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Seeds of Science

The Muscle-Readers, a Historical Sketch

Leverage Research[1]

The notion that subtle nonverbal cues play an important role in social interaction is relatively uncontroversial. What the upper bounds of this capacity might be, however—how much and what kind of information can be conveyed through these channels—remains unclear and, at present, under-explored. In the present work, we consider possible answers to the question and ways in which it could be addressed by considering an historical line of investigation known as muscle reading. Spurred by public interest in mentalism and the specific popularity of thought-readers, researchers in the late 19th and early 20th centuries began investigating the possibility that information about our thoughts and inclinations could be "read" from muscle tension, unconscious vocalizations, and other subtle cues. While covering some of the same ground as contemporary research on nonverbal communication, the literature of this era contains many reports that go well beyond this. Feats such as locating a hidden object, guessing the suit of a card, and determining words or names held in another's mind were said to be achieved in controlled conditions or by academic researchers themselves. In some cases, subtle but telling movements were also said to be captured by early biometric apparatuses. While we believe that such claims should be interpreted with caution, we contend that the reports of these early researchers should not be dismissed merely because of their age and that a better understanding of this literature offers important leads for investigators today.

The recognition that non-verbal cues can have significant psychological impacts is far from new. Like much else in psychology, however, empirical investigations of the relevant phenomena have their origins in the 19th century. That shifts in attention, imagery, and even unconscious mental processes manifest themselves in automatic or involuntary movements was a fairly common belief among early psychologists and physiologists, including Herman Lotze, Henry Maudsley, and William James, as was the notion that these cues played significant and under-studied roles in interpersonal interactions. "We gather what is passing in one another's minds," a classic article by C. S. Pierce and psychologist Joseph Jastrow concludes, "in large measure from sensations so faint that we are not fully aware of them, and can give no account of how we reach our conclusions from such matters...such faint sensations ought to be fully studied by the psychologist and assiduously cultivated by every man." What this cultivation might yield was far from certain, but at the time, many believed that attention to

[1] https://www.leverageresearch.org/

such cues would reveal a great deal about a person's frame and direction of mind—information useful in education, therapeutics, and myriad other domains of applied psychology. Accordingly, the study and cultivation of nonverbal communication were taken up with some zeal.

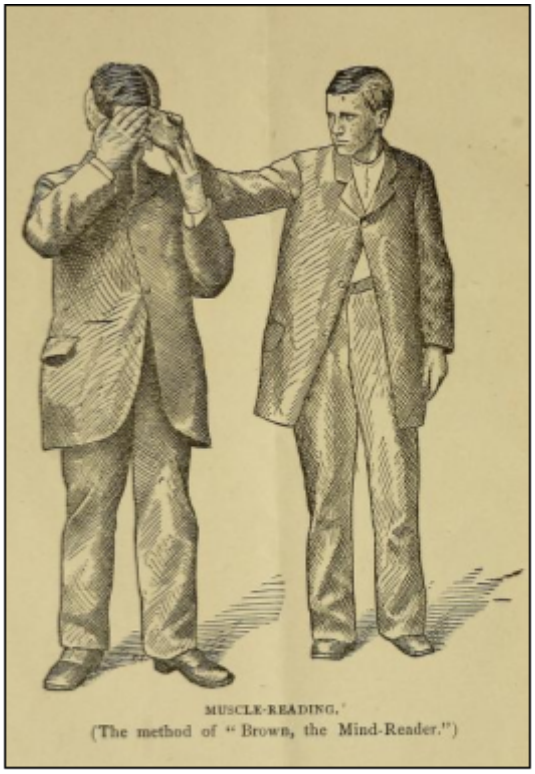

Figure 1. Muscle-reading technique using hand-to-forehead contact.

Like many popular notions, the topic went by a variety of names. There was "Cumberlandism," named for performer Stuart Cumberland, and "Hellstromism," for Axel Hellstrom. The earliest and most common, however, was the more descriptive "muscle-reading," a term coined by physician George Beard in an article debunking the famed contact mind-reader J. Randall Brown (figure 1).[1] At the time, performers like Brown were quite popular, claiming to read names and locate the smallest of hidden objects by tapping into the thoughts of volunteers. Much to Beard's chagrin, such assertions had gained credibility not only with members of the public but within the scientific community. Hoping to undermine these claims, Beard drew on the aforementioned ideas in physiology and began amassing evidence for a purely ideomotor explanation, working with amateur performers and acquaintances whom he'd asked to practice the proposed muscle-reading technique. His studies, first published in 1877, included a number of noteworthy results. For one, the performers all seemed to require physical contact to achieve above-chance performance. At the same time, his avowedly non-psychic subjects seemed capable of feats similar to Brown's. In one case, a judge named Blydenberg was reportedly able to select predetermined items from "a medley of keys, knives, trinkets, and miscellaneous small objects" by concentrating on "muscular thrill" in the hand of a knowing subject. In another, a participant was able to locate a hidden object "in nearly all cases" by attending to the subtle movements of volunteers holding either arm.

