LANDMARK: ANIMAL INTELLIGENCE

Charles H. Turner, pioneer in animal cognition

An African American scientist's early discoveries are forgotten for all the wrong reasons

By **Hiruni Samadi Galpayage Dona** *and* **Lars Chittka**

In the late 19th and early 20th centuries, Charles Henry Turner (1867–1923) established a research program that was in sharp contrast to prevailing ideas regarding animal behavior and cognition. Despite facing almost insurmountable barriers because of his African American ethnicity, he published more than 70 papers, including several in *Science* (*1*–*3*), on comparative brain anatomy in birds and invertebrates, individual variation of behavior and learning competences, and intelligent problem-solving in a large variety of animals, at a time when the dominant ideas only credited animals with the simplest of learning abilities. But his discoveries and conceptual advances failed to gain the recognition they deserved, and his works were later all but forgotten—indeed, some recent animal cognition research has reinvented wheels that had already been fashioned by Turner.

Charles Darwin (1809–1882) and George Romanes (1848–1894) were famously generous in attributing intelligent behavior and mental abilities to animals, but their musings were largely based on observation and inference. The predominant experimentalist theories of animal behavior in the early 20th century, however, largely rejected notions of advanced animal intelligence or insight. Early ethologists such as Oskar Heinroth, Charles Whitman, and Wallace Craig focused instead on innate behavior and imprinting, a simple form of learning. Where problem-solving was observed, such as when animals open puzzle boxes, behaviorists such as Edward Thorndike proposed that this materialized as a result of trial and error, not insight or understanding of the nature of the challenge. None of these scientists were interested in individual variation of behavior. Enter Charles H. Turner, who took seriously Darwin's assertion of the importance of individual variation as well as the idea that humans were not the only intelligent animal species. But Turner backed up this possibility with a rigorous experimental approach.

Turner was born just 2 years after the end of slavery in the United States in 1865. He obtained his M.Sc. from the University of Cincinnati in 1892 (*4*). In the same year, the 25-year-old published two single-author papers in *Science*—one of which was a short version of his B.Sc. work on the comparative anatomy of bird brains, whose relative size and complexity he compared with those of reptiles (*1*). Turner's verdict was, "When we compare the brain of a crow or a titmouse with the brain of a snake or a turtle, it is no longer a marvel that birds bear towards their reptilian cousins the relation of intellectual giants to intellectual dwarfs" [(*1*), p. 16]. The same year also saw the publication of another remarkable study on variations in web building by gallery spiders (*5*) that contained key ingredients of Turner's distinct interpretation of animal behavior that was to accompany his entire body of work. Like many of his future papers, the study interfaces careful field observations with meticulously controlled laboratory work. Contrary to the still-popular view that spider web construction is a prime example of invertebrates' robotic, repetitive action patterns, Turner reported variation between individuals in adapting their construction to the geometry of available space and the functionality in capturing prey: "we may safely conclude that an instinctive impulse prompts gallery spiders to weave gallery webs, but the details of the construction are the products of intelligent action" [(*5*), p. 110]. In the year of his Ph.D. (1907), Turner published on associative and spatial learning in ants and reported individual learning curves of their performance (*6*). Turner's focus on individual differences in behavior is a constant theme in his studies. It is deplorable that the now-popular field of "animal personality" has taken so little notice of Turner's trailblazing approach.

The list of Turner's discoveries and insights that should have garnered attention, but did not, is long. Every student of animal behavior knows Nikolaas Tinbergen's study from 1932 on spatial learning, in which the later Nobel laureate (awarded for studies of individual and social behavior in animals) first marked a beewolf's nest entrance with pine cones, then moved them to demonstrate that the insect was guided by a memory of the landmarks (*7*). But it is mostly unknown that Turner had already published similar findings in 1908, observing a solitary burrowing bee whose nest entrance was close to a discarded Coca Cola bottle cap. When the cap was moved to a nearby location next to an artificial burrow that Turner had made, the bee crawled into that burrow without hesitation—indicating, just as in Tinbergen's experiments, that the insect had a memory for landmarks rather than, for example, being guided by an instinct to follow the scent of the nest (*8*).

In 1912, in a study that explored how a prey-carrying walking wasp finds its way home around obstacles in the path, Turner explicitly confronted Thorndike, affirming that the wasp's behavior is not explicable by trial-and-error learning and is instead consistent with a form of intentionality and an awareness of the desired outcome of the wasp's actions (*9*). Moreover, Turner found that an ant stuck on a small island began assembling a bridge to the "mainland," using three different materials (*10*). The ant's behavior could not easily be explained by then-popular notions of instinct or trial-and-error learning; instead, the ant appeared to appreciate the nature of the problem, imagined a solution, and then worked toward this goal.

The view that animals are capable of insightful problem-solving was also apparent in Turner's interpretation of his field observations of the hunting behavior of a snake pursuing a lizard (*3*). The lizard had escaped up a tree and looked downward where it expected the snake to launch the next attack. The snake, which had been pursuing the lizard for some time, instead ascended another tree, crossed over when it had reached a point higher than the lizard, and then attacked from behind. These observations are reminiscent of the detour behavior seen when jumping spiders hunt—discovered in the 1990s (*11*). It is remarkable that Turner's views on animal intentionality preceded present-day explorations of the same topic by a century. Even though his experimental work was known to contemporary giants such as John Watson and Thorndike (*4*) and across the Atlantic by later Nobel laureate Karl von Frisch, Turner's visionary ideas about animal intelligence did not resonate in the field; perhaps they were simply too far ahead of the time. Accordingly, they are almost completely unrecognized in the current literature.

