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Common Creativity

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Creativity is often conceived in terms of insight, innovation, and invention realized through technical mastery and skill. Challenging this individualistic model are "inventions" like writing, something that surely gave no clue to the form it would ultimately take—script—or the ways in which it would reorganize behaviors and brains in the cognitive state known as literacy. Here writing is analyzed as a tool used collectively and collaboratively. Collective, collaborative use enabled the tool to become increasingly effective at eliciting specific behavioral and psychological responses. Collective, collaborative use also subjected the tool to the combined force of the individual variability represented by different user and material combinations over time. Combined variability influenced tool form toward features reflecting both the average behavioral, physiological, and psychological capacities of the tool-using community and points of maximal usability. The result offers a new model of creativity, one based not on the individual but on collective, collaborative use and incremental change in behaviors and brains, materially accumulated and redistributed between generations. The model presents aspects of human innovation that escape the individualistic model by focusing on ordinary tool-using behaviors and sustained use within social groups as the critical elements.

Keywords: creativity; innovation; writing; literacy; Material Engagement Theory

> *Concevons qu'on ait dressé un million de singes à frapper au hasard sur les touches d'une machine à écrire et que, sous la surveillance de contremaîtres illettrés, ces singes dactylographes travaillent avec ardeur dix heures par jour avec un million de machines à écrire de types variés. Les contremaîtres illettrés rassembleraient les feuilles noircies et les relieraient en volumes. Et au bout d'un an, ces volumes se trouveraient renfermer la copie exacte des livres de toute nature et de toutes langues conservés dans les plus riches bibliothèques du monde. (Borel, 1913, p. 194)*
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> *[Let us imagine that a million monkeys have been trained to strike at random on the keys of a typewriter and that, under the supervision of illiterate foremen, these typing monkeys work hard ten hours a day with a million typewriters of various types. The illiterate foremen would collect the blackened sheets and bind them in volumes. And after a year, these volumes would be found to contain the exact copy of books of all kinds and all languages kept in the richest libraries in the world.]*

In Borel's whimsical tale, a million hypothetical monkeys have somehow been trained to strike typewriter keys randomly and, by working diligently for ten hours a day, ultimately manage to produce exact copies of books of all kinds and languages. Since its initial publication, the story has both expanded and contracted in its retelling, with monkeys numbering anywhere between infinity

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and six, production lasting anywhere between the end of time and a year, and the results spanning all the books ever written in any language to merely *Hamlet* on its own (Adams, 1979; Maloney, 1960).

As competent as the tale may be at illustrating statistical improbability, it is perhaps even more effective in helping us start to visualize the collective use of tools, along with the implications this has for creativity. Think of a tool—the typewriter, as in Borel's account, or, as will be discussed here, writing itself—not just as it is used by an individual, but as it is used by a million individuals, or, more modestly, by dozens or hundreds of users in a generation and thousands or more across multiple generations. The comparison yields two distinct models for creativity: an *individualistic model*, in which a single lucky monkey eventually writes a sonnet, and a *collectivistic model*, wherein the vast totality of monkeys, all save one, produce a mix of nonsense, noise, and bruises by banging away at the keys. If the collective use of tools by human societies produces more fruitful results, the lucky monk[2] and his hapless fellows nonetheless epitomize how we conceive creativity: as a fortunate outcome of a solitary effort—the rare insight, innovation, or invention—that emerges unexpectedly and serendipitously from a boundless field of identical but uninspired toil.

To contrast the individualistic and collectivistic models, we will consider here two cases, each of which contains several elements: the tool user; the tools and materials; the productive act; and the results. The first case will be blacksmithing (Keller, 2001; Keller & Keller, 1996, 1999), which encompasses the blacksmith (the tool user); hammer, anvil, forge, and iron (the tools and materials); heating and hammering (the productive act); and ironwork, the set of implements the blacksmith can produce (the results). The second is writing, which encompasses the writer (the tool user); stylus and surface (the tools and materials); the act of writing (the productive act); and writing, not so much in terms of what is written but the set of characters that comprise the writing system itself (the result). Most of the time, it will be useful to consider these elements separately in order to unpack what each contributes and how each will change through their interaction. At other times, it may be useful to consider them together as events in which movements, judgments, tools, effects, materials, results, and contexts are combined into a single, inseparable whole, albeit one with multiple elements and variables. This inseparability is particularly appropriate when it comes to writing, where even the language we use to discuss it does not easily distinguish the productive act (*writing*, the verb, meaning the act of forming characters on a surface with an instrument) from what it produces (*writing*, the noun, meaning the characters serving as visible signs of ideas or words). Contrasting the models, then, will be a matter of considering these elements and events on an individual basis, as in the one-in-a-million monkey, or cumulatively, as in the 999,999 less talented of its fellows.

The Individualistic Model Applied to Blacksmithing

The individualistic model has become familiar through its use in analyzing *creativity*, the ability to transcend what is known—be it ideas, rules, forms, patterns, relations, etc.—to fashion something else that is both novel and meaningful. A classic illustration of individualistic creativity involved blacksmithing (Keller, 2001; Keller & Keller, 1996, 1999). The blacksmith was the quintessential artist, working tirelessly and most likely alone at his forge, with creativity "an 'internalist' process occurring solely in [his] head" (Kirsh, 2014, p. 5). If he worked by himself to produce his art, his creativity was nonetheless underpinned by enabling capabilities and conditions.

[2] The term "monk" is meant to evoke the monkey in "Animal Fair," a folk song attested as early as 1898 and still popular when the author was young. Artistic license presumably shortened "monkey" to rhyme with the elephant's trunk.

He was skilled at using his tools, knowing intimately what each one could do, which one to use to produce which effect, and how to wield them to achieve specific effects. He had used these tools to the point where his performance with them was automated, a degree of mastery requiring, on average, ten years; his performance had also become routinized, with individual motor movements seamlessly combined into packages whose choice and implementation could be strategized together, not unlike the moves in chess (Wynn & Coolidge, 2010). Behavioral automaticity and routinization, in turn, had freed his cognitive resources—attention and working memory—so they could wander, imagine, and detect and react to problems, mistakes, happenstance, and opportunities alike. He had become able to visualize a goal, work toward it, and alter it as needed. He had learned how his materials—metals like iron, tools like hammers—would perform. All his senses were engaged, such that he would know what his materials were doing under the various conditions of hammering and heat, not just by sight but also by feel, sound, smell, and perhaps even taste. Meaningful novelties would then emerge from the interactions of the blacksmith's skill, his tools, his materials, and chance (Wynn & Coolidge, 2014).