[1] George M. Beard, *The Study of Trance, Muscle–Reading and Allied Nervous Phenomena in Europe and America*, (New York, 1882), plate 1.

A few years later, a group of British scientists would arrive at a similar view when working with the mentalist Washington Irving Bishop, a one-time associate of Brown's who claimed not to know how he accomplished his readings. In a series of controlled experiments, Bishop showed himself quite adept at tasks involving direct contact. In a series of object-location tasks, for instance, the blindfolded performer was reportedly able to find a small object hidden under a drawing room rug, a pencil case stuck in a chandelier, and a matchbook hidden inside a shelved book, with some successes coming in under a minute. In another test, he was able to work out the specific body part held in mind by naturalist George Romanes (his right large toenail). He did not succeed with everyone or on every attempt, however, and most significantly, his abilities drastically declined when tactile communication channels were eliminated. While able to perform his act when in direct contact with an experimenter or connected by a rigid medium, such as a walking stick, he was unable to do so when connected by a loose strap. Likewise, when, at the mentalist's own request, they conducted a no-contact reading in which Bishop attempted to guess a letter of the alphabet viewed by one of the experimenters, his performance was at chance levels. The mentalist, as the group concluded in their 1881 report to *Nature*, was most likely relying on the unconscious cues of volunteers.

Both the American and British articles caused something of a stir, piquing the interest of those eager for a deflationary account of the popular thought-reading acts and challenging those who felt that more was at play. Within a few years, a slew of additional studies followed, each attempting to outline the limits of the technique. Researchers sympathetic to the telepathy claims pointed to results showing above-chance performance in the absence of physical contact and in cases where correct answers seemed to go beyond what one would expect to be communicated by "muscular thrill" alone—duplicating drawings, guessing cards, and so on. Proponents of unconscious signaling, meanwhile, pointed to additional channels of information, such as visible shifts in posture and "involuntary whispering," now referred to as subvocalization or covert speech.[2] Naturally, the skeptics were on guard against fraud and poor statistical reasoning, as well. Indeed, the thought-reading controversy would become a site of several major developments in this arena. Discussions of thought-reading include some of the earliest applications of probability theory in experimental psychology and were likely top of mind when R. A. Fischer was working out his influential notion of statistical significance.[3] Studies in the area were also early sites of randomization, with the practice becoming common after Charles Minot's

[2] Hansenand and Lehmann,"Ueber unwillkürliches Flüstern: Eine kritischen und experimentelle Untersuchung der sogennanten Gedanken-Ubertragung," *Philosophische Studien* 11, (1895): 471–530
[3] Ian Hacking, "Telepathy: Origins of Randomization in Experimental Design," *Isis* 79, no. 3 (1988): 427–51.

discovery that misleading success rates could result from the fact that freely chosen numbers and figures were not evenly distributed—that subjects were 35% likelier to choose a 3 than a 0, for instance, and that they were far more likely to draw a circle or square than, say, a pictograph.[4]

One noteworthy study employing such methods was a relatively late investigation by Berkeley psychologist George Stratton and collaborators.[5] To assess the limits of "muscle-reading" in circumstances of little to no contact, the psychologists worked with Eugen de Rubini, a performer known for accomplishing standard muscle-reading feats by looking at subjects or using only a slack watch chain for connection. To gain a rough quantitative measure of Rubini's abilities, the experimenters developed a simple binary choice task involving the placement of an object on the right or left-hand side of a table and a similar 10-option task in which he was to pick out a specific book or matchbox. Trials were conducted in blocks of 10, with the location or book on which the experimenter was to focus being determined immediately beforehand by a privately cast lot. To investigate the mechanisms underlying Rubini's performance, they tracked his performance under several distinct conditions. These included one in which the experimenter acting as "guide" was connected to Rubini by a slack watch chain and walked behind him; one where the guide followed behind with no chain; and a third where there was no chain and special care was taken to control any visual cues present in the second condition (auditory controls were also experimented with but found to have little effect). In the binary task, Rubini chose correctly on 24 of the 30 watch-chain trials and 45 of the 70 trials with no chain but the possibility of peripheral visual cues (e.g., when the experimenter was slow to follow).[6] When blinders, screens, and other stringent visual controls were implemented, however, he fell to 14 in 30. For the 10-option test, the results were a bit more complicated. Rubini was correct on 12 of 20 watch-chain trials, 4 of 20 with no chain, and 5 of 30 with additional cue controls of varying stringency (including a suggestive but non-decisive run of 0 in 10 when visual and auditory cures were both stringently controlled).[7]

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[4] Charles Minot, "The Number Habit," *Proceedings of the American Society for Psychical Research* 1, no. 2 (1886): 86–95; Charles Minot, "Second Report on Experimental Psychology: Upon the Diagram Tests," *Proceedings of the American Society for Psychical Research* 1, no. 4 (1889): 302–17.

[5] George M. Stratton, "The Control of Another Person by Obscure Signs.," *Psychological Review* 28, no. 4 (1921): 301-14.

