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SPECIAL ISSUE

Testimonial for and Reminiscences about Neal Miller

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The author served as a research assistant with Neal Miller at Yale from 1955 to 1959. He narrates Miller's research activities on social learning and imitation, on personality and psychotherapy, and on brain structures mediating biological drives and rewards. He describes Miller's classroom teaching and relationships with graduate students. He pays tribute to Miller's encouragement for Bower's own research, and the life lessons and scientific lessons he provided for many of his students and young researchers.

I had the supreme good fortune to receive a graduate research assistantship with Neal Miller at Yale from 1955 through 1959. By that time Neal was at the peak of his extraordinary productivity. He was a masterful role model for all of us graduate students and post-docs—energetic, enthusiastic, full of ideas, deeply engaged in the many research projects spinning around him, and eager to teach his students the tactics and joys of exploration and definitive experimentation. By the 1950s he had been world famous for some 15 years. He became my intellectual loadstone, my mentor, my guru. I continued to talk things over with him, and to be inspired and attached to him emotionally until his death in 2002.

Before coming to Yale, I was an undergraduate studying psychology at Western Reserve University in Cleveland, Ohio, where I had been steeped in Freudian psychoanalysis and the experimental psychology of learning—two early major interests of Miller's research. I learned at Miller's side the cannons of liberalized stimulus-response (S-R) reinforcement theory as illustrated in two famous books he co-authored with John Dollard, *Social Learning and Imitation* (1941) and *Personality and Psychotherapy* (1950). The books are well worth a brief digression here.

Social Learning and Imitation

Social imitation, of course, is a major mode of learning for humans, and some rudimentary forms of it appear even in young infants (e.g., Meltzoff & Moore, 1977).

The behaviorist approach in those days was to understand the learning conditions underlying a given human behavior by seeing how to reproduce its essentials with nonhuman animals, typically rats. Thus, *Social Learning and Imitation* described many of Miller's simple experiments showing how an ''observer'' or ''follower'' rat in a T-maze could learn to use the cues from the responses (the turns) of another rat (the leading ''expert model'' running in front of the follower) to duplicate or guide its own behavior to get a reward. The book also contained demonstrations of how to train an animal to *generalize* the imitative tactic so it would follow a new leader performing a novel response in a novel situation. Miller's training methods have been used and elaborated in many later projects for training other species to imitate in synchrony novel and creative performances of a ''leader'' (e.g., the dolphins of Louis Herman, 2002). The methods also formed the basis for much of the later work on imitation learning by human subjects who observe the behavior of a model (e.g., Bandura, 1969).

Personality and Psychotherapy

Dollard and Miller's second book, *Personality and Psychotherapy*, was an extremely important and influential text in the 1950s. (We students in Miller's learning seminar practically memorized it for the tests. I've kept my dog-eared copy as a memento.) The authors showed how a liberalized version of stimulus-response reinforcement theory could be used to interpret and explain many aspects of human personality. In particular, they aimed to understand personality, psychoneuroses, and psychotherapy by interpreting and translating into stimulus-response terminology the important concepts of Freudian psychoanalysis: unconscious contents and processes, motivational conflicts, symptom formation of ''defenses'' that reduce anxiety (e.g., repression, projection, sublimation), and the therapeutic value of ''uncovering'' unconscious conflicts in order to teach patients more adaptive, discriminating ways to interpret or resolve their conflicts.

Much of the background for these extrapolations came from Miller's important experiments on (a) his approach-avoidance conflict theory, (b) his experimental demonstrations of behavioral analogs of ''displacement''—how a

behavior toward an unattainable goal-object could be ''displaced'' toward a similar, substitute goal-object, (c) his demonstrations of how people's covert responses (silently saying or thinking the word ''shock'' or ''relax'') could be trained to exert partial control over their emotions and overt behaviors, and (d) his analysis of how trained covert or implicit responses (like ''danger'' or ''safe'') could help a person generalize a behavior from one to another situation, or how trained covert responses (from different learning conditions) could help the person discriminate between two similar situations. Two kinds of examples were used: experiments in which children learned to generalize avoidance of objects labeled ''dangerous,'' and experiments in which clinical patients learned to distinguish between safe versus frightening objects, persons, or memories of past situations (e.g., having consensual sex with one's partner contrasted with an earlier rapist).