Further highlighting the importance and insightful nature of Turner's work, in 1913 he reported on the effects of age and sex on cockroaches trained to navigate mazes (*12*). Turner found that individuals placed an em-

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From Charles H. Turner to comparative cognition: 1850–2020

Charles H. Turner made important observations about animal cognition, which went against the leading paradigms of the time. His ideas have stood the test of history, but Turner's work has largely been forgotten, likely because his ethnicity prevented him from becoming a research team leader and so he could not train scientists who might have continued his approach. Turner was active in the U.S. civil rights movement and advocated that education is key to overcoming ethnic barriers in society.

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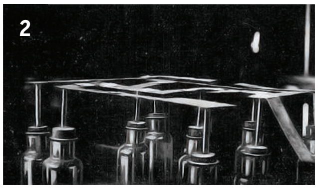

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St. Louis Globe-Democrat. EXTRA FINAL

100 NEGROES SHOT, BURNED, CLUBBED TO DEATH IN E. ST. LOUIS RACE WAR

Riot at Its Height Near Broadway and Fourth as Sketched by Artist Russell

1865 End of American Civil War

1867 Charles Turner is born in Cincinnati

1891 B.Sc., University of Cincinnati; publishes on comparative anatomy of bird brains

1892 M.Sc., University of Cincinnati; publishes on individual variation and intelligence in spiders

1907 Ph.D., University of Chicago; publishes individual learning curves of ants

1908 Demonstrates spatial learning in a bee by moving landmark at nest

1909 Discovers detour behavior in a snake

1913 Maze learning in cockroach; discusses a "will" in roaches

1917 E. St. Louis massacre while Turner teaches at school in St. Louis

1923 Turner dies in Chicago

1932 Tinbergen publishes his "pine cone" experiment on spatial learning in wasps

1994 Tarsitano and Jackson discover detour behavior in a spider

2009 Heisenberg discusses "free will" in insects

GRAPHIC: V. ALTOUNIAN/*SCIENCE*; (IMAGES, CLOCKWISE FROM LEFT) WIKIMEDIA COMMONS;C. H. TURNER *ET AL.* (12); *ST. LOUIS GLOBE-DEMOCRAT*, 3 JULY 1917, P. 1

phasis on either speed or accuracy: Older cockroaches choose slowly but more precisely. Extraordinarily, Turner suggests that the hesitation that cockroaches display when evaluating their options bears the hallmarks of will, a facet of consciousness. The question of whether humans and other animals exhibit free will continues to generate controversy among neuroscientists and philosophers. That insights from insect behavior could contribute to this debate has only recently been suggested again by neuroscientist Martin Heisenberg (*13*), who proposed that insects display an awareness of the consequences of their actions and evidence of free will in deciding between options.

Why is Turner not more widely credited as a major luminary in research on animal intelligence? Turner faced substantial obstacles because of his ethnicity. Despite publishing many important papers, he was not given a post at a major U.S. research university. Turner's work was thus conducted without access to state-of-the-art laboratory facilities or library resources. One reason for Turner's relative obscurity today may be that he had no possibility of mentoring research students who would have carried his ideas into subsequent generations. For comparison, Russian Nobel laureate Ivan Pavlov (1849–1936), famed for his studies on classical conditioning, trained more than 140 co-workers. One cannot help but wonder what Turner might have achieved if he had had comparable resources and manpower. The entire field of animal cognition may have developed differently. Would a "cognitive revolution" have been needed against the dominant ideas of behaviorism that ruled psychology for the first half of the 20th century (postulating that learning largely happens in the form of simple associations), if Turner's ideas about advanced cognition in animals had generated a movement at the time he expressed them?

African American historian William Du Bois (1868–1963) lamented that "C. H. Turner, one of the great world authorities on insects, nearly entered the faculty of Chicago University; but the head professor who called him died, and his successor would not have a "N-----," despite a reputation which was European; Turner died in a high school of neglect and overwork" [(*4*), p. 348]. The institution at which Turner taught from 1908 to 1922 was Sumner High School, a school for African American children in St. Louis. During his time there, he and his pupils would have witnessed the East St. Louis massacre in 1917, during which white mobs murdered more than 100 African Americans; another 6000 lost their homes as a result of arson attacks on their neighborhoods (*14*). Turner was active in the U.S. civil rights movement, and years before coming to St. Louis, he wrote that an emphasis on high-quality education and a conscious effort to abandon prejudices might eliminate barriers between Blacks and whites within a few decades (*15*).

One would hope that nowadays, a person of Turner's caliber might not face similar adversity in terms of academic employment opportunities or long-term recognition of their contribution to science. But even today, very few scholars in animal cognition, or indeed across biology, are Black. Turner clearly recognized the importance of ethnic-minority role models from the earliest stages of education; their near-complete absence in a field of scholarly study will require concerted counterefforts. Funded summer schools for ethnic minority students can also make a substantial difference to inspire budding scientists. Institutions must make still-stronger efforts to eliminate biases in hiring, promotions, and salary decisions and to celebrate the successes of ethnic minority scholars. Even where they do (and there is likely plenty of room for improvement), overt or poorly concealed racism is still commonly experienced by underrepresented ethnic groups, even in academia. This will likely discourage many aspiring scientists from venturing further. A hopeful development is that some conference organizers are taking steps in the right direction to increase inclusivity; for example, the Animal Behavior Society annually supplies the Charles H. Turner award that prioritizes traditionally underrepresented groups for conference travel funding. More than ever, humanity needs to be inclusive to confront current and future challenges. Diversity increases the pool of talent and, as Turner's example shows, has the potential to transform entire fields. ■

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