[6] The studies were conducted before the widespread adoption of statistical testing and the trial blocks were not identical (e.g., some featured auditory controls, some not), but for those who are curious, the probability of matching or beating the combined sight and watch chain results by chance is 0.000183 (uncorrected).

[7] The probability of obtaining the 12 in 20 result or better by random guessing is approximately 5.4226e−8. A more appropriate analysis of the 10 option choice task, however, would be one that accounts for closeness of the guess (e.g., guessing 8 when the thought-of position was 9). Pooling all the trials without stringent visual controls as in the analysis above and running the data through a no-intercept

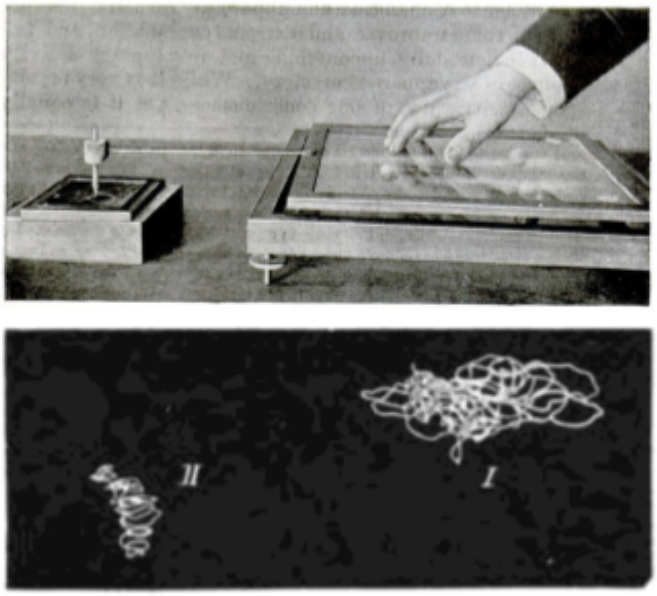

Figure 2. Top: automagraph designed by Jastrow. During the experiment, the etching device would be hidden from the subject. Bottom: etchings made while subjects were thinking of the letter "O."

The area was also at the cutting edge of psychological measurement, with the interest in unconscious cues spurring developments in head and eye tracking, as well as bodily indices of emotion.[8] A particularly noteworthy example may be found in the "automatograph," a machine used to record involuntary hand movements.[9] Introduced by Joseph Jastrow in 1892, the device consisted of a plate positioned atop ball-bearings and attached via rigid rod to a hidden etching device (figure 2).[10] Provided subjects kept their hand on the plate for the duration of a task, the machine would produce a detailed record of their movements. Often, Jastrow asserted, these etchings could be used to discern noteworthy information about the train of thought. Attention paid to objects at different locations generally produced drifts in the direction of the item, and counting the tics of a metronome yielded countable oscillations. In some cases, concentrating on visual forms, such as the letter "O" was said to produce corresponding movements (e.g., loops). One study, conducted by one Milo Tucker, even reported full-word tracing similar to the automatic writing seen in hypnosis and

ordinary least squares regression yields an r-squared of 0.871 with p=6.54e-19 (no corrections applied, calculated with statsmodels; Skipper Seabold and Josef Perktold, "Statsmodels: Econometric and Statistical Modeling with Python," *Proceedings of the 9th Python in Science Conference* 57, (2010): 92–96).

[8] See, e.g., Hugo Münsterberg and W. W. Campbell, "Studies from the Harvard Psychological Laboratory (II).," *Psychological Review* 1, no. 5 (1894): 441–495; Oskar Pfungst, *Clever Hans (the Horse of Mr. Von Osten): A Contribution to Experimental Animal and Human Psychology*, trans. by Carl Rahn (Holt, Rinehart and Winston, 1911), ch. 4; William T. Preyer, *Die Erklärung des Gedankenlesens: nebst Beschreibung eines neuen Verfahrens zum Nachweise unwillkürlicher Bewegungen* (Grieben, 1886), chapter 2.

[9] Joseph Jastrow, "Involuntary Movements," *Popular Science Monthly* 40 (1892): 743–750.

[10] Jastrow, "Involuntary Movements," figure 1; Joseph Jastrow, "Further Study of Involuntary Movements," *Popular Science Monthly* 41 (1892): 637–643, figure 14.

some forms of brain damage, though the neatness and singularity of the result raise suspicions.[11]