Most psychologists were impressed with the ingenuity of the Miller-Dollard conceptual analyses, including many therapists of the Freudian persuasion. It was only later with the advent of behavior therapy (Eysenck & Rachman, 1965) and social learning theory (Bandura, 1969; Bandura & Walters, 1963; Mischel, 1968) that the details of Freudian concepts were devastatingly criticized and began to wane. The Freudian approach was replaced increasingly with human research that relied upon delayed imitation of behaviors acquired from one trial of observing symbolic models. Still, the Miller-Dollard type of personality analyses continued to have appreciable influence on later thinkers.

Miller's Classroom Teaching

The only formal course I took from Neal was his year-long graduate seminar in motivation and learning, in which the readings covered essentially his theories and experiments. Neal obviously knew the material of the readings, but he'd arrive little prepared to lecture about them. Instead, he would typically start out by asking ''Any questions (about the readings)?'' and then he'd wing it spontaneously, perhaps with little ''mini-lectures'' thrown in during the session. If no one had any questions, he'd grill some poor student about various points in the readings. Students quickly learned to come prepared with questions. Although he did not excel as a classroom teacher, I soon came to appreciate his Socratic method. Moreover, his didactic value at Yale was as a fabulous researcher, an accessible, helpful consultant for young researchers, and an unforgettable mentor for motivated graduate students. His Yale colleagues understood perfectly his enormous value for the department's training program.

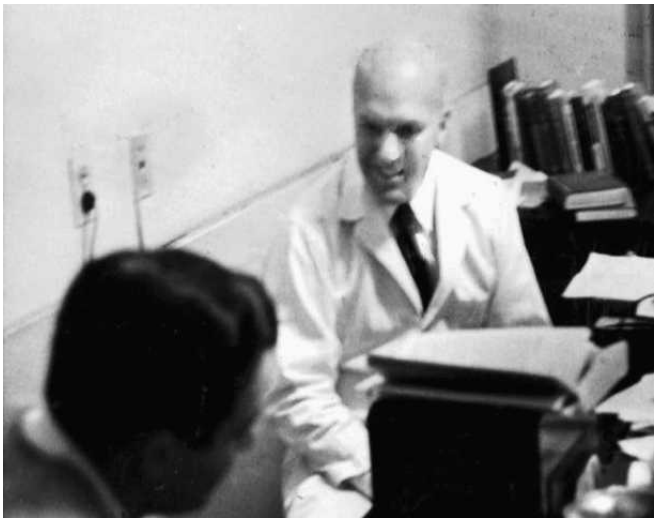

Figure 1. Neal Miller at his office desk in a typical research discussion with Gordon Bower circa 1957 when Bower was a graduate student.

The first photo recalls for me the typical ''brain storming'' interaction I was lucky to engage in at least once a week in Neal's office (Figure 1). He had a two-room office suite, and I had a desk just outside his office door, so we also got into countless spontaneous conversations in passing. Although Neal was overflowing with research ideas, he tried to foster students' original thinking and was interested in our coming up with new research ideas—provided they were not ''too fuzzy.'' He would listen to his students' ideas, give us honest feedback, and often give us financial support to carry out our research. In his publications and public speeches, he was magnanimous in giving credit to student collaborators, and he treated us as colleagues in the great exciting search for knowledge. I appreciated that style of mentoring, and I've tried to emulate it with my own students.

