

History of Psychology

Scientific Study of Magic: Binet's Pioneering Approach Based on Observations and Chronophotography

CYRIL THOMAS and ANDRÉ DIDIERJEAN
Université de Franche-Comté

SERGE NICOLAS
Université Paris Descartes

In 1894, French psychologist Alfred Binet (1857–1911) published an article titled "The Psychology of Prestidigitation" that reported the results of a study conducted in collaboration with two of the best magicians of that period. By using a new method and new observation techniques, Binet was able to reveal some of the psychological mechanisms involved in magic tricks. Our article begins by presenting Binet's method and the principal professional magicians who participated in his studies. Next, we present the main psychological tools of magicians described by Binet and look at some recent studies dealing with those mechanisms. Finally, we take a look at the innovative technique used by Binet for his study on magic: the chronophotograph.

KEYWORDS: Binet, prestidigitation, magic tricks, Marey, chronophotography

"All prestidigitation . . . rests on psychology."
Binet (1894c)

In his humorous critical study of prestidigitation, French illusionist Edouard Raynaly (1894) referred to a scientific article on magic published in *Revue Scientifique* on July 22, 1893, under the name of Edmund W. Rells (1893).¹ For Raynaly, the article had few merits and seemed to be essentially borrowed from the early studies by illusionist Jean-Eugène Robert Houdin (1805–1871). Raynaly stated,

I know of another study, this one of considerable importance, that is about to appear in a top-ranked journal. It comes from a particularly

scholarly center, and we can assume that its technical side will be covered more thoroughly since the author, one of our most eminent psychologists, has had lengthy interviews with the most competent professionals. I am certain that a great deal of interest will come out of this work, from both the literary and scientific standpoints. (pp. 87–88)

The eminent psychologist was none other than Alfred Binet (1857–1911), who in 1891, after having worked beside Jean-Martin Charcot (1825–1893) at

the Salpêtrière Hospital in the 1880s, joined the Laboratory of Physiological Psychology at the Sorbonne, headed by Henry Beaunis (1830–1921). Although Binet had not yet become the psychologist that the world would celebrate as the inventor of intelligence tests (Binet & Simon, 1905, 1908; see Nicolas, Andrieu, Croizet, Sanitioso, & Burman, 2013), he was already regarded as the pioneer and ambassador of “new” psychology, notably through his ingenious use of new experimental instruments and his original method to investigate some psychological and psychophysiological issues (Nicolas, 2016).

It was on October 15, 1894, that Binet’s article (1894c) on the psychology of prestidigitation was published in the *Revue des Deux Mondes*. It was the last of a long series of articles by Binet to be published in that literary journal, which contained his studies and *réflexions* on a variety of topics including experimental psychology (Binet, 1893b), mental calculators (Binet, 1892a), colored audition (Binet, 1892b), and the great chess players (Binet, 1893a). What led Binet to take an interest in the psychology of magic? It was not a mere taste for the miraculous that sparked his interest (e.g., Blondel & Bensande-Vincent, 2002; Lachapelle, 2011; Plas, 2000). It was during a period of his scientific life when he was attracted by the psychology of “exceptional” subjects in various domains, because he thought studying them might shed light on the mental functioning of ordinary people (Binet, 1894a). He thus considered himself to be the promoter of a method that expanded on Théodule Ribot’s pathological method (1839–1916; for a biography, see Nicolas & Murray, 1999), developed by one of his admirers, Jean-Martin Charcot (1825–1893). In this approach, if the study of pathological subjects can provide information about the mental functioning of normal individuals, then the same should be true for the study of exceptional subjects. By studying magicians, Binet extended his research to new topics in psychology. Whereas his earlier work dealt with memory, calculation, and creativity, the study of magic gave him access to attention, perception, and voluntary movements.

By taking an interest in how magicians perform tricks that escape the eye, Binet was able to present a psychological analysis of the art of magic. In Binet’s words (1894c), “Magic is an art that set itself a peculiar goal: that of searching for and developing

all influences likely to mislead us and trick us about what we are seeing” (p. 903). To be able to trick the spectator, the magician relies on flaws in our cognitive functioning and devises procedures aimed precisely at rendering those flaws salient. To study techniques that occur at high speeds, he called on Georges Demeny (1850–1917), the skillful collaborator of Étienne Jules Marey (1830–1904). It appeared that Binet had to use a revolutionary system designed by Marey that could record movements in slow motion. “Mr. Demeny, with the aid of the new chronophotography apparatus, willingly photographed several tricks of prestidigitation.... The series obtained in the experiment gives both the form of the phenomenon and the length of time it occupies” (Binet, 1896, p. 570). That same year, Marey (1894) managed to accomplish a then-extraordinary feat: He used chronophotography to analyze the fall of a cat by increasing the rate of his apparatus to 60 images per second. With this new chronophotograph, Binet thought he could “break down” his magicians’ movements as they performed their tricks, in order to show that the illusions would disappear when the movements were shown in slow motion.

In this article, we begin by presenting Binet’s unique method and the principal professional magicians who served as subjects in his studies. Then we will look at the psychological factors identified and enumerated by Binet to explain the amazing performance of magicians. In this second part, we compare Binet’s conclusions with current work on the same topic. Lastly, we emphasize the innovative nature of Binet’s techniques for that period. By the late 19th century, he was already using the newest processes and devices available at the time. His idea was to study magic tricks by using the new chronophotography technique developed by Marey. Here, we present the way in which Marey proceeded to develop this innovative instrument and how Binet used it to conduct his laboratory studies on magic.