Another, less popular approach saw experimenters develop the muscle-reading skill themselves. Rather than rely on performers who might have reason to misrepresent their experience or lack the introspective training prized by psychologists at the time, a few psychologists began practicing and reporting on the method. These included well-known figures like Oskar Pfungst (see below) as well as less famous researchers like Thomas Verner Moore, who claimed that close attention to a subject's face allowed him to guess the suit of thought-of cards at a rate "that would not have occurred by chance more than once in a thousand times."[12] Perhaps the most successful adopter of this strategy was University of Wyoming professor June Downey. After several years of practice, Downey reported that she could duplicate even the most striking acts of the era's stage performers, including the guessing of dates imagined by a subject, the reconstruction of multisyllabic words held in mind, and "finding a book and identifying therein a word chosen at random."[13] Like most muscle-readers, she argued that such results undermined the bulk of evidence cited in favor of telepathy. Unlike most of her predecessors, however, her primary interest in the method was not its use as a debunking tool but its potential as a psychometric measure. Specifically, her explorations in the area led her to suspect that muscle-reading might find applications in the assessment of personality and what would today be termed cognitive style.[14] Her efforts in this direction would not, in the end, prove successful. Nevertheless, her studies do provide a good sense of muscle-reading under naturalistic (if less tightly controlled) conditions, useful figures on individual variation, and a number of curious observations.

In general, Downey's studies suggested that most individuals—as many as 56 of 60 according to a 1909 investigation—could be "read" and that all but a few reported that they were not conscious of any movements on their part.[15] Rates of success were comparable between women and men (though the majority of her sample came from the former group) and relatively close when comparing subjects who visualized an object's location with those who rehearsed a verbal

[11] Milo Asem Tucker, "Comparative Observations on the Involuntary Movements of Adults and Children," *The American Journal of Psychology* 8, no. 3 (1897): 394–404. Precautions were usually taken to conceal the recording device from subjects, but given that they had to keep their hands on a plate during the exercise, the possibility that they discovered and responded to the experimenters' hypotheses must be taken into account.
[12] Thomas Moore, *Dynamic Psychology*, 330. Sadly, Moore does not give any further details.
[13] June E. Downey, "Muscle-Reading: A Method of Investigating Involuntary Movements and Mental Types.," *Psychological Review* 16, no. 4 (1909): 257–301, on p. 267.
[14] June Downey, *The Will-Temperment and its Testing*, 55.
[15] Downey, "Muscle-Reading," 269.

description of the locale.[16] Some differences were observed between credulous and incredulous subjects as well as those participating with eyes closed vs. those with eyes open, though the limited scale of the studies and the number of simultaneous comparisons render these observations merely suggestive. In general, the most interesting findings were not those arising from group comparisons but those concerning "peculiar automatic tendencies" that emerged over the course of the investigation.[17] One of the more unexpected phenomena was something labeled "recapitulation." In some 22.6% of trials in a 1908 study, the reader did not go directly to the hidden object but, as tracings made by observers indicated, followed the path that the guide had taken when hiding it.[18] If a guide had hesitated at a specific location, for instance, or deposited the object only after a circuitous route, the reader would do the same. When asked if they had kept their prior trajectory in mind during the reading, however, subjects insisted that they had not. Another curious observation was that objects could be located even as the guide's attention was absorbed by a distractor task, such as the rehearsal of random names or counting aloud.[19] These and a few other observations led Downey to suggest, somewhat tentatively, that muscle-reading might allow one to access unattended content in addition to actively entertained thoughts, though the lead was never followed up on in print.

Of all those participating in the muscle- and thought-reading literature, however, the most famous was not a psychologist but a farm animal. Overlapping with and to some extent drawing from the popularity of mentalism, the late 19th and early 20th centuries witnessed a significant growth of interest in "wonder animals," non-human animals said to be capable of substantial intellectual feats or, in many cases, telepathy.[20] Today, the best remembered is doubtlessly der Kluge Hans, a horse whose trainer, Wilhelm von Osten, claimed could read, identify calendar dates, and perform calculations up to and including cube roots.[21] A 1904 commission determined that fraud was not involved in the performances but recommended further study to determine the exact means by which Hans solved the problems, with member Carl Stumpf telling the press that he believed the

[16] Downey, "Muscle-Reading," 269, 278–79, 294–95.
[17] Downey, "Muscle-Reading," 295.
[18] June Downey, "Automatic Phenomena of Muscle-Reading," *The Journal of Philosophy, Psychology and Scientific Methods* 5, no. 24 (1908): 650–58.
[19] Downey, "Muscle-Reading," 279, 296. Other phenomena included
[20] See Fabio De Sio and Chantal Marazia, "Clever Hans and His Effects: Karl Krall and the Origins of Experimental Parapsychology in Germany," *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 48 (2014): 94–102; David Pence, "How Comparative Psychology Lost Its Soul: Psychical Research and the New Science of Animal Behavior," *Studies in History and Philosophy of Science Part C: Studies in History and Philosophy of Biological and Biomedical Sciences* 82 (2020): 101275.
[21] See Pfungst, *Clever Hans*, ch. 1.

horse was using sensory cues unintentionally produced by his trainers.[22] This lead was soon followed up by Stumpf's student, Oskar Pfungst, who released the results of his own studies in 1907. According to Pfungst, Hans' abilities ultimately depended on what his questioner did or did not know. In reading, calculation, and similar tasks, Hans showed near-perfect performance when the questioner happened to know the answer. When such knowledge was absent, however, his performance dropped to chance levels. A similar pattern emerged when the horse was made to wear large blinders, blocking his vision of the questioner, suggesting, Pfungst argued, that visual cues played an important role in his success.[23]