Initial Research with Neal

When I arrived at Yale, I was mainly interested in animal learning. By that time, however, Neal was looking for brain structures that produced biological drives and reward (his work on biofeedback and behavioral medicine was far in the future). So that direction dictated my first-year projects. Unfortunately, my initial research with Miller on this topic came up empty. He and Bill Roberts (a post-doc) had shown that injecting a tiny bit of saltwater into the ventricles of a cat's brain (near the hypothalamus) would cause it to drink copious amounts of water. We reasoned that if the salty injection were causing ''real thirst,'' then it should serve as a discriminative stimulus to guide the animal's choices. So my task was to get the cats (from Roberts' former drinking study) to turn one way in a T-maze to get a reward when

''thirsty'' (i.e., after they had just received a saltwater injection into the ventricles), and to turn the other way when not ''thirsty'' after an injection of isotonic saline (same as body fluids). To avoid contamination with other biological drives, Neal suggested that the cat's reward for correct choices would be to let it have a ''free romp in the lab room.''

After struggling for many weeks to get the cats to move through the T-maze at all (the romp proved insufficiently rewarding), they hadn't learned anything useful. I discovered upon rechecking that the saltwater injections were no longer causing excessive drinking, probably due to brain-tissue damage around the injection site. So, with great relief, I was allowed to abandon that project. This oversight taught me the value of rechecking the effectiveness of experimental manipulations. (One side benefit of this study was that one of my cats from the city pound delivered herself of several kittens that Miller's children, York and Sarah, were happy to take off my hands.)

The Dual Reward-Punishment Study

Neal was excited by the brain-stimulation reward effect that had recently been reported by Jim Olds. My first publication with Neal in 1958 (Bower & Miller, 1958) was a report on brain electrodes in the medial forebrain bundle where electrical stimulation produced a dual reward and punishment effect. Like most interesting findings, we fell into this finding by serendipity. We'd been studying pure punishment spots in the brain where rats would learn both to escape and to avoid its stimulation. But surprisingly, rats that had electrodes in this medial forebrain spot would escape but never learn to avoid—rather, they'd wait around for the electrical stimulation to begin, and then run quickly to turn it off. It suddenly struck us that maybe for these rats the onset of the stimulation was rewarding, but if it continued, it became punishing after a second or so. So we rigged up an apparatus that allowed us to test for that dual effect. The posed photo shows us testing one of my rats: The rat would press a lever on one side of the box to turn on the rewarding brain stimulation, but within a second or so the stimulation would start to hurt, and it would run over to the other side and rotate a wheel to turn off the stimulation. Then it would return to press the lever to turn it on, then run over and turn it off, on-off, on-off repeatedly, until it dropped from exhaustion after hundreds of such on-off cycles. This mocked-up photograph of Neal and me testing one of my rats was published in an edition of Ernest Hilgard's *Introductory Psychology* textbook of that era (1957) (Figure 2).

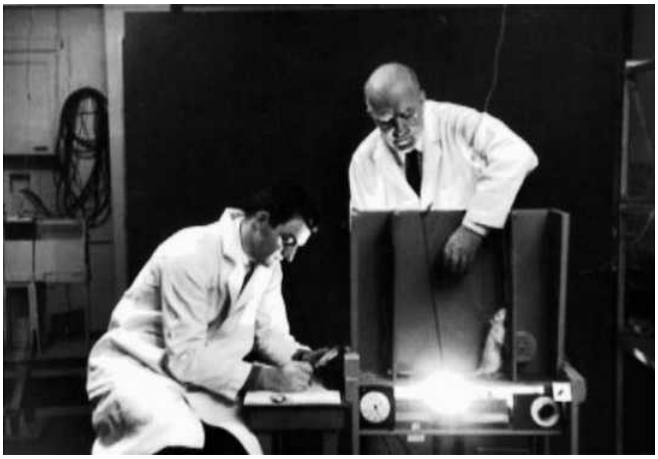

Figure 2. Neal Miller and Gordon Bower testing one of their rats demonstrating the dual reward-punishment effect from stimulating the same spot in the limbic system. See text for explanation.

