NATIONAL ACADEMY OF SCIENCES

WOLFGANG KÖHLER
1887–1967

A Biographical Memoir by

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Biographical Memoirs, VOLUME 81

PUBLISHED 2002 BY
THE NATIONAL ACADEMY PRESS
WASHINGTON, D.C.

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January 21, 1887–June 11, 1967

BY ULRIC NEISSER

WOLFGANG KÖHLER, distinguished psychologist and co-founder of Gestalt psychology, made many important contributions to science. Although he is probably best known for his empirical studies of chimpanzee problem solving (*The Mentality of Apes* [1925]), Köhler's deepest commitments were theoretical and philosophical. Perhaps his most fundamental commitment was to the principle of psychophysical isomorphism: Because brain and mind are identical, the structure of conscious experience during perception or memory or problem solving necessarily mirrors the physical structure of activity in the brain. "Experienced order in space," for example, "is always structurally identical with a functional order in the distribution of underlying brain processes" (1947, p. 61). In Köhler's view those underlying processes were trans-neuronal electrical currents flowing in well-defined regions of the brain. Isomorphism in this sense was one of the founding assumptions of Gestalt psychology, one that Köhler did more than anyone else to explore both empirically and theoretically.

In psychology the first half of the twentieth century was a time of competing schools: Titchener's structuralism, Freud's psychoanalysis, the behaviorism of Watson and Skinner, the functionalism of many American experimen-

talists, and—out of nowhere, it seemed, just after the First World War—the remarkable Gestalt psychology of Max Wertheimer, Kurt Koffka, and Wolfgang Köhler. Of course it did not really come out of nowhere. Its three founders were German, with intellectual roots in Husserl's phenomenology and in Kant. They saw themselves as fighters against positivism, as humanistic scientists engaged in a life-and-death struggle against vitalism on one side and against a series of dreary mechanistic psychologies on the other. Their chief opponents were behaviorism, associationism, and classical introspective psychology; much of Köhler's research was designed to refute the assumptions of those schools.

Wolfgang Köhler was born of German parents in Reval, Estonia, where his father was a schoolmaster; his family returned to Germany when he was six years old. He studied at several universities, receiving his Ph.D. from Carl Stumpf in 1909 with a thesis in psychoacoustics. After taking his degree at Berlin Köhler moved to Frankfort, where Kurt Koffka was also in residence and Max Wertheimer was just beginning his famous studies of apparent motion. Together they planned the future of what would soon become Gestalt psychology.

That future took a surprising turn in 1913, when Köhler was appointed the director of the Prussian Primate Research Center on Tenerife in the Canary Islands. Although he had no experience with animal research, the appointment was urgent. The Center was being directed by a graduate student, Eugen Teuber, whose term was about to expire (M. L. Teuber, 1994). Köhler and his family arrived at the Center in December 1913, expecting to stay for a single year. Eight months later, the First World War began.

Köhler tried to go home to do his military service, but this turned out to be impossible. No neutral ship would carry German nationals through waters controlled by the

British fleet. In the upshot he remained on Tenerife and continued to direct the primate station until it closed in 1920. Ronald Ley (1990) has made the interesting suggestion that Köhler—a German patriot isolated on a Spanish island—may have engaged in espionage during the war years. While some such espionage probably did take place (the Canary Islands lay close to major shipping lanes where British warships and German submarines were active), there is no convincing evidence that Köhler took part in it.

The station at Tenerife was the first primate laboratory ever devoted to behavioral research, and Köhler's experiments there are justifiably famous. From the beginning his chief aim was to show that the apes acted with *insight,* that their behavior was not governed by blind trial and error, their problem solving not due to chance. In this he was entirely successful. In experiment after experiment the apes took detours, pulled on strings, built climbing towers, broke up boxes to make sticks, and then fitted the sticks together to make longer implements. No one who reads Köhler's account of these achievements can seriously doubt the intelligence of chimpanzees; subsequent primate research has been built on the foundation that he established.