To bolster this interpretation, Pfungst then conducted a series of tests placing the experimenter himself in the role of Hans. Subjects were asked to think of a number (calculation, leter, etc.), and Pfungst attempted to discern the answer by attending visually to bodily cues. In most cases, he found that he could guess correctly, and with "more suitable subjects," Pfungst claimed the ability to determine not only the correct answer but incidental features, such as whether a subject imagined a letter in script or print form or the order of addends in an arithmetic problem (e.g., whether they thought of 3+2=5 or 2+3=5).[24] Lest any doubt persist, he then went about measuring these movements and subjects' breathing rates during the tasks, finding notable answer-revealing shifts as Pfungst, like Hans, tapped his answer. The case, he concluded, was remarkable not because of what it revealed about the horse's intellect but because of how strikingly it illustrated the ties between thought—emotionally tinted thought in particular—and action.

The years that followed Pfungst's analysis represent something of a high water mark for ideomotor phenomena in psychology. The case of Clever Hans was among the most famous results of psychology to date, with Pfungst's argument for the role of unconscious cues serving as a reminder of (or advertisement for) their greater relevance for the discipline. Theories of the phenomena were debated in the pages of leading journals and incorporated into pedagogical practices, encouraging the use of motor imagery and active learning on the assumption that motor and ideational influences were bidirectional. Practitioners like Downey hoped that muscle-reading might be used in psychometric testing, and criminologists looked to it as a way of extracting useful information. The Harvard psychologist Hugo Münsterberg went so far as to suggest that automatographs be used to identify perpetrators from a lineup when witnesses

[22] Pfungst, *Clever Hans*, Supplement II; Pfungst, *Clever Hans*, 5.
[23] Pfungst, *Clever Hans*, 42–47.
[24] Pfungst, *Clever Hans*, 104–105.

were unwilling or unable to comply.[25] As time went on, however, interest in the phenomenon proved difficult to sustain. Discussions continued for another two decades, buoyed by the occasional telepathy claim and a sustained interest in measurement technologies like Jastrow's, but by the 1930s, there was no muscle-reading literature to speak of.

Looking back, there are a number of reasons for this. For one, they were difficult to scale. Muscle-reading proper was limited to interactions between two or at most a handful of people and generally required a significant time investment from the would-be reader. As Downey's investigations made clear, moreover, it was not fully reliable. Some individuals simply could not be "read," and even with the majority who could, the time it took Downey to locate a hidden object ranged anywhere from 4.6 to 245 seconds, depending on the subject and how they thought of the item (e.g., verbally or imagistically).[26] There was variability in the skill of readers, as well, with little way of telling *a priori* who would be able to acquire the skill. Even among practiced readers and reasonably expressive individuals, outcomes depended on temperament. Some subjects seemed to work better with some readers.[27] Finally, success depended to some extent on the cooperation of those involved. As was noted early on, a wary subject could misdirect or, in some cases, block the relevant cues by concerted effort, and while this mattered little for the kinds of studies cited above, it proved a lingering issue for suggested legal applications.[28] (Unfortunately, awareness of this concern was not enough to prevent adoption of the ill-fated polygraph, a descendent of Jastrow's automatograph).[29]

At an earlier time in psychology's history, the absence of such scalable applications may have been less of an issue. Yet the early 20th century was one of increasing professionalization for the field, particularly in the United States. Many of the first psychology departments in the English-speaking world were formed at land-grant colleges—institutions founded with practical ends such as agriculture and basic education in mind. To secure funding, then, psychologists

[25] Hugo Münsterberg, *On the Witness Stand: Essays on Psychology and Crime* (Doubleday, 1908), 124–25.
[26] Downey, "Muscle-Reading," 288.
[27] June Downey, *The Will-Temperament and Its Testing* (World Book, 1923), 55.
[28] That Münsterberg's suggestion of using automatographs on witnesses would fall prey to dissimulation requires little comment, but even less extravagant uses of unconscious movements were recognized as problematic by some observers (e.g., William Sullivan, *Crime and Insanity* (Physicians and Surgeons Book Company, 1925), 157).
[29] As the National Research Council concluded in its 2003 review of the technology, polygraph results appear to work well in laboratory studies of individuals not employing countermeasures but face profound problems when used in the field with subjects potentially capable of willfully shifting the results, see National Research Council, *The Polygraph and Lie Detection* (National Academies Press, 2003), executive summary.