Binet and the Magicians at the Robert-Houdin Theater

At the beginning of Binet’s scientific career, he was particularly interested in the works of Hippolyte Taine (1828–1893) and Théodule Ribot (1839–1916), the two proponents of new psychology. As Carroy and Plas (1993, 1996) stressed, the prefaces of Taine’s (1870) and Ribot’s (1870) books became the texts that

marked the beginning of the “French method” in psychology (Danziger, 1990). This method relies on case studies of pathological or exceptional individuals, that is, people who “fall outside the norm.” Although, under Ribot’s influence, French psychology would focus on the study of pathological cases over time (see Nicolas & Murray, 1999), Binet turned his attention to case studies of exceptional individuals (exceptional in the sense that they were experts in a particular domain) and to developing a psychology of the individual, which he promoted a few years later (Binet & Henri, 1896; see Nicolas, Coubart, & Lubart, 2014).

BINET’S METHOD OF EXCEPTIONAL CASE DESCRIPTION AND HIS PSYCHOLOGY OF THE INDIVIDUAL.

In the early 1880s in France, Ribot (1881, 1883, 1885) developed a plan for scientific psychology based on abnormality (pathological and neurological disorders) as a model for studying “normal” subjects. According to this approach, also called the pathological method, the utility of pathology is that it can distort the mechanisms of one or more specific mental functions, thereby uncovering certain processes that remain hidden during normal functioning. This was the angle Binet used first to pursue his work with hysteria patients in Jean-Martin Charcot’s (1825–1893) ward at the Salpêtrière Hospital. The psychology he practiced at that time was thus closely tied to the treatment of mental illness, as evidenced by Binet’s publications during that period (e.g., Binet, 1886, 1888, 1890, 1892a; Binet & Féré, 1887), all of which were translated and published in English. In the early 1890s, however, Binet left the Salpêtrière Hospital to join the new laboratory of physiological psychology at the Sorbonne (see Nicolas & Samitioso, 2012). This change of workplace provided the opportunity for Binet to change his research paradigm. He decided to use the experimental method advocated by Wundt’s German School, although without strictly following the Leipzig model (Danziger, 1990). For Wundt, the experimental method could be fully applied only within the confines of the study of sensations and perceptions and only partially in the study of memory, images, and attention. Higher mental functions were thought to be inaccessible to experimentation. Binet was not as radical, in that he thought resorting to the experimental method was possible in a wider range of situations. Furthermore, according to Binet, psychology had to rely on experimental physiology

methods such as those developed at the time by their most prominent representative, Etienne Jules Marey (1830–1904), a professor at the Collège de France. For Binet, it was a question of establishing a genuine psycho-physiological science. Another major difference between Wundt’s and Binet’s points of view is that Binet thought it was useful to study individual differences. As Danziger (1990, p. 108) wrote, “Before the advent of intelligence tests, Alfred Binet’s name was associated with an ‘individual psychology’ that was truly a psychology of individuals, in the sense that measures of psychological performance were used to assess the individual style of a person’s functioning.”

It was in this context that Binet developed his research on the psychology of children and experts. To the experimental method, he sometimes added the “descriptive” method, that is, on observational methods and inquiries. In certain situations, he even considered this approach to be better than experimentation (Binet, 1894a). According to Binet, studies on the work methods of playwrights, for example (Binet & Passy, 1894, 1895), or on the memory of blindfolded chess players (Binet, 1894b) could be done solely by observation. Thus, descriptive psychology, above all, was the psychology of questioning and inquiries. “For descriptive psychology, the truth criterion lies in the concordance of the observations; aside from this rule, there is only illusion and fantasy” (Binet, 1893b, p. 445). Equipped with these two tools, experimentation and observation, Binet began his study of magic by recruiting several experts currently working at the Robert-Houdin Theater.

THE MAGICIANS COME TO THE SORBONNE LABORATORY.

In his article on the psychology of prestidigitation, Binet (1894c) listed his main collaborators in alphabetical order: Gustave Arnould (1850–1920), Professor Dickson (Paul-Alfred, the Count of St. Genies du Grand-Breucq; 1857–1939), Georges Méliès (1861–1938), Clovis Pierre, and Edouard-Joseph Raynal (1842–1918).² To arrange meetings with them, Binet contacted the French Association of Prestidigitators, which was founded in 1893 and headed by Méliès since its inception.

At that time, Georges Méliès (Figure 1) was the director of the famous Robert-Houdin Theater in Paris, located at 8 Boulevard des Italiens (Bessy & Duca, 1961). He had bought the theater in 1888 from the descendants of Jean-Eugene Robert-Houdin (1805–



FIGURE 1. Portrait of Georges Méliès (1861–1938), director of the Robert-Houdin Theater (from *L'illusioniste*, 21, September 1903, p. 169)

1871), certainly the most renowned illusionist of the 19th century (Fechner, 2002). On the theater's program, a continuous series of attractions and novel acts could be found, all created by its new director (Aris, 1984). In 1896, Méliès produced the first rigged film (*Escamotage d'une dame au théâtre Robert-Houdin*) in the history of French cinema and called on the greatest specialists of the discipline to present his creations to the public. Among these masters, we find Arnould and Raynaly, who worked with Binet and agreed to be filmed as they performed their magic tricks.