There is an ingredient essential to this individualistic creativity. It is not, as might be imagined, the creative impulse—the somewhat mystical spark that yields an idea, rule, form, pattern, or relation that is both novel and meaningful—but the malleability of the material form, its ability to change through use. For the blacksmith, the iron being heated and hammered is the malleable form. It transforms and takes shape within the range permitted by its substance, its temperature, the way in which it has just been struck, and the smith's abilities to judge its responses to heat and blows and react to those responses. For the million monkeys, the characters imprinted on the page are the malleable form. The idea that writing is malleable is perhaps counterintuitive, since it isn't typically thought of as a material form at all, but rather, as something symbolic, and hence, in some fashion, something that stands outside the material realm altogether as purely mental. This categorization as mental and immaterial is especially true of writing in the sense used here: not the stream of gibberish most monkeys will produce but the alphabet used to write this sentence. Its ability to recombine into endless streams of just about anything we can conceive, including the gibberish that the million hypothetical monkeys would undoubtedly produce, makes it seem the very opposite of material—a term associated with solidity, fixedness, durability, rigidity, and inflexibility—as does its ability to stand for something else, the symbolic quality wherein its meaning has almost nothing to do with its material form.

Nonetheless, writing is a material form, and its malleability becomes perceptible when it is considered diachronically, as chronologies of characters considered over cultural spans of time rather than synchronically, as any particular set of characters at a specific time or in a specific body of work. It took a long time for the material form of writing to become the various sets of characters, the scripts highly expressive of language, that we now take for granted—perhaps several thousand years and all the generations they imply. Its incremental change in form depended on generation after generation of individuals learning to read and handwrite whatever form was currently available to them—an ontogenetic acquisition involving a suite of behavioral and psychological changes—and then merely reading and handwriting. As will be argued here, these common, everyday interactions with writing had the potential to change its form, both as verb and as noun, however slightly.

Similarly difficult to apprehend is the material form's ability to accumulate and distribute these almost imperceptible changes, which represent cognitive effort (Hutchins, 1995). This is difficult because we don't often think of our own learning to read and write in terms of the behavioral and psychological changes these things entail, or of the current form of writing— for example, the Latin alphabetic characters as embodied by the Times New Roman font in regular style at size 12—as reflecting not only our own behavioral and psychological changes when we learned to read and write but also those of the generations of users who preceded us in learning, using, and shaping the material form. As these behavioral and psychological changes were accumulated and distributed, they transformed the earliest forms of sustained writing, the handwritten pictures of Mesopotamia and Egypt, into scripts like cuneiform and demotic. Writing also represents inventions and refinements in multiple domains, from reed styluses, papyrus, and clay to quills and ink and paper, to the metals and plastics of typewriters, the electronics of computers, and the physics and biomechanics that govern the QWERTY keyboard. These contributions, which are not an exhaustive list, reflect an amount of cognitive effort that far exceeds what any one individual or society could feasibly assemble.

Since it is well known in the literature, individualistic creativity will not be detailed here further, except to consider the effects that engaging with tools and materials in productive behaviors has on their users. Using tools changed both blacksmith and writer psychologically, physiologically, and behaviorally; such change is implicit in any form of learning, especially when it involves repeated motor movements. Their brains formed synaptic connections, creating memories, both declarative and procedural. Hand–eye coordination and fine motor control improved, and for the blacksmith, muscles became stronger and larger, particularly those of the arms. At some point, both users became able to execute, without conscious thought, the movements with tools they had once performed with focused attention and careful deliberation. As they gained proficiency, their interaction with the tools changed too: they used them with greater precision, and they held them at slightly different angles and pressures. But these changes were not unidirectional, since both use and habits also affected the tools, which wore differently as they were used and by which individual. Nor were these the only variables, as days of peak and off performance, better and worse materials, environmental fluctuations, and chance elements combined to make each new interaction of user, tools, and materials different, however slightly, than any other, past or future.

Tools had further effects still, though these differ for blacksmithing and writing. If the blacksmith had lacked, or been unable to develop, the physical capacity to wield the hammer with sufficient force, he wouldn't have become a blacksmith, a hurdle he once faced. If he hadn't been able to apply his tools with sufficient precision to produce ironwork with an adequate usable functionality, he wouldn't have stayed long in his profession, another potential impediment. The tools, in effect, allowed him to become part of a profession, the community of those who can use and do use blacksmithing tools. They selected him to his task and, in doing so, determined his daily activity, his concerns and career, his social role, and even his self-conception. If the tools now functioned to admit particular individuals into their community of users, it is because, as they assumed their current form, they did so in ways that reflected the psychological, physiological, and behavioral capacities of past users and purposes. Their forms and functions were shaped by the many hands that wielded them before the blacksmith picked them up; their changes have accumulated the results of that collective use, distributing them to the blacksmith to influence both what he does and how he does it. Thus, the blacksmith's tools and procedures represent technological continuities that overlap the collectivist model to no inconsiderable extent.

In comparison, writing—as both verb and noun—is more accessible than blacksmithing. Within the range of access permitted by any particular society, writing is something that most people are expected to do, unlike blacksmithing, which is a more specialized endeavor. Writing is also something that most people can do. The fact that most people can read and write, given the opportunity to learn, is a crucial difference. Whether it's performed with pen or keyboard, writing is not particularly picky about its users. They require no unusual attributes of attention, working memory, eyesight, physical strength, or, for that matter, fine motor control, though the latter certainly enables their better performance in matters like handwriting and typing speed. All that writing requires its users to have is average human capacities and capabilities. This high accessibility reflects the number of hands and generations that writing has passed through, a process of use that enabled it to change in form yet remain synchronized to the human average (Overmann, 2016, 2021, 2022). But these effects—tools on users, as in blacksmithing, and users on tools, as in writing—have now taken us well beyond the individual, so we must now turn to the collectivistic model of creativity to discuss them further.

The Collectivist Model of Creativity

To aid the comparison with the individualistic model and avoid overtaxing the metaphor, we will replace the monkey business with typewriters with an equally impressive number of blacksmiths. We must then recognize a million blacksmiths for what they really are: a boundless field of mundane activity. But they are also a million individuals, as well as a million million opportunities for different outcomes, since each interaction of user, tools, and materials is a unique combination of capacity, context, and chance. Some of the blacksmiths will be stronger or more determined than their fellows, and these will wield their hammers with greater force. Some will be more observant, or perhaps have better eyesight, maybe greater analytical powers, slightly finer motor control, or a better working memory capacity, and these may learn to correlate the striking of iron with the production of symmetry and shape perhaps more quickly than the norm. Some, within the span of attention typical for humans and required for blacksmiths, will get bored more quickly than others, and as a consequence, these will not be as likely to develop their potential for proficiency in their art, relative to those who practice longer. Most will attend their task with diligence, though their motivations for this will differ. Some will practice longer but will also lack the capacity for true mastery, becoming competent but not gifted. Many will prefer working during the day; a few may like to work at night. Some will make mistakes, and not all of these will be unfortunate outcomes.