leaned heavily on their discipline's contributions to pedagogy and organizational management.[30] With the onset of World War I, moreover, the field saw a strong push for standardization of the kind seen in army personnel testing. The highly individualized practice thus found itself in a field where uniformity and mass deployment were at a premium. Ideologically, the period also saw the development of behaviorism and a widening distrust of methods requiring individual skill or too much of an interpretive element. Thus, while Jastrow's recording technologies continued to hold interest, methods requiring active involvement and/or introspective reports on the part of the experimenter largely fell from favor. To some extent, the very notions of unconscious cueing and ideomotor phenomena (understood as idea-mediated actions) became suspect. As early as 1917, one sees researchers complaining that consciousness was "rapidly losing its standing as a respectable member of the psychologist's vocabulary," and with the rise of stimulus-response vocabulary, the notion of "ideas" came to be seen as dispensable or outmoded.[31] The prominent psychologist Edward Thorndike went so far as to compare ideomotor action, with its reliance on ideas bringing about corresponding movements in the body, to imitative magic, the belief that desired events may be elicited through ritualized mimicry (e.g., injuring an enemy by effacing a wax figure of them).[32]

Timing was also poor in that spiritualism, the perennial foil for muscle-readers, was on the decline. Though academic and popular interest in the paranormal would experience a resurgence later in the century, the topics never reached the heights seen in the Victorian era, when seances were a regular feature of bourgeois society and psychical research a common topic in major scientific publications. This left a good deal of unconscious cueing research lost at sea. The old program had been so strongly tethered to the bugbear of spirit mediumship that, when the latter began to decline, it lost much of its relevance. At a certain remove, the fact that ideomotor phenomena were so associated with Ouija boards and mind-readers even worked against them. When spiritualism was at its peak, many saw engaging with it as a responsibility. With increasing marginalization, however, any interactions—even hostile ones—could be seen as keeping the issue alive. At best, traditional muscle-reading work would risk fighting yesteryear's battles. By the 1930s, then, researchers had largely abandoned the topic, discussing ideomotor phenomena in a far more circumscribed manner or simply eschewing it in favor of more respectable topics. The old muscle-reading results could be dusted off when new reports of telepathy

[30] See John M. O'Donnell, *The Origins of Behaviorism: American Psychology, 1870-1920* (New York University Press New York, 1985), ch. 3; Geraldine M. Jonçich, *The Sane Positivist: A Biography of Edward L. Thorndike* (Wesleyan University Press, 1968), ch. 8.
[31] H. W. Chase, "Consciousness and the Unconscious," *Psychological Bulletin* 14, no. 1 (1917): 7–11, on p. 7.
[32] Edward L. Thorndike, "Ideo-Motor Action," *Psychological Review* 20, no. 2 (1913): 91–106.

began to gain traction, but the area saw exceedingly little direct study in the coming decades.[33] Only with the growth of cognitive neuroscience and renewed interest in implicit and unconscious psychological processes have theories of ideomotor action and related phenomena gained significant attention.[34]

The last decade has arguably been the most hospitable in over a century for the study of subtle nonverbal cues. Though the specific methods and theoretical constructs remain hotly contested, a host of implicit measures—means of assessing mental processes or attributes that do not rely on self-report—have become popular in both social and cognitive psychology.[35] An active literature has also emerged on brain-to-brain coupling, or the synchronization of neural activity between individuals during social interactions (nonverbal interactions included).[36] Nevertheless, discussions of high-precision "reading" like those of Downey, Pfungst, and the stage magicians have yet to resurface. At one level, this is understandable. The demands in terms of time and effort would be substantial, and even under ideal circumstances, results clearly varied from reader to reader and subject to subject. Most of the evidence also comes from an era when reporting and record-keeping were not what they are today. The most striking claims—guessing equations, multisyllabic words, and so forth—are ultimately anecdotal. Still, we should not be too quick to dismiss the testimony of so many independent, trained psychologists. The early researchers' methods differed from those in use today, but most studies were subject to at least some degree of experimental control. While the most striking reports are anecdotal,

[33] One may make exceptions for Greenwald's influential studies of ideomotor conflict in the 1970s.

[34] For recent work, see Bernhard Hommel et al., "The Theory of Event Coding (TEC): A Framework for Perception and Action Planning," *Behavioral and Brain Sciences* 24, no. 5 (2001): 849–78; Yun Kyoung Shin, Robert W. Proctor, and E. John Capaldi, "A Review of Contemporary Ideomotor Theory," *Psychological Bulletin* 136, no. 6 (2010): 943. A particularly significant role was played by ideomotor theory in opposition to facilitated communication, a now discredited practice in which a facilitator helps individuals with autism or other communication-impacting conditions to type or point as a way of indicating their preferences, answering questions, and so on. Numerous studies using methods analogous to those employed by Pfungst have found that responses generated by the technique are heavily influenced by unrecognized ideomotor actions on the part of facilitators (see Wegner, Fuller, and Sparrow, "Clever Hands: Uncontrolled Intelligence in Facilitated Communication," *Journal of Personality and Social Psychology* 85, no. 1 (2003): 5–19).

[35] It should be noted that "implicit" has often been taken to refer to the processes and attributes being measured, as well, implying some degree of automaticity and/or unawareness on the part of the subject. For a recent review, see Bertram Gawronski et al., "Twenty-Five Years of Research Using Implicit Measures," *Social Cognition* 38 (2020): S1–S25.