Gustave Arnould (Figure 2) began his career as a magician in 1873. He was a tireless traveler. Indeed, he put on shows in many Asian and American countries before founding a theater in Helouan, Egypt, in 1891. Back in Paris, he performed at various theaters and became known as a professional mnemotechnician. In 1893, Binet became acquainted with Arnould, who agreed to assist Binet in his research on mental calculation (see Binet & Henri, 1893), aimed at comparing Arnould's arithmetic abilities with those of Inaudi (1867–1950; see Burman, Guida, & Nicolas, 2015).

As for Edouard-Joseph Raynaly (1842–1918; Figure 3), he was a stage and salon magician. He began

his career in association with Isidore Bonheur. Under the name "Les Frères Bonheur," the two stage artists conducted then-fashionable "transmission of thought" sessions, which had been started up by Donato (Alfred-Edouard De Hont, 1845–1900). After this period, Raynaly was hired at the Robert-Houdin Theater under the direction of Méliès, where he worked between 1888 and 1901. In March 1904, Raynaly recalled meeting Binet 10 years earlier at the Sorbonne laboratory:

I was watched, interrogated, tested, photographed, and even timed, to the point . . . where they noticed that I was doing a sort of "saut de coupe" in a fifteen-hundredth of a second. . . . Despite this, the imposing and severe Sorbonne loaned its austere locale and allowed the manipulation of its scientific instruments in honor of magic, for the purpose of assessing and determining the sum total of its psychology. (p. 218)

In the article mentioned by Raynaly (1894), Binet (1894c) attempted to present a detailed account of the psychological mechanisms used by magicians. These studies were made possible by the collaboration of the magicians Arnould and Raynaly, who came to the psychology laboratory over a period of several months. During these visits, they performed



FIGURE 2. Portrait of Gustave Arnould (1850–1920) (in *L'illusioniste*, 47, November 1905, p. 93)

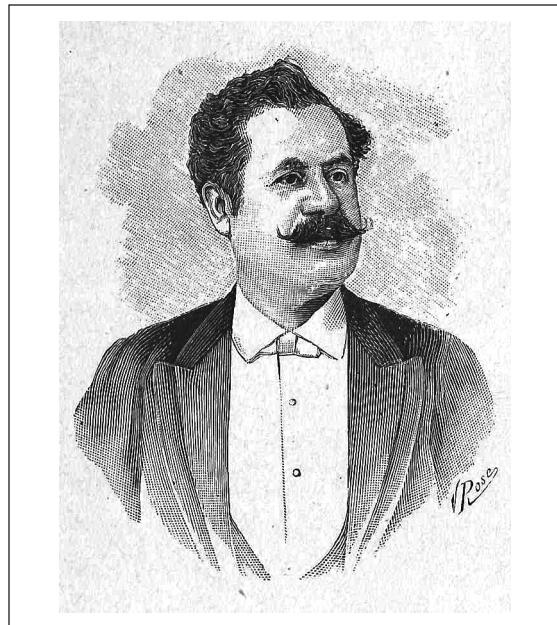


FIGURE 3. Portrait of Edouard-Joseph Raynaly (1842–1918) (in Raynaly, 1894)

their magic tricks, free of charge, breaking down the movements, slowing down or speeding up the passes, and agreeing to reveal what they usually hid (Binet, 1894d; for a discussion of what motivated these magicians to divulge their secrets in front of Binet, see Lachapelle, 2008).

Contribution of the Observation and Interrogation Technique: All Prestidigitation Rests on Psychological Processes

In the second half of the 19th century (considered as the golden age of magic³), magicians abandoned their capes and magic wands to present themselves as scientists or physicists (Lachapelle, 2008). During this period, “modern” magic shows mixed scientific lecturing with illusions. One of the most famous and representative magicians of modern magic was the French conjurer and scientist Jean-Eugène Robert-Houdin. In his book *Les secrets de la prestidigitation et de la magie* (1868), Robert-Houdin theorized some psychological ways in which conjurers fooled the mind.

In a footnote to his article, Binet (1894c) describes how he drew the initial elements of his psychological study of magic from the writings of Robert-Houdin (1868) and psychologists James Sully (1881, 1883) and Max Dessoir (1893).

But as mentioned earlier, Binet not only focused his investigation on the magician’s writings, but he especially took a “real-life” approach, relying mainly on observation, interviewing, and questioning. Even though Binet did not have at his disposal the theoretical concepts available to cognitive psychology today, it is striking to notice the visionary dimension of his writings.

In the past 10 years, a resurgence of interest in the science of magic has led to new insights into the cognitive processes associated with the magical experience of wonder. As stated by Rensink and Kuhn (2015, p.1), “despite being only a few years old, this ‘new wave’ has already resulted in a host of interesting studies, often using methods that are both powerful and original.” Surprisingly, some of the psychological subtleties recently discovered in the science of magic can be closely linked to the observations provided a century before by Binet (1894c).

Binet’s article (1894c) described a number of psychological mechanisms involved in magic tricks. He stated, “All prestidigitation . . . rests on psychology,” and during a magic show, “It is not our senses that trick us, it is our mind” (p. 564). Here, we briefly present some of the conclusions Binet drew from his observations. We show that in certain respects Binet’s initial research on the links between magic and psychology are aligned with some of today’s studies on this topic.

Using the tools described here, Binet focused mainly on some facets of one of the most important magical devices: misdirection (for a complete taxonomy of misdirection, see Kuhn, Caffaratti, Teszka, & Rensink, 2014).