Nor do these behavioral, psychological, and physiological dispositions and traits exhaust the possibilities for variation and variability. Fluctuations in environmental conditions— lighting, temperature, humidity—will affect things like visibility, motivation, and how quickly iron cools. And, while the million hypothetical sets of blacksmith tools are deemed identical and assumed to function as advertised, some percentage of the inventory will in fact be newer and less familiar; others will be more worn, thinner, lighter, and perhaps a bit persnickety; and a few will have faults that may become apparent at some point during use. Each and every time the blacksmith uses these tools, they will differ, and he will wield them in a slightly different manner. Every bit of material he works with will differ too, however slightly, from all of the other material he has ever worked with. His ability to produce invariant results—despite his own variability and the variability of his tools and materials— depends on his ability to learn to integrate and control the variable domains and sense and respond to their variability (Nonaka, 2011, 2013; Nonaka et al., 2010).

All this variability is essential to achieving occasional insight, innovation, and invention, just as the individualistic model predicts. And yet, it is the mundane field that has greater utility in examining something like the "invention" of writing. Consider now the writer and writing, not just as an individual tool user practicing his craft, but as generations of them working in concert. Some are masters of their domain, others are novices or apprentices, and a few are simply less talented, no matter how long they've practiced. Their variability in proficiency and skill combines with all of the other matters potentially influencing how they use their tools and materials: all the different combinations of behavioral, physiological, psychological, material, environmental, and contextual capacities and traits, along with chance. Cumulatively, all this variability will have several interesting effects, particularly on the product (*writing* as noun), its production (*writing* as verb), and its users (the writers themselves).

This cumulative variability will influence writing, as it changes through use, toward average user capabilities and capacities because—when it is considered in its totality across the broad range of collective use—some of the highs in user performance will cancel out some of the lows. The material form of writing, as it changes, will accumulate the behavioral and psychological changes in its users, and it will distribute these changes to new users when they learn to read and write. And finally, writing will change the writer in ways that reflect the acquisition of knowledge and the development of skill. Changed writers will write differently because their experience and proficiency will affect their hand–eye coordination, recognition and recall functions, habituation, automaticity, fine motor control, and response flexibility; and changed writers writing differently will produce new written forms with the potential to change the writing system even further, within the averaging effects of cumulative variability.

What's at issue is the process whereby a material form like script is realized. It's not something that can be invented or realized through innovation or insight. This is because its effects on behaviors and brains cannot be foreseen, predicted, or imagined. Without those effects on behaviors and brains already being present, script is unusable. Cuneiform and demotic, the scripts of Mesopotamia and Egypt, are meaningless to anyone who has not been trained to read them. In other words, there's no way to invent a tool that requires the inventor to possess behavioral and psychological qualities that can be gained only by already having and using the tool. Indeed, a method of invention shouldn't presuppose what it invents. Individual effort, whether invention, innovation, or insight, is simply not the way that script and the associated cognitive state—*literacy*, in the way we understand the term in conjunction with our own reading and writing—came into being.

But the collectivist model offers a process of achievement, one that occurs through and because of the boundless field of everyday, commonplace activity. Not unlike the million blacksmiths, hundreds of individuals in ancient times, perhaps thousands, wrote small pictures by hand—enough hours per day, days in each year, and years over a lifetime—that their behaviors and brains changed in response. These behavioral and psychological changes in the users, in turn, enabled them to make incremental adjustments to the way in which they wrote the characters. These subtle adjustments to character forms became the new standard, with those now indoctrinated into the system of writing learning to read and write with the subtly adjusted forms and acquiring, in the process, the requisite behavioral and psychological changes needed to engage with and through them. Script and literacy were realized through generations of incremental psychological and behavioral change that were in turn realized by engaging slightly altered versions of the material form of writing. Collaborative, temporally distributed use enabled the material form of writing to change under the weight of its use in ways that reflected and thus accumulated the incremental change in the behaviors and brains of its users. It also redistributed those changes to new users when they learned to use the tool, giving them a new starting position, if you will, from which to modify the tool.

A Collectivist Case Study: A Short-ish Description of How Script and Literacy Developed

Writing emerged in Mesopotamia and Egypt in the middle of the 4th millennium BCE. Initially, it took the form of small pictures—representations that almost anyone could produce and interpret with a minimum of training. The requirement for training was so minimal, in fact, that knowing the language in question wasn't even required, then or now, to approximate the semantic meanings that the pictures conveyed. By the 2nd millennium BCE, these systems of writing had become *scripts*, systems of contrastive elements able to express particular languages with fidelity and whose understanding required specific exposure to and training with the material form that was writing. It also assumed a knowledge of the represented language.[3] The ability to engage these later forms constituted a literacy analogous to our own. If today we understand literacy as the ability to read and write, it must nonetheless be recognized that this definition is broad enough to encompass both the initial recognition of pictures and the later engagement of script, while utterly failing to capture significant differences between the two.

Essentially, developing script and literacy was a process in which engaging the tool (*writing* as both verb and noun) changed the participants in ways that let them change the tool, so that the tool ultimately took a form quite different from the one with which it started. But while each individual writer changed the tool by producing the characters in a slightly different way, this was not an individual effort but a collective one. Think of it now, not as a million blacksmiths or writers, but as a million critics, each offering a different opinion on how things ought to be, a dialogue of difference followed by a million negotiations and compromises. Nor was this the only influence on the material form, as each individual engagement contained its own potential for variability and chance. The end result was a little bit of all of them, nicely averaged to maximize agreement. This averaging effect is why almost anyone can learn to read and write today: we learn to use a tool that has been shaped by so many hands that it now requires only average capabilities and capacities in things like attention, working memory, and coordination (Castles et al., 2018; Daneman & Carpenter, 1980, 1983; Daneman & Green, 1986; Nakamura et al., 2012).