[36] In one widely-cited study, Pavel Goldstein et al. ("Brain-to-Brain Coupling During Handholding is Associated with Pain Reduction," *Proceedings of the National Academy of Sciences* 115, no. 11 (2018): E2528–E2537) found that holding a partner's hand during painful stimuli was associated with synchronization across numerous brain regions, increases in the accuracy of pain assessments by partners not receiving the stimulus, and lower reported pain from those receiving the stimulus. For a more general review, see Elizabeth Redcay and Leonhard Schilbach, "Using Second-Person Neuroscience to Elucidate the Mechanisms of Social Interaction," *Nature Reviews Neuroscience* 20 (2019): 495–505.

moreover, the literature also contains detailed and systematic investigations, such as Pfungst's and Stratton's. These may not and should not convince us of all the claims made in these early years, but at the very least, the reports suggest that a tightly controlled investigation of the kind possible today is in line. If the results prove half as strange as the old reports suggest, it will have been well worth the effort.

Gardener Comments

Note: the authors' responses to several comments are interleaved below.

Andrew Neff (Assistant Professor of Psychology & Neuroscience):
Fascinating topic. In addition to the historical characters mentioned in the article, novels and other humanistic works have long speculated about how informative muscle reading can be. To expand our current academic treatment of this topic beyond simple stuff like recognizing facial expressions of emotion does seem like a worthwhile endeavor. I strongly support this article's publication. One suggestion, which is by no means a condition for publication - I would have been interested to see a version of this article that's lighter on the history, and heavier on the methods of how we can/should approach this research today, and maybe even more specificity on the types of things that we ought to try to measure.

Simon T. van Baal:
I thoroughly enjoyed reading this article; it is written well. I generally think that this style of article is an interesting setup for scientific inquiry. It can function as a safeguard against reinventing the proverbial wheel by providing an introductory-level overview of a topic or discipline. I am no subject matter expert, however, so I cannot comment on the validity of the content. The only suggestion I have is that, even though it is implied in the title, I would have liked a few sentences preparing the reader for what the article is about and what it is trying to achieve.

Jan Kirchner:
This article discusses the history of the study of "muscle-reading" or the ability to read nonverbal cues to understand what another person is thinking. Beginning in the 19th century, psychologists and physiologists became interested in the idea that subtle movements could communicate a great deal about a person's thoughts. This interest was driven, in part, by the popularity of performers who claimed to be able to "read minds" through physical contact with volunteers. Skeptical researchers debunked these claims by demonstrating that the performers were likely relying on unconscious cues provided by their volunteers. However, the idea that people could "read" one another through subtle movements continued to gain interest. Studies in the early 20th century

explored the limits of this phenomenon and attempted to understand the mechanisms behind it. By the 1930s, however, interest in muscle-reading declined. This was due to a variety of factors, including the growing professionalization of psychology and the decline of spiritualism (which had previously driven interest in the topic). Today, with renewed interest in implicit and unconscious psychological processes, some researchers are revisiting the study of nonverbal cues.

1. I believe this article contains novel ideas and analysis that have the potential to advance science. The author's comprehensive review of the history of muscle-reading provides important context and background for contemporary researchers who are interested in the study of nonverbal cues. By outlining the development and decline of this field, the author is able to offer valuable insights into the factors that may be important for future work in this area.

2. The article is also well-justified in terms of how it could advance science. The author clearly outlines the relevance of muscle-reading to the study of implicit and unconscious psychological processes, and provides a number of suggestions for potential future research directions. By doing so, the author offers a roadmap for how this historical review could inform future work.

3. Finally, I believe this article is well-written. The author provides a thorough overview of the history of muscle-reading, and does so in an engaging and accessible manner. The writing is clear and concise, and the author is careful to define technical terms where necessary. I would be happy to recommend this article to a friend.

For these reasons, I recommend that the article be accepted.

Minor points:

- The author may wish to consider including a table summarizing the key studies and findings outlined in the article.

- As an editorial note, the author may wish to break the article into more clearly delineated sections in order to improve readability.

Dr. Payal B. Joshi:
The article is well-written and is found consistent with the theme. Though no major flaw is seen in the article, there are some concerns with the article in the present form. The title needs to be revised to reflect the exact tone of what the author/s wish to deliver to readers. As the genesis of the article lies on historical perspectives, Carl Hertz works on muscle reading perspective is missing. The historical works on mentalism with magic by D. Blaine et al, Dunningher and Kreskin are missing. Overall, the reading displays a

linear growth of the mental-reading field which is certainly not true, given the number of mentalists and muscle-readers of that time. The application of muscle reading utilized on famous personalities and sports persons are not provided. Overall, the article is certainly publishable, however, it needs crucial historical details to not be left behind.