Magicians use misdirection to prevent people from noticing the method of a magic trick whilst still experiencing this effect (see Kuhn, Teszka, Tenaw, & Kingstone, 2015; Lamont & Wiseman, 1999). Misdirection of attention is close to the well-known phenomenon known today as inattentional blindness (Barnhart & Goldinger, 2014; Kuhn & Tatler, 2011), where people fail to see salient and potentially relevant events whenever their attention is directed elsewhere (Simon & Chabris, 1999). Based on this principle, misdirection is aimed at attracting attention to an object, a movement, or a place, in order to “blind” the audience to a manipulation the magician will perform outside that area of interest (for several recent experiments about misdirection, see Kuhn,

Amlani, & Rensink, 2008; Kuhn & Tatler, 2011; Kuhn et al., 2014, 2015).

Magicians have been using the principle of misdirection from the very beginning of magic. For example, in his book concerning the “secrets of magic,” magician Robert-Houdin (1868) wrote,

The goal of the gesture . . . is to attract the audience’s attention to a point far away from the place where the prestige is taking place. For instance one might, with a certain affectation, put an object in the corner of the table where one is working, at the same time as one’s left hand moves behind the table to grasp a hidden object and make it appear. (p. 88)

In his article on magic, Binet (1894c) described the mechanisms underlying the misdirection phenomenon using terms very similar to the psychological descriptions of attention filters being proposed today in the science of magic works:

All perception is a choice, a sorting out; countless sensations make our sense organs vibrate relentlessly; we neglect most of them because they offer nothing of interest; our attention fixates only on a few, the significant sensations; they alone cross the threshold of clear consciousness, become the object of our reasoning, remind us of our memories, and play a role in our inner life. (p. 913)

Sometimes misdirection is based not on movements but on expectations created by the magician, either through what he says or, very often, by where he looks. For example, the magician will guide the spectator’s attention by looking at a particular point in the surroundings, such as his hand as it moves (for the role of the magician’s gaze in misdirection, see Kuhn & Findlay, 2010; Kuhn, Tatler, & Cole, 2009; Kuhn et al., 2014, 2015). In short, our attention is automatically directed toward the place where others are looking. Magicians have been using this principle for a long time to direct the audience’s attention and gaze. In Robert-Houdin’s (1868) book, he talks about this magnetic aspect of the magician’s gaze:

The eye . . . also contributes to increasing the effect of conjuring tricks. A skillful magician uses his direction of gaze to spread a conviction

among the spectators. . . . This apparent conviction is communicated to the spectators and the illusion wins over. (p. 94)

In Binet’s analyses of magicians’ techniques, he too was well aware of the importance of the eyes. He notes that the magician must start by capturing people’s gaze and getting them to pay attention to the area where he himself is looking (1894c):

When all the spectators’ eyes are fixated on the artist, he can make all of them shift their gaze to some point by looking at that point himself, in a natural way; if he looks to the right, the spectators will obediently look in that direction. (p. 914)

Another tool available to the magician for misdirecting the spectator’s attention is his discourse or explicit instructions, which in magic is called patter (Kuhn et al., 2014, 2015; for the role of the magician’s verbal suggestions in the spectators misremembering, see Wiseman & Greening, 2005). For example, the magician may ask the spectators to “pay attention to the cup on the table” in order to misdirect their attention away from the zone where the method takes place. According to Kuhn et al. (2015), the patter (i.e., “keep your attention on the card”) can modulate the spectator’s attentional process through top-down control. As Robert-Houdin (1868) stated,

The operator in simulated magic is a profound dissimulator, in his words and in his actions: he says what he doesn’t do, doesn’t do what he says, and does what he is careful not to say. (p. 92)

Binet (1894c) was well aware of the importance of patter:

There exists another artifice that makes the effect of a trick ten times stronger, it is patter, a pleasant little speech through which the spectator’s mind is oriented in the direction most favorable to the illusion. (p. 912)

According to Kuhn et al. (2014), magicians can also use nonverbal suggestions to influence spectators’ attention, perception, and memory. For example, magicians can manipulate spectators’ expectations and perceptual anticipations in order to make them

“see” what does not exist and overlook the method behind the trick. A well-studied illusion based on perceptual anticipation is the vanishing ball illusion (VBI) (Kuhn & Land, 2006; Kuhn & Rensink, 2016; Thomas & Didierjean, 2016; Triplett, 1900). In VBI, the magician throws a ball up in the air several times. The ball seems to vanish into the air on the third throw. What really happens is that after the second throw, the magician secretly keeps the ball in his hand and only pretends to do a third throw. The spectator nevertheless “sees” the ball leave the hand before it vanishes. The mechanisms involved in VBI are probably similar to those found in the representational momentum effect (Freyd & Finke, 1984; for a review, see Didierjean, Ferrari, & Blätter, 2014). Binet (1896) described the vanishing ball illusion and some of the psychological mechanisms it involves:

A feint is made of throwing an orange into the air, when in reality it is still retained in the hand. . . . As soon as we perceive the first act, we assume the second because it is the logical consequence, or simply the habitual accompaniment. We do even more than suppose it; we represent it so vividly to ourselves that we believe we see it. (p. 560)

Finally, magicians can prevent participants from noticing the method of a magic trick by using a physical occluder. For example, the magician can hide the secret opening of a ring behind his fingers to create some magical penetration illusions (e.g. Chinese linking rings routine).⁴ According to amodal completion theory (Kanizsa & Gerbino, 1982; Michotte, Thines, & Crabbe, 1991), perceptual mechanisms have a natural tendency to fill in what we do not see, thus enriching our perceptual trace with elements that are not visible. For example, in the multiplying billiard balls illusion, the magician tricks the spectator’s mind by using an empty shell that the audience falsely perceives as a complete ball (Ekroll, Sayim, & Wagemans, 2013).