Although Köhler spent half a decade in Tenerife, almost all his important experiments were completed in the first six months. (An early version of *The Mentality of Apes* appeared as a technical report in 1917.) The rest of his time was occupied with a very different book, one that he hoped would establish the scientific basis of Gestalt psychology beyond any doubt. Its title—a mouthful even in German—was *Die Physischen Gestalten in Ruhe und im Stationaren Zustand* (1920), which goes into English as *The Physical Gestalten at Rest and in Steady State.*

Die Physischen Gestalten has one introduction "for philosophers and biologists" and another "for physicists." There

is none for psychologists; perhaps Köhler thought it would be too difficult for them. Although the book does occasionally resort to differential equations and other mathematical devices, its purpose is easy to understand. Köhler wanted to show that *Gestalten* could occur in purely physical settings, and specifically in the electrochemical systems that he assumed must exist in the brain. What are *Gestalten*? "Since von Ehrenfels, the term 'Gestalten' has been used to denote those mental phenomena and processes whose typical properties and effects cannot be derived from the similar properties and effects of their so-called parts" (p. ix). A Gestalt is a whole that is more than the sum of its parts.

There are indeed many organized wholistic systems in the world: Why should there not be? On this point the triumph of Gestalt psychology has been so complete that it is hard to understand how this was ever disputed or why Köhler had to demonstrate it. Interestingly, his demonstration anticipated many of the dynamic concepts that are now the "bread and butter" of cognitive science. Self-organizing systems, parallel distributed networks, and attractor states (for example) are all physical Gestalten. It is unfortunate that the scientists who developed those concepts in the 1980s and 1990s were largely unfamiliar with this aspect of Köhler's work. (One exception is Stephen Palmer, who cites *Die Physischen Gestalten* in his book *Vision Science* (1999, p. 220): "Marr and Poggio's . . . stereo algorithm is . . . an interesting example of dynamic neural networks as physical gestalten."

The last chapter of *Die Physischen Gestalten* introduces a new concept, one that came to have particular significance for Köhler and Gestalt psychology. When a dynamic process reaches a steady state, that steady state must differ somehow from the "unsteady" states that preceded it. But in what way? Physical processes tend toward energy minima,

but what do psychological processes tend toward? Are their end states especially simple? Regular? Symmetric? Köhler thought that all these candidate principles were inadequately defined, but he could find nothing better himself. He did manage to give the problem a name: "We will provisionally refer to this incompletely specified parameter as a 'tendency to establish simpler Gestalt structure,' or just [a tendency] 'to Pragnanz of the Gestalt'" (1924, p. 259).

Köhler was well aware of and embarrassed by the circularity of the "law of Pragnanz." Although his interests soon turned elsewhere, he never stopped hoping that a better definition would be found. When I took "the Köhler seminar" at Swarthmore in 1952, decades after *Die Physischen Gestalten*, one of the first tasks he put before us was to suggest definitions for "Pragnanz." I don't recall that we had anything useful to say.

Whatever doubts Köhler may have had about Pragnanz, he had none about isomorphism. On any particular occasion the phenomenal field has a given structure (i.e., the world looks as it does) because the electrical currents flowing in the visual cortex have that structure too. In his William James Lectures of 1934 (later published as *The Place of Value in the World of Facts* [1938]), Köhler developed the implications of this idea for such issues as evolution, the mind-body problem, and the distinction between fact and value. This was primarily a philosophical enterprise, and a very ambitious one at that. By the end of the 1930s, however, Köhler had returned to empirical research. He did so in a new setting, on a new campus, in a new country.

The 1920s and early 1930s had been a very successful time for Wolfgang Köhler. On his return from Tenerife he was briefly appointed professor at Göttingen, but soon (1922) moved to Berlin as professor of psychology and director of the psychological institute. (He succeeded his old teacher

Carl Stumpf, who had held the chair since 1894.) In the Berlin institute Köhler attacked a wide range of problems from the Gestalt point of view; these included psychophysics, apparent movement, and especially memory. With his student Hedwig von Restorff he studied the role of uniqueness in memory, establishing a phenomenon that is still called "the von Restorff effect." He also wrote a new book, *Gestalt Psychology,* which was first published in English (1929). By this time Köhler was an international figure, and Gestalt psychology was flourishing under his leadership.