The process, as thus described, is not meant to preclude the possibility that insights, innovations, and inventions occurred as part of the development of script and literacy. These traditional forms of creativity were undoubtedly part of the process, for they are implicit in the use of tools. But this raises another point, one that also tends to be missed in the individualistic model's implicit prioritization of exceptionality and genius. This is the everyday realization of small efficiencies, something most people do, often without much conscious awareness or realization of its creativity. Anyone who must perform a manual task—especially if it entails significant resources of time or effort or if it is performed frequently—will find ways to make the task easier, both physically and mentally. This is somewhat different from automaticity, though automaticity in motor movements and its concomitant freeing of cognitive resources is a plausible mechanism for noticing and analyzing things that might make the task easier. The motor movements needed

[3] Today, many people learn to read and write as children, and most children are taught to read and write their own language. There are situations in which people learn to read and write with a language they don't speak; this is not an uncommon situation for modern refugees.

to perform the task, the “what I need to think about to do this,” and the “where I put things” will economize, so that both using the tool and performing the task become just a little bit easier, a bit more organized, and perhaps a bit quicker (Kirsh, 1995). These small shortcuts and efficiencies can pass from person to person through observational means, both as the economizer performs the task and when others view its results; through demonstrations and corrections, when the economizer performs the task for novices and critiques their performance of the behavior; and possibly through discussions, on the condition that the efficiency becomes something the economizer finds worth mentioning.

While this multigenerational process of criticism, negotiation, compromise, and reorganization toward efficiency was underway and influencing the tool form, the users themselves were changing too, behaviorally and psychologically, in ways that reflected their use of the tool. These changes to behaviors and psychological processing enabled them, in turn, to change writing as they wrote, a mutualistic process of becoming (Malafouris, 2015). Perhaps they controlled the stylus more precisely, wrote more quickly, or ordered the characters or their elements differently. Such differences meant that writing changed in the precision and standardization of its form. The social nature of the tool use meant that the differences in the form of writing were communally displayed, exposing new readers to the alterations.

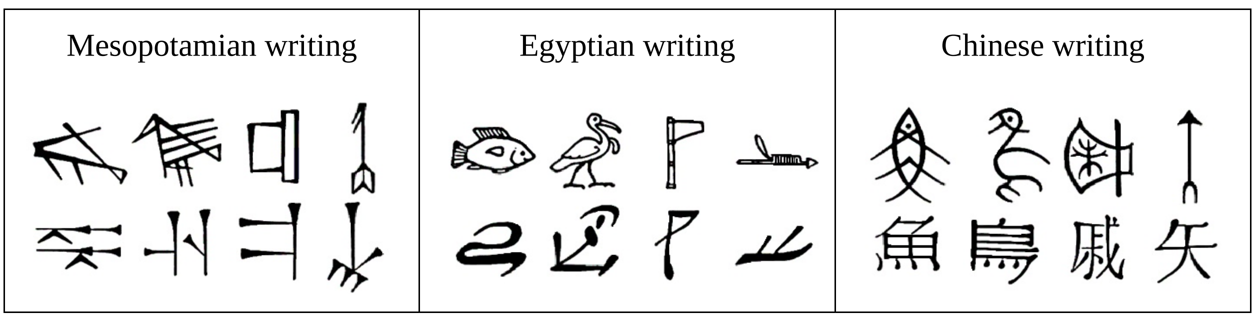

Figure 36.1 Change in form in early writing. Note: Early signs (top) are easy to identify as *fish*, *bird*, *ax*, and *arrow* because they resemble these objects. After a thousand years or more, the corresponding script forms (bottom) are more difficult to identify and differentiate. This change in form, known as “increasing abstractness,” was a training effect, wherein increased topological recognition relaxed the need for characters to depict and allowed written elements to become contrasted and defined in relation to each other. Key: Mesopotamian writing, top: Proto-Elamite (4th millennium BCE); bottom: cuneiform (2nd mil. BCE). Egyptian writing, top: hieroglyphs (4th mil. BCE); bottom: demotic (1st mil. BCE). Chinese writing, top: archaic (2nd mil. BCE); bottom: modern (CE 2nd mil.). Adapted from De Morgan (1905, p. 243, Fig. 38), a document in the public domain.

Writing not only responded to the changes in its users, its change in form accumulated their changes, so that each new generation of users had a slightly different material form to use. This meant that each new generation started in a slightly different place—not just with a different material form, but with a slightly longer learning curve to acquire a set of slightly larger changes to their behaviors and brains (these changes are detectible only when considered over centuries and millennia, as in the signs shown in Figure 36.1). This, in turn, necessitated increases to the duration and formality of the training and practice needed to acquire the ability to read and write. And in the meantime, the material form kept improving its ability to elicit specific behavioral and psychological changes in its users.

These changes paralleled many of the things that the blacksmith experienced as he became skilled at using his tools. At first, the tools were unfamiliar to him. Moving them required him to concentrate, and the results he produced with them were relatively clumsy. But with practice, the blacksmith—like the writer—became more coordinated, and so he was able to move the tools with greater precision and less conscious thought. The latter enabled him to pay more attention to his task, rather than the mechanics of tool use. He too discovered small economies—things he gained through trial-and-error, observations, and corrections. He became able to discern finer features in the implements he produced, and they, in correspondence, became increasingly finer in their form. It can be reasonably argued, however, that the ironwork he forges is somewhat less malleable than the characters of writing. Certainly, ironwork is produced with much less frequency than writing is. It is also socially transacted less often, with the individual pieces much less likely to be compared and interchanged with other ironwork, relative to the amount of between-member comparison and interchange implicit to a set of written characters. These qualities undoubtedly slow the pace at which the malleable form of ironwork changes, reducing—but arguably, not eliminating—collectivist effects.

We have not yet addressed the most dramatic change in written form: the transformation of sets of small written pictures with approximate semantic meanings into *script*, systems of contrastive graphic elements that are highly expressive of the meanings and sounds of particular languages. To understand this change, we must briefly detour into the modern neuroscientific understanding of literacy, for it provides the necessary insight into the suite of behavioral and psychological reorganizations that attend, for most people, the behavior of handwriting.[4] In a literate brain, the capacity for recognizing physical objects has become trained to recognize written objects as if they were physical objects, and to associate them with both the functions of language and the motor functions of handwriting (Nakamura et al., 2012; Perfetti & Tan, 2013; Roux et al., 2009). Training repurposes an evolutionarily provided ability to recognize objects, a function of the fusiform gyrus in the temporal lobe. Through training, the fusiform gyrus becomes able to respond not just to the stimuli that occur naturally in the environment but also to cultural inputs like written marks as well, a process known as neuronal recycling (Dehaene & Cohen, 2007). Today, we call that training "learning to read and write" and the suite of behavioral and psychological changes acquired in the process "literacy." What we learn to read and write with are characters: letters, if our script is alphabetic; syllables, for syllabaries; complex logograms, for logographic scripts. These are associated with protocols wherein we learn to produce the characters by hand, in a manner that specifies the elements and the order in which they are to be made, and with a frequency of repetition that ultimately enables us to recognize and produce characters not just with ease and legibility but automatically.