In his work on magicians’ tools, Binet (1894c) proposed an analysis somewhat similar to that found in current studies on the role of screens or visual concealment (Barnhart, 2010; Ekroll et al., 2013; for more details about the role of screens in magic, see Thomas, Didierjean, Maquestiaux, & Gygax, 2015). According to Binet (1894c), when spectators are ex-

posed to a trick involving the use of an occluder, they are not suspicious because “a detailed mental image that remains constantly activated fills in the sensation and prevents us from noticing the gaps” (p. 918).

Although Binet’s psychological study of magic was based largely on real-life observations, interviews, and analysis of magicians’ writings, he was also a pioneer of experimental psychology by being the first to use the newest optical tool of his time, the chronophotograph, to decompose magicians’ moves.⁵

The New Technique Adopted by Binet:

Marey’s Chronophotography

To prove that, in magic, our minds trick us, Binet (1894c) took a series of photographs of the execution of several magic tricks, one of which is called the two-handed *saut de coupe* (jump cut), where the magician discreetly switches the upper and lower halves of a deck of cards. This was done by a collaborator of Marey, a pioneer of photography, using an innovative technique called chronophotography, a precursor of today’s cinema. Binet (1894c) wrote, “These photographs were taken with a chronophotograph, which puts out a series of ten to fifteen frames per second, each one separated from the preceding one by an interval of a tenth of a second” (pp. 346–347).

MAREY, INVENTOR OF CHRONOPHOTOGRAPHY.

Pierre Flourens’s (1794–1867) successor to the chairmanship of physiology at the Collège de France, Etienne Jules Marey (1830–1904), was the most eminent representative of the new French physiology. For Marey, “Most of the progress achieved in the experimental sciences as well as in the sciences of pure observation is due to improvements in the methods and instruments employed” (Marey, 1868b, p. 3). In this vein, he promoted the “graphic method” in the experimental sciences (see Marey, 1897).

The graphic method is a technique using recording instruments that produce a graphic representation of several complex and imperceptible variables, such as time durations, temperature variations, and muscle movements. This method was first used for the analysis of physical processes, such as the determination of the trajectories of falling bodies, and was subsequently introduced into physiology, which enabled physiological events to be directly recording by “slowing down and magnifying hitherto indistinguishable or unobservable biological events” (Borell,

1986, p. 114). According to Marey (1868a, pp. v–vi), “The use of the graphic method makes the illusions of the observer, the slowness of descriptions, the confusion of facts, disappear.”

To popularize the use of the graphic method in the experimental sciences, Marey (1868a) disclosed some of his recording inventions (kymograph, myograph, sphygmograph, cardiograph, hemodrograph, pneumograph, portable polygraph) in his lectures at the Collège de France.⁶ However, one of the limitations of the graphic method is that it requires a physical link between the animal or human under study and the recording instrument.

Very early on, Marey nevertheless developed a strong interest in the study of movements and locomotion in animate beings, which the naked eye is incapable of analyzing. In 1873, he published his book *La Machine Animale*, where we find, for example, drawings of a horse trotting and galloping (Marey, 1873). Inspired by this book, American photographer Eadweard Muybridge (Edward James Muggeridge, 1830–1904) decided to try to solve the puzzle of horse locomotion using photography. In the December 14 issue of the journal *La Nature*, an article about horse locomotion, presenting Muybridge’s work, was published (“Les allures du cheval représentées par la photographie instantanée”; Tissandier, 1878). Marey was enthralled by the method, even though Muybridge’s technique required taking a series of pictures with 12 cameras spread out along a track about 10 meters long. The new method Marey hoped to develop had to avoid using several lenses and be able to photograph the moving object from a single viewpoint. In the years that followed, he managed to satisfy these conditions using cameras that produced increasingly large numbers of successive images (from 10 to 60 per second). For Marey, the “chronophotographic” method he developed allowed him to mea-

sure the duration of each stage of the phenomenon being studied, thanks to the regular displacement of a light-sensitive plate. In this respect, it was quite comparable to the graphic method (Marey, 1893).

As early as December 1878, Marey set out to build a photographic rifle that solved some difficult questions, such as “What are the successive phases of movement of a flying bird’s wings?” It is true that the photographic gun was based on earlier, incomplete inventions, the first of which goes back to Jules Janssen (1824–1907), one of Marey’s colleagues at the Institute of France (Science Academy), who in 1874, using a series of successive photographs, “recorded” the positions of the planet Venus passing in front of “the disc” of the sun (Launay, 2012).

It was not until 3 years later, between January and February 1882, that Marey (1882) completed the first version of this device (Figures 4 and 5), which he presented at the Science Academy of Paris.