I presented my first APA paper on this dual reward-punishment effect. As a graduate student I was anxious because Jim Olds, the founder of that field, was speaking just after me on the program. I nearly collapsed with relief when after my talk Olds popped up to say that he ''would like to support these important observations.'' They'd found confirming evidence. From such small rewards, professional dedication is made.

Neal's Support for My "Purely" Behavioral Research

Although I published another paper on brain stimulation, I was dissuaded from continuing by the daunting technical paraphernalia and many skilled assistants required for conducting such research. For example, one would need an operating room for implanting stimulation and recording devices in the brain, another for perfusing, preserving, and preparing animals' brains, microtomes for slicing brain tissues, equipment for staining and preserving usable histological slides to be read, and finally identifying what brain structures had probably been stimulated or recorded. All that was in addition to space and equipment for setting up an associated behavioral lab. I realized that when I graduated and went out on my own, it would be difficult to receive funding to buy the extensive equipment and pay for technicians to help with such elaborate arrangements. Moreover, I was far more interested in straight behavioral studies of learning. So that's what I've done.

Starting with my second year in graduate school, and with Neal's encouragement, I applied for and received an NIMH fellowship so I could work on other topics. Nonetheless, I continued to consult with Neal, attended his lab meetings, and contributed to his research agenda.

For example, one of our behavioral studies confirmed a simple implication of Neal's theory of approach-avoidance conflict. The idea was that the stronger the motivation for approaching the goal (at the end of a runway) where novel punishments began to occur, the closer the animal is expected to approach the goal before it stops and begins vacillating between hesitant steps forward, then backing up. I varied the strength of the approach habit by varying the size of the food reward—some animals receiving a big reward during training, others a small one. Not surprisingly, the results came out as expected, so we published it as one more confirmation of his theory (Bower & Miller, 1960).

Another study confirmed certain aspects of Miller's ''drive reduction'' theory of reinforcement; most such studies confound drive level with amount of drive reduction from the reward. To ameliorate that confound, Harry Fowler, Milt Trapold, and I (Bower, Fowler, and Trapold, 1959) used an escape learning paradigm allowing us to vary drive level and drive reduction independently. We found that the performance (speed) of rats running down a runway to escape a foot shock from the floor increased with (a) the drive level (shock intensity from the floor) and (b) the amount of immediate drive-reduction (lower shocks) received when the rats reached the end box. As Miller and we predicted, the rats' performance increased with both the drive-level and, independently, the amount of immediate shock reduction they received in the end box.

At this time, I also began straight learning research with another Yale faculty member, Frank Logan, a brilliant Hullian theorist trained by Kenneth Spence. I was impressed by Logan's micromolar theory of behavior (Logan, 1956, 1960), the idea that in a learning analysis, one could treat quantitative aspects of a response such as its speed or amplitude as distinct, learnable behaviors modifiable by contingencies of reinforcement. I continued my association with Miller while coordinating several experiments with Logan. Eventually Logan and Miller were co-advisors for my dissertation research, finished in 1959.

Some Things Neal Taught Me

From Neal I learned many methods and strategies for thinking and for conducting experimental research. He taught me to look for novel variables that produced ''big effects'' on behavior and to use simple experimental designs that yielded crystal clear results. He taught me to pre-test new procedures, to search for the best manipulations of a variable, to go for the simplest valid assessment of its behavioral effect. Neal and the department's shop manager (Gus Ogren) taught me how to build experimental equipment and electrical circuits to make a lab hum along. Also he taught me useful strategies for navigating my way through a professional life: how to listen to and think along with other scientists while discussing their research; how to avoid endless scientific disputes; how to give clear research presentations, publish one's work, and write grant proposals; and how to deal with conflicting inconsistent findings (we both would later have our share of those!). Importantly, he modeled for me a genuine and profound affirmation about research in psychology, a deep commitment to the value of empirical testing, and effective methods for mentoring and collaborating with research students. I have tried to follow his example in dealing with my own students.

