, 92–93.

[547] Neisser, *Cognition and Reality*, 105.

—Conclusion—

"No one knows how to build common sense into computers." This is the reason given for why "autonomous" technologies such as self-driving cars will not be safer or more effective than human beings at responding to and operating within uncertain environments, as published in 2021 by the Stanford-initiated publication *The Gradient*.[548] Meanwhile, the journal *Nature reviews physics* in 2022 commissioned a seminar and special-issue series on the subject of AI-led scientific discoveries. A handful of invited scientific experts commented on the editors' question: "As physicists are increasingly reliant on artificial intelligence (AI) methods in their research, we ponder the role of human beings in future scientific discoveries. Will we be guides to AI, or be guided by it?"[549] Despite the question's subject being posed as concerning scientific discovery, the contributors nonetheless debate about how the AI program and the human scientist will interface with one another. Some argue that we need to train AIs to obtain a level of scientific understanding such that they could output not simply observed patterns but could communicate already abstracted laws and theories.[550] Others in the *Nature reviews physics* issue favor training people in the ways of the AI, such that the human scientist should, in the future, be able to perceive and rationalize as does the machine. With all of this emphasis on translation, the contributors betray a concern for a profound perceptual gap between the respective ways of human and machine understanding.

The debate also raises a more basic and generalizable question: how might we recognize the machine's discoveries *as* discoveries instead of errors, mere anomalies, or misrecognitions? As much as doing so may require expert knowledge among those individuals and groups identifying a discovery as such, my foregoing analysis of key moments in the history of automated perception and cognition has stressed how initiatives to understand and model in the computer human processes of abstraction have time and again encountered the central role of common sense in both situating bodies in space and enabling coherent if also discordant social discourse. What levers would we have for coming to agreement around, for example, the threshold of "meaningful human control" in semi-autonomous systems in our existing and future social and political institutions if we strip the conditions for common sense making?

Even if the technological conditions prompting this question—artificial intelligence programs oriented toward "general intelligence"—are historical exceptions, the underlying

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[548] Steve Shwartz, "Art Self-Driving Cars Really Safer Than Human Drivers?", *The Gradient* (2021), https://thegradient.pub/are-self-driving-cars-really-safer-than-human-drivers/.

[549] *Nature reviews physics* editors, "Defining physicists' relationship with AI," *Nature reviews physics* 4 (December 2022): 735.

[550] See Mario Krenn et al., "On scientific understanding with artificial intelligence," *Nature Reviews Physics* (*Perspectives*) 4 (December 2022) 761–768. This proposition aligns with a broader subfield within AI called mechanistic interpretability, which aims to probe the black-boxed algorithm to reveal itself by way of the use of other, interpreter algorithms that output data representations of the black-box's inner workings. See the research profile of Max Tegmark, who is working in the field of AI safety and mechanistic interpretability with neural networks: https://physics.mit.edu/faculty/max-tegmark/.

concerns regarding the place of perceptual experience in the realm of scientific and technological advancements is not. In 1963 *Encyclopedia Britanica* invited key thinkers to muse on whether "man's conquest of space [had] increased or diminished his stature."[551] The political philosopher Hannah Arendt responded with an essay that probes at the dual meaning of "stature" with respect to not only expeditions into outer space but also modern science's "conquest" of quantum space and its splitting of the atom.[552] This crowning intellectual and practical human achievement, if we want to call it that, was contingent upon a disinterest in its implications—the development and use of nuclear weapons—which Arendt argues is a consequence of modern science's displacement, excision, of human worldly experience.

Arendt formulates her critique not based on arguments that alienate modern science but from within scientific conceptual discourse itself. For example, in describing the pursuit of scientific understanding of atomic structure, physicist Niels Bohr had argued for "an appropriate widening of the conceptual framework" within which scientists were working:[553] "Only by renouncing an explanation of life in the ordinary sense do we gain a possibility of taking into account its characteristics."[554] Ordinary refers to the stuff of perceptual experience that makes natural phenomena available to the human senses, but Bohr was recognizing the impossibility of apprehending both the states of things—capable of being represented pictorially or symbolically—and their processes of becoming, or the regularities and laws that disclose "what lies *behind* natural phenomena."[555] But Arendt alerts us to the condition that, as the modern physicist has pursued a wider conceptual frame, its perceptual frame has narrowed. This phenomenon is explained by Werner Heisenberg's discovery of the uncertainty principle, which states that "'there are certain pairs of quantities, like the position and velocity of a particle, that are related in such a way that determining one of them with increased precision necessarily entails determining the other one with reduced precision.'"[556] Heisenberg expresses the implication of the uncertainty principle for scientific discovery: "We decide, by our selection of the type of observation employed, which aspects of nature are to be determined and which are to be blurred.'"[557]

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[551] For a description of the initial prompt, see "Hannah Arendt on the conquest of space," *Britannica,* https://www.britannica.com/topic/Hannah-Arendt-on-the-conquest-of-space-2003648.