Scripts are a highly modified version of writing. They are systems of contrastive elements, in which the individual elements and features—lines, curves, angles, directions, and orientations—are meaningful both for what they are and in opposition to one another. For example, in the Latin alphabet, ***b*** differs from ***p*** in the direction of its vertical line (up or down), while ***q*** differs from ***p*** in its orientation (left- or right-facing). When writing had the form of small pictures, there were no protocols for learning to recognize or produce them. Nor was much learning required, as the pictures resembled familiar objects. The people using the tool just had to produce forms adequate

[4] Today, people learn to read and write, regardless of whether they have unimpaired or impaired mobility and can write by hand or not. Nonetheless, manipulating the material form of writing through handwritten production was essential to its ability to transform, necessitating the involvement of people with unimpaired mobility.

for recognizability; the production of these forms was highly individualized and variable. Nor were there dictionaries wherein their meanings could be ascertained; rather, the small pictures were meaningful for one of two reasons. Either they resembled something or their meaning was conventional. In Mesopotamia, for example, a drawing of a jar meant *jar* because it looked like a jar, while a quartered circle meant *sheep* through a social agreement that the particular sign had that particular meaning. While these signs were semantically meaningful, within a range of likely words, which word they actually meant was, to some degree, ambiguous. This placed the system under pressure to specify the intended words in some fashion, leading to the gradual inclusion of various techniques for specifying words and sounds: signs and elements that identify semantic categories (determinatives for names and places); convey sounds through visual resemblances (the *eye* for an *I* of the rebus principle); or express sounds through auditory resemblances (homonyms like *write* and *right*). These techniques made the visual appearance of the signs more complex, with the additional elements becoming subject to the same processes changing the written form.

The places where writing is thought to have emerged independently—Mesopotamia, Egypt, China, and Mesoamerica (Houston, 2008; Senner, 1989)—had several things in common. First, they not only invented writing, they kept at it for enough generations that literacy could develop.[5] And, within each generation, writers wrote a lot. As we now know from our neuroscientific understanding of literacy, repeatedly producing small characters by handwriting had training effects on the brains and bodies of the writers. As writers wrote by hand, hours per day and days per year, they became proficient at it. They experienced improvements in their ability to control the fine motor movements needed to produce the characters, coordinate the movements of their hands and eyes, recognize and recall the written signs they read, associate them lexically, and tolerate ambiguity in the written forms (Giovanni, 1994; James & Engelhardt, 2012; Longcamp et al., 2005; Roux et al., 2009; Sülzenbrück et al., 2011).

These effects can be seen in the forms of the characters themselves, considered over time in sign chronologies. In Mesopotamia, for example, the movements used to make signs became standardized; this is detectible in the elements used and the order of strokes, things that are recoverable because of the way clay surfaces behave when marks are superimposed onto them (Bramanti, 2015; Cammarosano, 2014; Taylor, 2015); the medium channels the form. This standardization implies routinization and automaticity, which enhance lexical recall (Giovanni, 1994) and free capacity in cognitive processes like attention and working memory for other purposes. Automaticity meant writers were better able to think about what they were writing (its content), rather than how they were writing (its production). In Egypt, two forms of cursive script developed: hieratic, a cursive form of the original hieroglyphs, and demotic, a script with far less resemblance to hieroglyphs. As a written form, cursive is distinguished by two things: It's more ambiguous—as a written form, it is characterized by "abbreviated signs, crowded writing, and unclear sign boundaries" (Veldhuis, 2011, p. 72)—and it can be produced more quickly than if the characters are drawn precisely. Cursive's increased ambiguity shows that writers had become able to tolerate a fair amount of imprecision in character form, a known effect of handwriting. The greater speed of production that cursive enables was also important, for it enabled writing to keep up with the increasing demands for its production, as well as better match the users' speed of thought.

[5] Mesoamerican writing does not appear to have achieved literacy to the same degree as the others, at least in the sense of the term as used here (and as defined in Overmann, 2016, 2022 and other publications), wherein literacy involves specific neurological reorganizations in the brain and the material form of writing becomes a system of contrastive elements. See discussions in Boone (1994) and Brokaw (2010).

There were further changes in the material form of writing. Signs became recognized topologically, through the combinations of their local details (lines, directions, angles) and global cues (surrounding characters). This is because as writers produced written characters that were meaningful in virtue of resemblances and conventions, their brains became trained to recognize these characters by their features, the elements or characteristics used to identify an object as itself (individuating) or tell it apart from others of the same type (distinguishing). Topological recognition relaxed the need for signs to resemble objects or retain conventionalized forms. This, in turn, enabled their elements to converge on points of maximal usability, features and contrasts that enabled them to be individuated and differentiated more easily. In Mesopotamia, this process took most of a millennium (Overmann, 2016, 2022), while in Egypt, it appears to have taken longer. Differences in social use may explain the temporal dissonance. In Mesopotamia, writing was primarily a bureaucratic tool, while in Egypt, writing was used for state and religious purposes that seemingly prioritized precise resemblance for artistic reasons. Loss of depictiveness, in turn, entailed that training and practice, along with the behavioral and psychological changes they implied, were increasingly required in order to recognize signs as they became more alike, contrastive, and simpler (Overmann, 2016, 2022; Overmann & Wynn, 2019).