In Germany at large, however, the 1920s and early 1930s were anything but successful. It was a time of chaos, of inflation and depression, of fascism and communism, of the ill-fated Weimar Republic and the stridently anti-Semitic National Socialists. By early 1933 conditions were ripe for Adolf Hitler, and his Nazis came to power. Hitler quickly turned his attention to the universities, issuing a decree that all Jewish professors and academics—from Nobel Prize winners down to laboratory research assistants—were to be dismissed at once. There was surprisingly (and disturbingly) little open resistance to this decree. Wolfgang Köhler was one of the few non-Jews who spoke out against it, publishing an eloquent protest that Henle calls "the last anti-Nazi article to be published openly in Germany under the Nazi regime" (1978, p. 940). In the same year the Nazis ruled that all professors must begin their lectures with the Hitler salute, a decree that Köhler openly mocked. For some months longer he tried to retain his professorship while maintaining his academic autonomy, but it was a losing battle. Eventually he resigned. In 1935 Wolfgang Köhler took up a professorship at Swarthmore College in Pennsylvania. He became a naturalized American citizen in 1946.

Hans Wallach, who had been Köhler's assistant at Berlin, also moved to Swarthmore. There they conducted their

famous studies of "figural after-effects," which Köhler presented as new support for the hypothesis of psychophysical isomorphism. These experiments, which Köhler described briefly in his book *Dynamics in Psychology* (1940), showed that prolonged inspection of visual patterns can change the apparent shapes and positions of other figures that are shown subsequently. (For a more complete account see Köhler and Wallach [1944].) He had expected such effects because an electric current flowing in a medium may produce localized changes that alter the conductivity of that medium itself, and hence alter the distribution of any new current that uses the same conductor at a later time. If this happens in the visual cortex of the brain, it may have noticeable consequences for the structure of the visual field. Somewhat surprisingly, it turned out that such after-effects appear not only in frontal displays but also in the third dimension of visual space and even in other sensory modalities. Although figural after-effects were a real discovery, it is by no means clear today that they are best explained by Köhler's isomorphism hypothesis.

In his later years at Swarthmore Köhler tried to test that hypothesis more directly. Did visual patterns really give rise to figure currents in the brain? With Richard Held he succeeded in recording direct currents from the brains of waking human observers, using scalp electrodes placed over the occipital region (1949). Their experiments were initially successful: With eye movements controlled, the direction of current flow changed in synchrony with the back-and-forth movement of a visible object. Similar flows were observed in the human auditory cortex during stimulation of the ear and also more directly in the cortex of the cat. Köhler was encouraged by these findings, but he was never able to prove that such currents play the key role in perception that is assigned to them by the isomorphism hypothesis.

Many honors came to Wolfgang Köhler in later life. Elected to the National Academy of Sciences in 1947, he became an international figure again. One of the few Americans to be named an honorary citizen by the Free University of Berlin, Köhler was awarded both the Warren Medal (by the Society of Experimental Psychologists) and the Wundt Medal (by the German Society for Psychology). He was elected president of the American Psychological Association for 1959 and was made honorary president of the analogous German association on the occasion of his eightieth birthday.

The international scientific community honored Wolfgang Köhler in these ways not only for his wide-ranging theoretical and empirical contributions but also for his courage and his character. As the holder of one of Germany's most distinguished professorial chairs in the 1930s he could easily have collaborated with Hitler as so many others did. Publicly rejecting that course, he spoke out against the brutal Nazis for as long as it was possible to do so. Then, here in the United States, Köhler resumed his productive research career and continued to make new contributions to science in his adopted country. A genuinely creative thinker as well as a person of great dignity and honor, a physicist and philosopher as well as a psychologist, a cultured citizen of a war-torn world, Wolfgang Köhler showed us by his own personal example what it can mean to be a scientist.

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