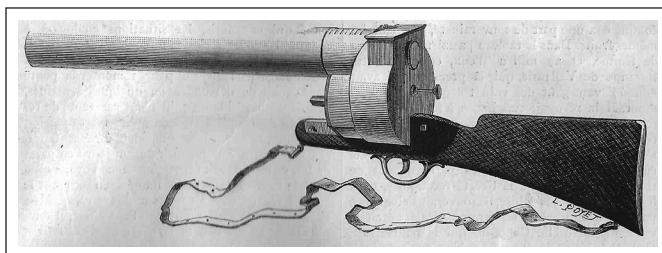


FIGURE 4. Marey’s chronophotographic rifle (in *L’Illustration*, April 22, 1882, p. 260)

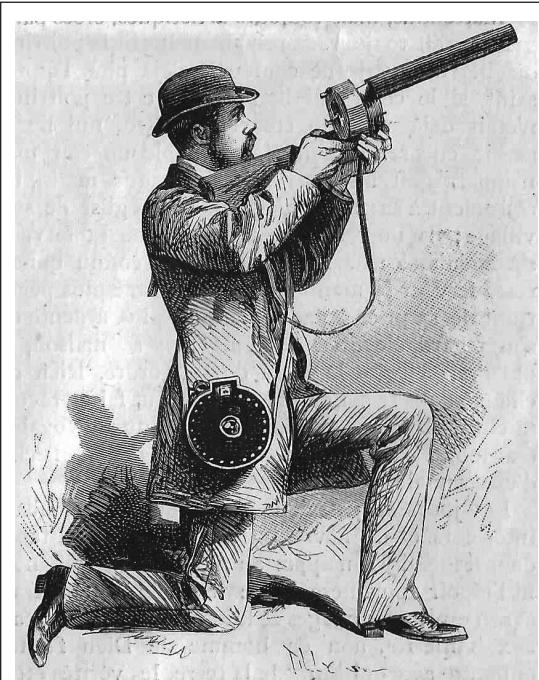


FIGURE 5. “In chronophotography, the scholar turns into a hunter. The magazine is equipped with 25 photographic plates that are put into position one by one at the back of the barrel, which has been converted into a lens. When the hunter sees the bird at the desired distance, he aims, fires. . . . The bang is replaced by a clanking and rattling noise. . . . The noise lasts a mere second, and the plate gets covered with twelve little photographs representing the different positions of the bird, taken a twelfth of a second apart” (in *L’Illustration*, April 22, 1882, p. 260)

Behind the shutter there is a light-sensitive plate (Figure 6) in the shape of an octagon, activated by a jerky but regular rotating movement. Twelve successive images are inscribed around the edge of the plate. However, the frames produced by the photographic rifle were unsatisfactory, and its technical problems were frequent and difficult to solve. This led to Marey's invention of a chronophotographic movie camera with a fixed plate (Figure 7), which he presented to the Science Academy of Paris on July 3, 1882.

From that date on (1882), Marey and his new lab assistant, Georges Demenÿ (1850–1917), conducted scores of experiments in which men and numerous animals were "chronophotographed." But Marey remained dissatisfied with the technique because many movements still could not be captured in chronophotographic investigations. Certain movements

produced intermixed images. On October 29, 1888, Marey (1888) presented his first chronophotographic film on paper to the Science Academy: "I have the honor today of presenting a strip of sensitive paper showing a series of images obtained at a rate of twenty images per second." It was on November 3, 1890, that Marey presented a new apparatus to the Science Academy, the photochronograph, of which Binet (1894c) spoke in his article. This device (Figure 8) was composed of a photographic apparatus containing a special type of shutter: a disc that turns on an axle and has rectangular holes in it. The disc makes a full revolution in 1 s, and behind the lens, a light-sensitive film unrolls and provides a new strip to imprint every time a hole passes by. The film stops for a very short time as the plate is being imprinted. The apparatus produced up to 60 frames per second.

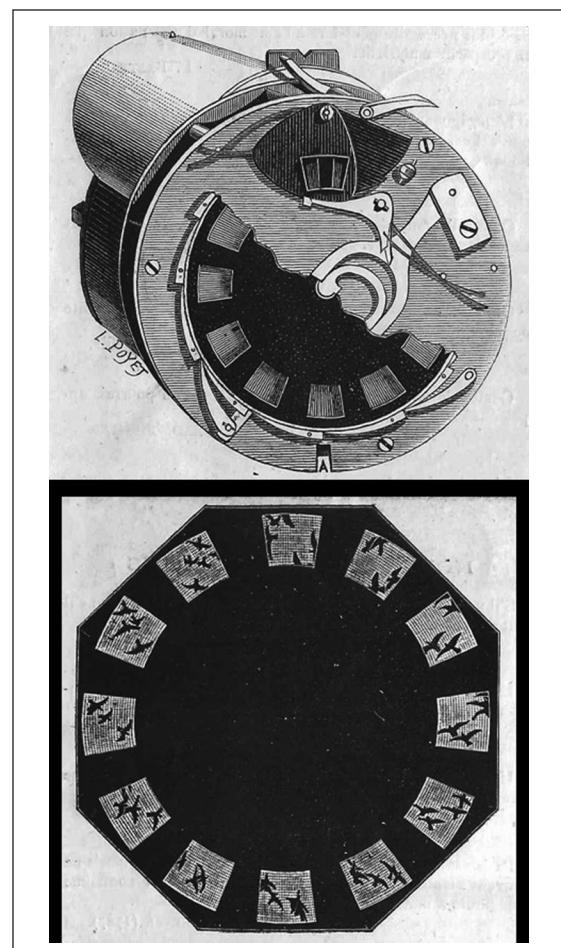


FIGURE 6. Close-up view of the chronophotographic rifle's mechanism (upper) and photographic frames obtained on the plate (lower) (from *L'Illustration*, April 22, 1882, p. 260)