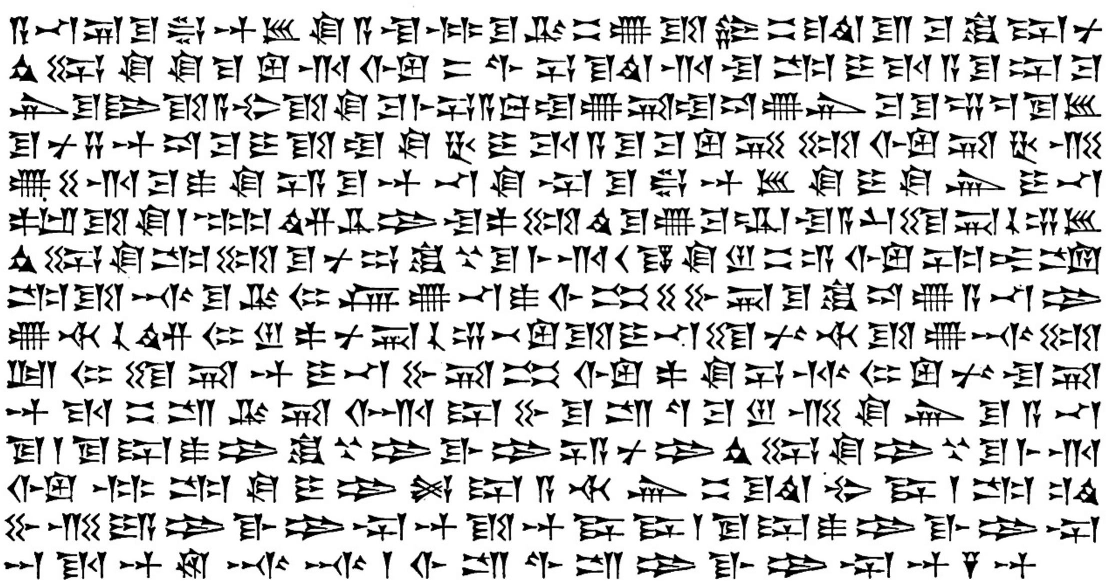

Figure 36.2 Cuneiform writing. Note: Lines 15–21 of the Cyrus cylinder, an artifact currently held in the collection of the British Museum that contains an account of the capture of Babylon by Cyrus the Great in 539 BCE. The cuneiform characters are relatively similar to one another, compared to the amount of variability that would be present if they were small pictures of the type that typified early writing. This decreased variability entailed that the clues distinguishing the signs were more subtle, such that training and practice were needed to individuate and distinguish them. Source: Budge (1884, p. 80), a document in the public domain.

As depictiveness was lost, the set of characters lost most of its variability (Figure 36.2); this is simply the observation that there are more differences between pictures than there are within a set of characters in a script. To a large extent, this is a function of familiarity (Overmann, 2021, 2022). When we are familiar with things, the features that individuate and distinguish them can be subtle, and we can still tell them apart, though we require exposure and practice. The corollary is that when we are unfamiliar with things, the clues that distinguish them must be overt, with the result that there is less need for exposure and practice. As the set of characters became recognized by their features and lost their depictiveness and much of their variability, they reorganized within the remaining variability in ways that emphasized the features individuating and distinguishing them. They would ultimately simplify, because simpler characters are easier to produce. This helped increase speed, both in production and in reading, as simpler characters can be written faster and aid proficient readers. The latter effect has modern parallels: diacritics for tone in African languages and vowels in Hebrew (Bird, 1999; Ravid & Haimowitz, 2006).

The critical point is that script and literacy were collectivist outcomes, effects of the boundless field of mundane activity we first encountered with the million hypothetical and statistically improbable monkeys. Script and literacy represent a process of creative invention that depends not on the solitary artist or a random genius, as was true of the individualistic model, but rather, on the larger society of average people performing their everyday tasks in their everyday ways. Now that we have examined how script and literacy emerged historically from a sustained, collaborative behavior with a particular tool and its product, probably the most important question to address is this: is writing unique in this regard? Or do other tools, productive behaviors, and products have similar collectivist effects?

An Evolutionary Perspective on Collectivist Making

Writing dramatically illustrates the collectivist effects of tool use. But in realizing forms and cognitive states that no single individual or generation could possibly innovate or invent, writing may seem qualitatively different than other technological endeavors. Again, take blacksmithing as a comparison. If hammering iron into shape has similar effects on hand–eye coordination and the discrimination of finer detail, some of the effects that writing has—like recognizing the productive gesture in the written form (Dehaene, quoted in Konnikova, 2014)—seemingly have little counterpart in the types of things a blacksmith might produce, like horseshoes, hinges, sickles, swords, wheel rims, and chains. Implements like horseshoes and hinges don't continue to transform or seem to involve particular cognitive states when we interact with them. Partly this is because we generally don't engage a material form like a horseshoe or a hinge with the same amount of sustained attention that we invest in writing and reading. Partly, too, this is because these iron forms tend to be used singly—not as sets with the kind of recombinability and malleability that written characters have, and not as sets with the degree of social transactability that writing has. Nor does learning to use a horseshoe or a hinge require substantial investments of training and practice, though learning to produce one at the forge most certainly does.

Here we must also circle back to the idea that user, tool, production, product, and use are inseparable, a quality that writing has to the extent that it's even reflected in the language we use to describe it. For when it comes to writing, language does not clearly differentiate the productive act from what it produces. As a tool, writing certainly involves the human capacity for language to a degree that other kinds of tools do not appear to share. Recognizing that the iron being hammered is cooling, determining the speed at which it should be reheated, and discerning that it has achieved the desired temperature by its color, the sounds it makes, and the shapes it assumes when struck again after reheating are complex sensorimotor judgments. The ability to make such judgments is acquired through experience and practice, and even then, they are typically difficult to express in words. In comparison, the idea of writing and reading without involving language is inconceivable—something that takes us back to the gibberish a monkey with a typewriter would produce, if only it could somehow be coaxed to tap the keys with its fingers instead of smashing them with its palm or fist.

Arguably, these are differences of degree and not of kind, quantitative distinctions that perhaps range across a spectrum, with one end emphasizing linguistic explication and the other sensorimotor experience. The oldest tools known are more than 3 million years old (Harmand et al., 2015), a remote era that anticipates the *Homo* lineage by an amount of time that is not inconsiderable. This implies that tool use emerged well before language did, which is unsurprising given the number of non-human, alinguistic species that use tools. This suggests that the end of the spectrum emphasizing language is much more recent than the one emphasizing the engagement of material forms and the sensorimotor experience it implies. Nonetheless, the sensorimotor experience of engaging material forms remains critical to writing and literacy, and so what unites both ends of the spectrum is the collective, collaborative use of material forms as tools. This includes the stone tools of ancestral species, where shared use was particularly important for qualities like heft and balance that couldn't be appreciated visually and that couldn't be passed on through language, either because language didn't yet exist (for whatever pre-*Homo* species were using tools more than 3 million years ago) or because it's difficult to put such things into words (for us, the contemporary human species, today).

Borel's million monkeys have now produced more than gibberish and statistically improbable books, for their output has generated contrastive models of creativity. The first remains the rare and lucky individual: the innovative artist, the inventive genius, the one who gathers whatever applause and accolades are awarded to novel yet meaningful work, the one we think of when we think of creativity. The second is what we often do not consider part of the creative story at all. It is the throng of mundane toilers—the generations of comparatively uninspired laborers and their works, *en masse* anonymous, banal, and bland—whose common industry, the simple getting-on-with-it business of everyday life, creates things no individual could ever manage. They have turned out to be the unsung heroes of an unsuspected but compelling story. They have revealed an unexamined side to the creative account and given us a new metric by which to question how we conceive creativity. They have provided us a vision of our engagement of material forms, whereby our use of tools changes us as we effect change with them. Their change in form represents their use and usefulness, and as they change, they store and forward our incremental behavioral and psychological change, in the process also becoming better and better at influencing our behaviors and psychological makeup. These material abilities, the interactions of brains, bodies, and world they represent, and the millions of years of change they accumulated and distributed are what created the human species as it exists today.