[552] Hannah Arendt, "The Conquest of Space and the Stature of Man," *The New Atlantis* (Fall 2007 [1963]): 43–55, 48.

[553] Arendt, "The Conquest," 47, citing Niels Bohr, *The Philosophical Writings of Niels Bohr* (Woodbridge, CT: Ox Bow Press, 1934), 61.

[554] Arendt, "The Conquest," 44, citing Niels Bohr, *The Philosophical Writings*, 31, 71. See also: See also Henk W. De Regt, *Understanding Scientific Understanding* (Oxford, 2017) for a discussion of the problem of visualization and intelligibility in twentieth-century quantum physics, especially Chapter 7: Visualizability and intelligibility: Insight into the quantum world." De Regt's theory of scientific understanding is a source for Krenn in the *Nature* article, which also cites De Regt and Dennis Dieks, "A Contextual Approach to Scientific Understanding," *Synthesis* (March 2005) 144, no. 1, pp 137–170).

[555] Arendt, "The Conquest," 44, citing Niels Bohr, *The Philosophical Writings*, 31.

[556] Arendt, "The Conquest," 52, citing Werner Heisenberg, *Philosophic Problems of Nuclear Science* (London: Faber and Faber, 1952), 73. We may note that such a "widening" would have to coincide with a pragmatic condition of the twentieth-century physicist, as described by the Gestalt psychologist Wolfgang Köhler, who recognized the highly narrow perceptual frame of the twentieth-century physicist a la Heisenberg's principle. See his discussion of contemporary physics in Wolfgang Köhler, *Gestalt Psychology: An Introduction to New Concepts in Modern Psychology* (New York: Liveright, 1947).

[557] Arendt, "The Conquest," 52, citing Heisenberg, *Philosophic*, 73.

Heisenberg's conceit establishes a periodizing feature of the modern era, and Arendt then draws out its political and philosophical implications. The "categories of ideas and human reason … have their ultimate source in human sense experience," and human beings only ever achieved these abstracted ways of the mind through being firmly rooted in a world, and further a world that was held to be sensed in common.[558] If not through perceptual experience, how might we obtain a shared sense of reality? Arendt ultimately argues that, as Heisenberg's uncertainty principle also reveals, "man in his hunt for 'objective reality' suddenly discovered that he always 'confronts himself alone'"[559] Who or what is in this reflection?: "ever more ingenious machinery" that does the observation and the thinking in our stead, as well as the more alarming condition that "whereas the often mentioned 'lag' of man's political development with respect to his technical and scientific know-how is no more than a red herring…; it can only divert attention from the main problem, which is that man can *do*, and successfully do, what he cannot comprehend."[560]

Arend's mid-century critique coincided with the development of the then-nascent artificial intelligence technology, which was both making human perception a subject for modeling and was operating according to operational and electrical principles that simultaneously evaded observation and mimetic representation. Meanwhile, the very theories of human perception, offered by the likes of William James, the Gestalt psychologists, James J Gibson, Gregory Bateson and Ulric Neisser, were emphasizing not so much a means of capturing the states of things as they appear in any abstracted flash to the senses—and therefore as a straightforward means for representing knowledge in a way of the Enlightenment-era —as a temporally unfolding, (neg)entropic flow. Human seeing was conceived as a doing, and the subject of analysis moved from the spatialized *stuff of perception* to the biologically, psychologically, and institutionally determined and temporally ordered *rules of perception*—even if they were always just out of immediate view of conscious awareness. But such a pursuit, these humanistically oriented empirical researchers found, would always reveal the exchange between the representation and the processes that made it possible, and how conscious awareness arises in the recognition of the gap—the recognition that there is always an implicit or explicit selection of the frame of observation and experience. Perhaps Arendt was most pointedly critiquing, then, an evacuation of autonomy, and therefore political responsibility, regarding cultural and scientific the selection of frames.

In the twenty-first-century, a predominant theme in artificial intelligence research is the pursuit of machines that operate flexibly amid ambiguous conditions. Uncertainty in both perceptual, external environments and in a deep-learning program's internal structures is understood to be the condition that will enable machines to exhibit "general intelligence." The project of *Patterning Recognition* has been to show how this negotiation of indeterminate environments and determinative perceptual frames has organized modern ideas about how humans access and co-create a shared world and meanwhile how the pursuit of intelligent machines has confused that autonomic, and sometimes autonomous human activity, as one that can be outsourced to the realm of automation.

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[558] Arendt, "The Conquest," 47.

[559] Arendt, "The Conquest," 52.

[560] Arendt, "The Conquest," 46.

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