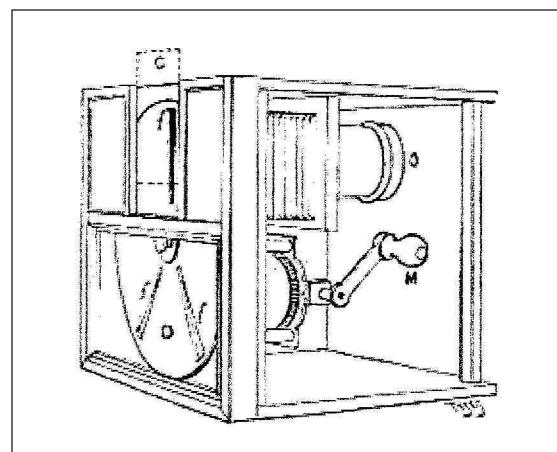


FIGURE 7. Fixed-plate chronophotograph of 1882 (from Marey, 1891, p. 691)

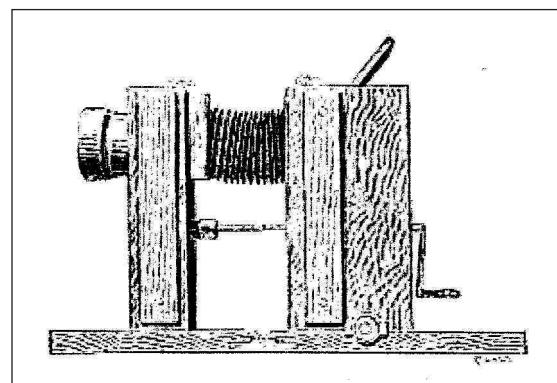


FIGURE 8. Complete chronophotograph or photochronograph of 1890 (from Marey, 1891, p. 693)

Each frame was separated from the preceding one by a constant time interval (1/10 of a second), in such a way that the chronophotograph gave both the shape and the time in an accurate manner.

CONTRIBUTION OF MAREY'S CHRONOPHOTOGRAPH TO THE STUDY OF MAGIC.

Binet had Demenÿ take chronophotographs of the hand movements of the two magicians, Arnould and Raynaly, as they performed the *saut de coupe* with one or two hands, the secret change of the top card, the vanishing crochet ball, and other tricks. If we look at the photographic collection still on exhibit today at the Paris Institute of Psychology (Figure 9), we are struck, as was Binet in his time, to find that we cannot see the illusion that appears so easily when the trick is performed in front of our eyes. Binet (1894a) went on to say that “if one examines this small collection of photographs, one is stunned to never find the illusion that is so clearly sensed when the trick is executed before one’s eyes” (p. 347). The reason why the photographic film completely destroys the illusions is that it eliminates all of the psychological factors that account for them. “The illusion does not rest solely on the precision of the movement, but also on its speed, the ‘patter’ that accompanies it and diverts attention, and also on several other psychological causes” (Binet, 1894d). Photography provided a measure of the exact duration of each movement. With this, Binet noted that the fastest card trick was the two-handed *saut de coupe*, which Raynaly executed in one tenth of a second. As Binet (1894c) explained, during a *saut de coupe*,

The invisibility is not dependent solely upon the short duration of the sensation received by

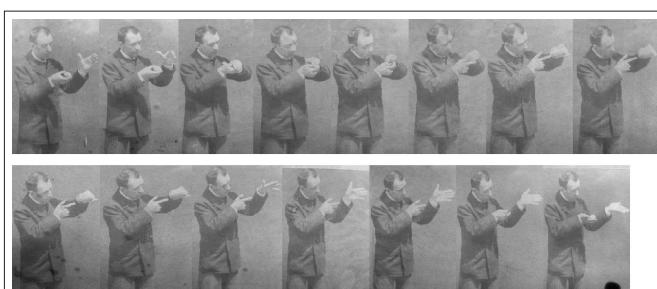


FIGURE 9. Series of 15 photographs taken by Demenÿ in 1894 using Marey's chronophotograph. The photographs break down Arnould the magician's movements during the vanishing crochet ball trick. (Courtesy of Bibliothèque Henri Piéron, Paris Descartes University)

the eye. . . . There are therefore two causes that concur to produce the illusion: the rapid movements of the hands and the complicated and inexplicable character of the operation. As soon as the second cause of the illusion is done away with, the illusion disappears. (p. 567)

By introducing Marey's innovative technology into his laboratory, Binet proved the interest of this new graphic method in the experimental sciences. The chronophotograph offers the scientist a spatio-temporally precise and detailed representation of living beings in their complexity. This new method opened new doors for experimental investigations by overcoming some limitations of empirical observation. For example, in the field of visual illusions, the chronophotograph offers the researcher an original way to distinguish the phenomena that that result from the limits of human vision from those that specifically result from mind failures.

Conclusion

Alfred Binet loved to work with exceptional subjects to discover the secrets of their remarkable capabilities (for a recent study, see Nicolas, Andrieu, Sanitioso, Vincent, & Murray, 2015). His goal was to uncover the mental mechanisms underlying their expertise in order to understand the psychological functioning of “normal” individuals. Among the magicians, Raynaly and Arnould were his preferred subjects. Not surprisingly, a certain affinity tinged with admiration grew between them, as we can see in Raynaly's (1894, 1904) remarks evoked here. On the other side, Binet (see Binet & Vaschide, 1898) wrote about the good qualities he saw in these outstanding people.