Let's take a final look at Borel's million monkeys and their hypothetical typewriters and our hominin ancestors and their comparable but actual millions of years of tool use. If the metaphor helps us glimpse cumulative mutuality, its success is limited because it offers only a unidirectional view. The typewriters, we may assume, will be much the worse for wear, given the simian pounding they will receive, but they will not transform in ways that reflect their uses or facilitate specific purposes. And the monkeys, we may assume, won't and don't change a bit, no matter how enthusiastically or long they pound the keys, given our firm belief that their likelihood of ever producing anything akin to Shakespeare is so minute that it is functionally equivalent (though technically not identical) to zero.[6] If we set aside the flattering self-view that privileges our human cognition and disparages the cognitive capacities of even our nearest living relatives, we must admit that this might not be what would actually happen to the monks, were they given enough typewriters and time, because it is not what happened in our case. When our hominin ancestors began pounding things with rocks about three million years ago (Harmand et al., 2015), that very engagement of material forms would ultimately yield not just bifacially shaped handaxes (after a million or so years) and modern material culture (after three million or so years), but *Homo erectus* and *Homo sapiens sapiens* and whatever came between and whatever comes next.

Consider the human species, not just collectively but so collectively that it becomes a super-organism, an association whose existence is continuous and independent of its individual members and whose abilities and liabilities are distinct from those of its members.[7] Its collective interaction with the material world, by its nature, makes the human species function as a single being, a super-organism, albeit one whose actions and thinking are massively decentralized and thus unguided. We effectively constitute a super-organism, not just through and because of our collaborative use of material forms, though that is a significant mechanism, but because our highly social nature means we share ideas and transmit learning through social interactions and language. The interaction of this colossus with the material world rearranges that world. It's explored, parsed, and subdivided, and eventually split down to its constitutive atoms; it's taken apart and analyzed, measured and massed, sorted, and compiled until it ultimately encompasses the infinite universe.

Now let us ask again: what does all this material-interactivity create? Is it merely modern material culture in all its technological glory and problems? That answer somehow seems too small. Conceivably, what is being created is so much more than just material culture as it exists around the planet today, plus the extra-planetary debris that now marks our territorial extent. For that material culture is the material accumulation of millions of years of cognitive effort, the material trace of behaviors and brains being changed by interacting with material forms, the material reflection of the behavioral and psychological characteristics of their users, and the material intensification of features that reflect both their users and their purposes. It is the mind-stuff of the contemporary human species, the species uniquely adapted for leveraging material forms for cognitive purposes, whose cognitive evolution has been guided and shaped by the way it leverages material forms—whose cognitive evolution is an iterative process wherein the collective use of material forms has realized changes in the things we use as tools, in the things we produce with tools, and in ourselves as well, the very essence of what has made us human.

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[6] These assumptions have been partially supported through empirical means. In 2002, a team of British researchers from the University of Plymouth placed a single computer in a zoo enclosure containing six Sulawesi crested macaques for a month. According to later news reports, the monkeys mostly bashed the machine with a stone and defecated and urinated on it (AP, 2003; BBC, 2003). By the end of the month, however, they had produced a five-page text later published as a limited-edition book (Elmo et al., 2002). It consisted of 13,062 characters: 9,925 (76.0%) were the letter S, 1304 (10.0%) the letter Q, and 938 (7.2%) the letter A, with the letters G, J, H, V, L, M, N, B, F, K, P, D, and C (in descending order of quantity) accounting for the remainder. The simian authors did not disclose their scientific vision for the work, perhaps disappointed by the insignificant findings or irritated by the constraints on personnel, time, and equipment, relative to the resources Borel had proposed; neither did they comment on the generalizability of their results. In 2011, nearly a decade later, a member of the same species would again make international headlines after taking selfies and becoming predictably embroiled in a multi-year lawsuit over copyright ownership with the camera's human owner (Slotkin, 2017).

[7] The definition of the super-organism was adapted and extended from corporation, both as dictionaries commonly define it and as interpreted through the notion that such entities enjoy a form of personhood, in law if not in actuality.

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References

Adams, D. (1979). *The hitchhiker's guide to the galaxy*. Pan.

AP. (2003, May 9). Monkeys don't write Shakespeare. Associated Press. https://web.archive.org/web/20040201230858/http://www.wired.com/news/culture/0%2C1284%2C58790%2C00.html

BBC. (2003, May 9). *No words to describe monkeys' play*. British Broadcasting Corporation. http://news.bbc.co.uk/2/hi/3013959.stm

Bird, S. (1999). When marking tone reduces fluency: An orthography experiment in Cameroon. *Language and Speech*, *42*(1), 83–115.

Boone, E. H. (1994). Introduction: Writing and recording knowledge. In E. H. Boone & W. D. Mignolo (Eds.), *Writing without words: Alternative literacies in Mesoamerica and the Andes* (2nd ed., pp. 3–26). Duke University Press.

Borel, É. (1913). La mécanique statique et l'irréversibilité. *Journal of Physics: Theories and Applications*, *3*(1), 189–196.

Bramanti, A. (2015). Rethinking the writing space: Anatomy of some early dynastic signs. In E. Devecchi, G. G. W. Müller, & J. Mynářová (Eds.), *Proceedings of the 60e Rencontre Assyriologique Internationale, Warsaw 2014: Current research in cuneiform palaeography* (pp. 31–47). PeWe-Verlag.

Brokaw, G. (2010). *A history of the khipu*. Cambridge University Press.

Budge, E. A. T. W. (1884). *Babylonian life and history*. The Religious Tract Society.

Cammarosano, M. (2014). The cuneiform stylus. *Mesopotamia*, *XLIX*, 53–90.

Castles, A., Rastle, K., & Nation, K. (2018). Ending the reading wars: Reading acquisition from novice to expert. *Psychological Science in the Public Interest*, *19*(1), 5–51.

Daneman, M., & Carpenter, P. A. (1980). Individual differences in working memory and reading. *Journal of Verbal Learning and Verbal Behavior*, *19*(4), 450–466.

Daneman, M., & Carpenter, P. A. (1983). Individual differences in integrating information between and within sentences. *Journal of Experimental Psychology: Learning, Memory, and Cognition*, *9*(4), 561–584.

Daneman, M., & Green, I. (1986). Individual differences in comprehending and producing words in context. *Journal of Memory and Language*, *25*(1), 1–18.

De Morgan, J.-J. (1905). Note sur les procédés techniques en usage chez les scribes babyloniens. In G. Maspero (Ed.), *Recueil de travaux relatifs à la philologie et à l'archéologie Égyptiennes et assyriennes*, Vol. XXVII (pp. 234–249). Emile Bouillon.