May 9, 1980
Dear Neal,
It is difficult for me to accept the fact that you will be retiring—closing down your labs, crating up your books, leaving an empty office behind. I can only imagine you working in your lab, talking and teaching science, like God in his heavens. Knowing that you were also at work inspired and sustained us disciples now scattered around the world. We drew our strength from yours, our inspiration from your example. But you have filled your students with such vivid images of the honest toil of a supreme scientist that we may be able to survive on only our memories of you. So perhaps you can go fishing now because the glowing image and meaning of your life continues to inspire us.

The years have gone much too fast and I feel like a man hurtling on a rollercoaster towards the silent tunnel ahead. I don't want to enter that silence with my debt to you unspoken. You have been a master teacher to me, a consummate scientist, and I am grateful that fate brought me to work with you. By word, deed, and example, you taught me, reshaped and molded me, set me forth on the path of my career and the path of self-discovery. So much of me comes from you—my values, my work habits, my style of expression, my way with my students. You provided the framework of my professional existence—you even got me the job at Stanford that I still have. You were father to all your worshipping students, watching over our hopes and dreams for a life in science, nurturing, encouraging us, helping us grow. You turned the hard work of experimentation into the mysterious excitement of digging for buried treasures. You exemplified the call for critical examination of hypotheses in one's own work as well as in other's. Your straight-arrow honesty in dealing with people, as well as with scientific issues, shaped all of us.

I feel privileged to have worked with you. You are clearly among the premier psychologists of your generation. You have touched the lives of many students and colleagues and have passed on the torch of knowledge from your scientific forefathers to your scientific children and grandchildren. You have been vital, visionary, glorious—the complete scientist and teacher. We celebrate what you are. I thank you for being you. I'm going to miss you in your retirement.
With love and respect,
Gordon

My Indebtedness to Neal

Neal Miller and Bill Estes were the most important and influential mentors I had throughout my career. I owe them an enormous debt of gratitude for their inspiration, their intellectual help, and their support. Perhaps the best way to close out this testament for Neal is to reprint here a copy of the letter I sent to him in 1980 upon his retirement from active research at Rockefeller (Inset Box).

References

Bandura, A. (1969). *Principles of behavior modification*. New York: Holt, Rinehart and Winston.

Bandura, A., & Walters, R. H. (1963). *Social learning and personality development*. New York: Holt, Rinehart and Winston.

Bower, G. H., Fowler, H., & Trapold, M. A. (1959). Escape learning as a function of amount of shock reduction. *Journal of Experimental Psychology*, *58*, 482–484.

Bower, G. H., & Miller, N. (1958). Rewarding and punishing effects from stimulating the same place in the rat's brain. *Journal of Comparative and Physiological Psychology*, *51*, 669–674.

Bower, G. H., & Miller, N. (1960). Effects of amount of reward on strength of approach in an approach-avoidance conflict. *Journal of Comparative and Physiological Psychology*, *53*, 59–62.

Dollard, J., & Miller, N. E. (1950). *Personality and psychotherapy*. New York: McGraw Hill.

Eysenck, H. J., & Rachman, S. (1965). *The causes and cures of neurosis*. San Diego, CA: Knapp.

Herman, L. M. (2002). Vocal, social, and self-imitation by bottlenosed dolphins. In K. Dautenhahn & C. Nehaniv (Eds.), *Imitation in animals and artifacts* (pp. 63–108). Cambridge, MA: MIT Press.

Hilgard, E. R. (1957). *Introduction to psychology* (2nd ed.). New York: Harcourt Brace.

Logan, F. L. (1956). A micromolar approach to behavior theory. *Psychological Review*, *63*, 63–73.

Logan, F. L. (1960). *Incentive*. New Haven, CT: Yale University Press.

Meltzoff, A. N., & Moore, M. K. (1977). Imitation of facial and manual gestures by human neonates. *Science*, *198*, 75–78.

Miller, N. E., & Dollard, J. (1941). *Social learning and imitation*. New Haven, CT: Yale University Press.

Mischel, W. (1968). *Personality and assessment*. New York: Wiley.

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