These people don't mind being acclaimed, and the idea of seeing their name in print, with a few sentences of praise in a well-known journal, is sufficient for them to accept hours of boredom at the laboratory; for our part, we never offered them any kind of remuneration; they showed an interest in our research, or they responded to the kindness we exhibited in their favor. (p. 4)

The in-depth study of these distinguished subjects established Binet as a forerunner in the scientific study of expertise in various domains (e.g., calculation, reasoning, writing, painting). His interest in exceptional subjects was accompanied by an original

scientific approach that went beyond the pathological method advocated by French psychology at that time.⁷ Binet was the promoter of the “exceptional case” method, which until recently continued to contribute substantially to our understanding of how normal subjects function, in areas that fall beyond the miraculous to which his name is often attached (for a review, see Didierjean & Gobet, 2008).

Binet’s (1894c) article was well received, as evidenced by the fact that the Smithsonian Institute translated it into English (Binet, 1896); the illusionists also gave it a favorable welcome and had it reprinted in 1905 in the journal *L’Illusioniste* (Binet, 1904–1905). However, it is surprising to note that current studies on the psychology of magic do not refer to it. Yet by studying the psychology of magic from the scientific standpoint, Binet (1894c) was able to unveil a number of psychological processes mastered by magicians but little known to psychology at the time (e.g., misdirection of attention, perceptual anticipation). It is striking to see the extent to which these psychological processes are like those “rediscovered” within the past 10 or so years by researchers in cognitive psychology and the neurosciences (e.g., Kuhn, Amlani, & Rensink, 2008; Rensink & Kuhn, 2015). As the founder of a new discipline, Binet has indeed offered psychology an original and fertile research domain: the psychology of magic.

In addition to the historical and theoretical qualities of Binet’s work, we must mention its methodological merits. Binet thought psychology should use instrumentation to address psychological issues. In fact, he never stopped inventing, perfecting, or using certain technical devices (see Nicolas, 2016) to gain insight into specific questions (e.g., handwriting movements; see Nicolas & Sanitioso, 2012). Marey had a great influence on Binet’s work concerning the application of technical instrumentation to psychological questions. As mentioned earlier, even in his very first studies at the Sorbonne laboratory in the 1890s, Binet used the graphic method to solve psychological or psychophysiological problems. And thanks to Marey and Demeny, the use of chronophotography gave Binet new research possibilities. His interest in this method did not dwindle in the years that followed, as we can see in Demeny’s (1899) article published in *L’Année Psychologique*. To support Binet in January 1902 for a position at the Collège de France

(Nicolas & Ferrand, 2002), Marey wrote a long report summarizing Binet’s scientific career in the following terms:

The study of the physical man brought into play a large number of known methods and necessitated the intervention of quite a few new procedures. . . . These investigations required using either the graphic method, various aspects of which Mr. Binet had improved, or developing a certain number of new devices.

... His studies on the adult, on the child, on schoolchildren, on the abnormal, on calculation experts, on chess playing, on magic, his research on the measurement of sensations, showed him that it was necessary to submit the highest functions of the mind to methodical experimentation; and in this way, he founded individual psychology, a new science aimed at determining the aptitudes of each one of us, which does not lack importance from the social point of view.

NOTES

Address correspondence about this article to Cyril Thomas, University of Franche-Comté, 30 Rue Mégevand 25030 Besançon, France (e-mail: cyril.thomas@univ-fcomte.fr or andre.didierjean@univ-fcomte.fr).

1. The article was an abridged translation of an article that appeared in the American journal *The Open Court*, whose true author was Max Dessoir (1893).

2. Binet’s experiments were conducted mainly with Arnould and Raynaly. Because of a lack of biographical references concerning Pierre and Dickson, this part will only give some information about Méliès, Arnould, and Raynaly.

3. The golden age of magic designates the period (between the second half of the 19th century and the mid-20th century) during which the art of magic was considered a favorite and major form of entertainment all over the world.

4. In the Chinese linking rings routine, the magician seems to link and unlink several solid metal rings together multiple times.

5. In this vein, today’s research in cognitive psychology uses some of the many technical advances designed to analyze the processes at play in magic. Some works on this topic rely on techniques for recording eye movements (Kuhn & Land, 2006; Kuhn et al., 2009, 2015), on functional magnetic resonance imaging (Parris, Kuhn, Mizon, Benattayallah, & Hodgson, 2009), or on motion tracking (Cavina-Pratesi, Kuhn, Ietswaart, & Milner, 2011; Phillips, Natter, & Egan, 2015).

6. In his works on human psychophysiology, Binet used the graphic method (cf. Nicolas, 2016), and he resorted to

several instruments invented by Marey, such as the sphygmograph (to record blood pressure) or the pneumograph (to record the velocity and the force of chest movements during respiration).

7. For example, Ribot claimed that morbid derangements of the organism in the psychological order were experiments prepared by nature. In his monograph *Diseases of Memory* (Ribot, 1881), he elucidated normal psychological mechanisms through the study of psychopathology (amnesia and dementia). For Binet, prodigies in the psychological order were also experiments prepared by nature. In his monograph *Psychology of Great Mental Calculators* (Binet, 1894b), he elucidated normal psychological mechanisms through the study of outstanding arithmetic virtuosos and computational geniuses (see Nicolas, Gounden, & Levine, 2011).

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