Dehaene, S., & Cohen, L. (2007). Cultural recycling of cortical maps. *Neuron*, *56*(2), 384–398.

Elmo, Gum, Heather, Holly, Mistletoe, & Rowan. (2002). *Notes towards the complete works of Shakespeare* (G. Cox (ed.)). Kahve-Society.

Giovanni, F. B. d'Arcais. (1994). Order of strokes writing as a cue for retrieval in reading Chinese characters. *European Journal of Cognitive Psychology*, *6*(4), 337–355.

Harmand, S., Lewis, J. E., Feibel, C. S., Lepre, C. J., Prat, S., Lenoble, A., Boës, X., Quinn, R. L., Brenet, M., Arroyo, A., Taylor, N., Clément, S., Daver, G., Brugal, J.-P., Leakey, L., Mortlock, R. A., Wright, J. D., Lokorodi, S., Kirwa, C., … Roche, H. (2015). 3.3-million-year-old stone tools from Lomekwi 3, West Turkana, Kenya. *Nature*, *521*(7552), 310–315.

Houston, S. D. (Ed.). (2008). *The first writing: Script invention as history and process*. Cambridge University Press.

Hutchins, E. (1995). *Cognition in the wild*. MIT Press.

James, K. H., & Engelhardt, L. (2012). The effects of handwriting experience on functional brain development in pre-literate children. *Trends in Neuroscience and Education*, *1*(1), 32–42.

Keller, C. M. (2001). Thought and production: Insights of the practitioner. In M. B. Schiffe (Ed.), *Anthropological perspectives on technology* (pp. 33–45). Amerind Foundation.

Keller, C. M., & Keller, J. (1996). *Cognition and tool use: The blacksmith at work*. Cambridge University Press.

Keller, C. M., & Keller, J. D. (1999). Imagery in cultural tradition and innovation. *Mind, Culture, and Activity: Seminal Papers from the Laboratory of Comparative Human Cognition*, *6*(1), 3–32.

Kirsh, D. (1995). The intelligent use of space. *Artificial Intelligence*, *73*, 31–68.

Kirsh, D. (2014). The importance of change and interactivity in creativity. *Pragmatics & Cognition*, *22*(1), 5–26.

Konnikova, M. (2014, June 3). What's lost as handwriting fades. *The New York Times*, D1. https://www.nytimes.com/2014/06/03/science/whats-lost-as-handwriting-fades.html

Longcamp, M., Zerbato-Poudou, M.-T., & Velay, J.-L. (2005). The influence of writing practice on letter recognition in preschool children: A comparison between handwriting and typing. *Acta Psychologica*, *119*(1), 67–79.

Malafouris, L. (2015). Metaplasticity and the primacy of material engagement. *Time and Mind*, *8*(4), 351–371.

Maloney, R. (1960). Inflexible logic. In J. R. Newman (Ed.), *The world of mathematics: A small library of the literature of mathematics from A'h-mosé the Scribe to Albert Einstein, presented with commentaries and notes* (Vol. 4, pp. 2262–2267). George Allen and Unwin Ltd.

Nakamura, K., Kuo, W.-J., Pegado, F., Cohen, L., Tzeng, O. J.-L., & Dehaene, S. (2012). Universal brain systems for recognizing word shapes and handwriting gestures during reading. *Proceedings of the National Academy of Sciences of the United States of America*, *109*(50), 20762–20767.

Nonaka, T. (2011). What is the behavior of a C4 quadriplegic mouth calligrapher constant function of? *BIO Web of Conferences*, *1*, 1–4.

Nonaka, T. (2013). Motor variability but functional specificity: The case of a C4 tetraplegic mouth calligrapher. *Ecological Psychology*, *25*(2), 131–154.

Nonaka, T., Bril, B., & Rein, R. (2010). How do stone knappers predict and control the outcome of flaking? Implications for understanding early stone tool technology. *Journal of Human Evolution*, *59*(2), 155–167.

Overmann, K. A. (2016). Beyond writing: The development of literacy in the Ancient Near East. *Cambridge Archaeological Journal*, *26*(2), 285–303.

Overmann, K. A. (2021). The material difference in human cognition. *Adaptive Behavior*, *29*(2), 123–136.

Overmann, K. A. (2022). Early writing: A cognitive archaeological perspective on literacy and numeracy. *Visible Language*, *56*(1), 8–44.

Overmann, K. A., & Wynn, T. (2019). Materiality and human cognition. *Journal of Archaeological Method and Theory*, *26*(2), 457–478.

Perfetti, C. A., & Tan, L.-H. (2013). Write to read: The brain's universal reading and writing network. *Trends in Cognitive Sciences*, *17*(2), 56–57.

Ravid, D., & Haimowitz, S. (2006). The vowel path: Learning about vowel representation in written Hebrew. *Written Language and Literacy*, *9*(1), 67–93.

Roux, F., Dufor, O., Giussani, C., Wamain, Y., Draper, L., Longcamp, M., & Démonet, J. (2009). The graphemic/motor frontal area Exner's area revisited. *Annals of Neurology*, *66*(4), 537–545.

Senner, W. M. (1989). Theories and myths on the origins of writing: A historical overview. In W. M. Senner (Ed.), *The origins of writing* (pp. 1–26). University of Nebraska Press.

Slotkin, J. (2017, September 12). "Monkey selfie" lawsuit ends with settlement between PETA, photographer. NPR. https://www.npr.org/sections/thetwo-way/2017/09/12/550417823/-animal rights-advocates-photographer-compromise-over-ownership-of-monkey-selfie

Sülzenbrück, S., Hegele, M., Rinkenauer, G., & Heuer, H. (2011). The death of handwriting: Secondary effects of frequent computer use on basic motor skills. *Journal of Motor Behavior*, *43*(3), 247–251.

Taylor, J. (2015). Wedge order in cuneiform: A preliminary survey. In E. Devecchi, G. G. W. Müller, & J. Mynářová (Eds.), *Proceedings of the 60e Rencontre Assyriologique Internationale, Warsaw 2014: Current research in cuneiform palaeography* (pp. 1–30). PeWe-Verlag.

Veldhuis, N. (2011). Levels of literacy. In K. Radner & E. Robson (Eds.), *The Oxford handbook of cuneiform culture* (pp. 68–89). Oxford University Press.

Wynn, T., & Coolidge, F. L. (2010). How Levallois reduction is similar to, and not similar to, playing chess. In A. Nowell & I. Davidson (Eds.), *Stone tools and the evolution of human cognition* (pp. 83–104). University of Colorado Press.

Wynn, T., & Coolidge, F. L. (2014). Technical cognition, working memory and creativity. *Pragmatics & Cognition*, *22*(1), 45–63.