Author Response: *We certainly acknowledge that the article is, at most, a cross-section of the history. Viewed in its entirety, the story of muscle reading more closely resembles a delta of crossing streams than a linear series, and much has been set aside for reasons of space. Building the research out would, as Dr. Joshi notes, necessarily involve more discussion of muscle readers like Hertz and the practice of stage muscle reading, and we hope that more work will be done in the area.*

Mario Pasquato:
While the historical account is very interesting and detailed, it is surprising that there have been no experiments with more recent technology. If the concept works at all it would seem possible to implement a 'muscle reader' as an app relying on a phone accelerometer. Machine learning models could be trained to automatically predict the thoughts corresponding to relevant patterns. This seems too good to be true, but who knows?

Author Response: *Prima facie, it seems likely that muscle reading should be detectable by sufficiently sensitive accelerometer. We think this is an excellent avenue of further investigation. One could imagine attempts at muscle-reading between people holding hands while also holding an accelerometer, though there is an important challenge here of how to account for the potential effects of subjects accommodating perceived researcher wishes.*

It would also be interesting to see results obtained from neuroimaging techniques such as EEG or fNIRS. For example, successful muscle reading may be associated with correlated brain activity (i.e., interpersonal neural synchrony) similar to what has been observed in other collaborative social tasks.

Josh Randall:
This article provides an interesting overview of a sub-discipline that has fallen out of favor. In doing so, they describe methods and analyses that were developed and later appropriated by other fields. One area that is lacking is a broader suggestion for practitioners considering re-engaging specifically with muscle-reading as opposed to modern approaches to unconscious behaviors. Conclusions derived from these two areas could be vastly different, partly as a result of the practitioner/individualistic nature of muscle-reading compared to the modern potentially more reductionist, siloed

experimentalist approach. A plurality of theory and data on the ways that humans transform information physically and mentally is vital to improving our modern understanding of the brain and psychology.

Author Response: *In terms of avenues for further investigation, we think there are a variety. In addition to the two suggested above (use of accelerometers or neuroimaging), one could study muscle reading in circumstances where it is likely most easily detectable, either between humans or in human-animal communication.*

With respect to muscle reading among humans, relevant phenomena might be more easily detected among married couples, whose period of courtship and cohabitation might be expected to yield some insight into each other's trains of thought. Alternatively, one might study professional poker players.[37]

With respect to human-animal communication, one might look at bomb-sniffing dogs; one widely-cited study, for instance, suggests that handler beliefs influence detection. Another possibility would be to study animal behavior when interacting with humans with lower sensitivity to nonverbal communication; an initial study by Meyer and Forkman suggests that in such circumstances, dogs may show more insecurity-indicating behaviors than usual.[38]

There is also the route of training new subjects, or experimenters training themselves, in muscle reading. This is more time-intensive, and may come with certain dangers, but also may prove fruitful.

Ted Wade:
This was an engaging, scholarly, and informative history of the dark matter of nonverbal communication: the apparent passing of messages occurring below the level of awareness of sender and receiver. Necessarily it includes issues about how hard the phenomena are to study. It concludes by mentioning some current related work, but stops short of advocating any reason to pursue it except to say that current research methods might allow better-controlled studies.

[37] Cf. Slepian et al, "Quality of Professional Players' Poker Hands Is Perceived Accurately from Arm Motions," *Psychological Science* 24, no. 11 (2013): 2335–38, which seems to indicate that visual cues are enough for university undergraduates to assess hand quality at above-chance levels.
[38] Lisa Lit, Julie B. Schweitzer, and Anita M. Oberbauer, "Handler Beliefs Affect Scent Detection Dog Outcomes," *Animal Cognition* 14, no. 3 (May 1, 2011): 387–94; Iben Meyer and Björn Forkman, "Nonverbal Communication and Human–Dog Interaction," *Anthrozoös* 27, no. 4 (2014): 553–68. An important caveat for Lit et al's results is that they were unable to distinguish between effects due to the handlers' beliefs directly impacting the dogs and effects due to handlers' beliefs impacting how they interpret the dogs' behaviors. Teasing the two apart in working pairs will be a major challenge going forward.

At a time when in fact research practices are known to be in need of much improvement, it is not helpful to suggest doing a “tightly controlled investigation” with no hypothesis or direction. If you consider how studies on subjects like psychokinesis or lie detection have apparently not been able to satisfy critics, then maybe convincing work on reading subliminal nonverbal cues might also be elusive.

The history suggests that practitioners of “psychic reading” may not understand how they acquired their skills, nor are they aware of what stimuli they are responding to. Maybe a reason to pursue “muscle-reading” types of phenomena might be found by considering theories about (1) what causes different mental and physical activities to be conscious or unconscious, or (2) nonverbal communication in general.

Mark:
While interesting, I feel this work is not arguing a strong point. I'd love to hear what the author thinks or wants to argue here, as opposed to what feels more like just a review or related work section of a longer paper.

Partha Ghosh:
It's a most interesting topic. Sounds like the really remarkable historical claims are anecdotal and have not been replicated to a degree that can be tested. The simpler ones are relatively well-understood. Where do we get the data to further this?

Jack Arcalon:
Seems like a good overview article about a much neglected and since "forgotten" older research field that might lead to new interface technology applications.