

The golden anniversary of Melzack and Wall's gate control theory of pain: Celebrating 50 years of pain research and management

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November 2015 marks the 50th anniversary of the 1965 *Science* publication "Pain Mechanisms: A New Theory" by Ronald Melzack and Patrick D Wall (1), in which the authors introduced the gate control theory of pain that has since revolutionized our understanding of pain mechanisms and management. The brilliance, creativity and critical thought that went into the formulation and explication of the gate control theory of pain can best be appreciated by reading the original article. Fifty years later, having become part of our scientific history and accepted as common knowledge, the essence of the theory is often conveyed by the familiar diagram in Figure 1.

In 1982, the article was recognized as a Citation Classic in Eugene Garfield's weekly publication *Current Contents*. Citation Classic commentaries were introduced by Garfield to provide the scientific community with "a kind of living history" illustrating the "human side of science" (2). The Citation Classic commentary by Melzack and Wall (3) was a one-page synopsis that included an abstract describing the gate control theory and the authors' reflections on the article's importance and popularity, its ongoing scientific relevance (17 years after publication) and the transformation in treatment it brought about. Because it is as relevant today as it was in 1982, we have reproduced it as Figure 2.

Two years later, Garfield (4) highlighted the publication's unusual pattern of citations, noting "the resistance of the research community to new theories, particularly when they are at odds with established dogma". He pointed out that it had taken 12 years from the time of publication, for the article to reach its peak number of yearly citations of 112 in 1977, for a total of 1027 citations in the 19-year period from 1965 to 1983. The initial resistance (3,4) was gradually overcome by acceptance, as an increasing body of scientific findings supported the concept of a spinal gating mechanism. Remarkably, as we approach the 50th anniversary of its publication, the article's citation rate has continued to climb, reaching an all-time yearly high of 525 (in 2013, measured by Google Scholar [Google Inc, USA]) or 195 (in 2011, measured by the ISI Web of Science [Thomson Reuters, USA]) for a cumulative citation count as of 2014 of >8800 (Google Scholar) or >4500 (ISI Web of Science) (Figure 3).

As noted by Melzack and Wall (3) (Figure 2), the acceptance and popularity of the theory was, in part, facilitated by the concept of a gate:

A fortunate aspect of our publication in 1965 is the use of the phrase 'gate control.' It evokes an image that is readily understood even by those who do not grasp the complex physiological mechanisms on which the theory is based.

Fifty years later, this aspect of the publication continues to ring true. In particular, the 'gate' metaphor serves as a convenient and useful way to explain to patients what pain is, and how and why it fluctuates from day to day. Many current chronic pain education and pain self-management programs refer to the gate control theory and, in

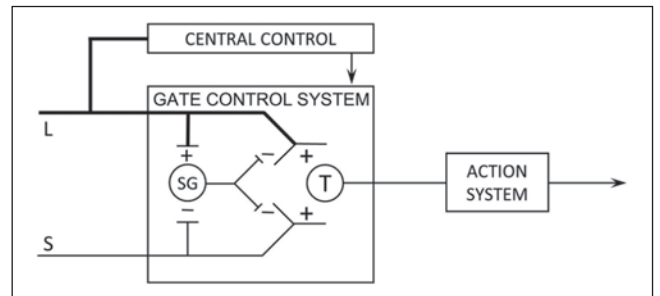


Figure 1 A schematic illustration of the gate control theory of pain proposed by Melzack and Wall (1), demonstrating how the gating mechanism in the spinal dorsal horn modulates transmission of nerve impulses from afferent fibres to spinal cord transmission cells. The gating mechanism is affected by the relative activity in large- and small-diameter fibres, with the former inhibiting transmission (closing the gate) and the latter facilitating transmission (opening the gate). Notably, the spinal gating mechanism is also modulated by descending nerve impulses from the brain. The authors proposed that the spinal transmission cells activate an action system in the brain comprising regions that underlie the experience and behaviours characteristic of pain. Reproduced with permission from Melzack and Wall (1)

particular, to the gating mechanism in the spinal cord. For example, in one of the more influential pain self-management books, LeFort et al (5) state:

Melzack and Wall said that there is a transmission station in the spinal cord that influences the flow of nerve impulses to the brain. They called this transmission station a 'gate'. Think of it just like a gate you can open or close to get to your backyard. ... The gate can be opened or closed in a number of ways, including by the brain itself. ... The brain can send electrical messages down nerve pathways to close the gate and shut out or reduce the flow of nerve impulses to the brain, or send messages that do just the opposite. Many factors can open or close the gate. ... For example, positive mood, distraction, and deep relaxed breathing can act to close or partially close the gate while strong emotions like fear, anxiety, and expecting the worst can open the gate.

Moreover, Melzack and Wall's comment (Figure 2) about the article's relevance to a multidisciplinary base continues to be true. Citations to the article can be found in almost every field, including subdisciplines within science and technology, medicine, veterinary science, the social sciences, and the arts and humanities.

The gate control theory has had a major clinical impact on how pain is viewed by health care practitioners, how patients are treated, and, perhaps more importantly, it has provided patients with hope that pain relief is possible (6). The modulation of afferent input by the

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This Week's Citation Classic

Melzack R & Wall P D. Pain mechanisms: a new theory. *Science* 150:971-9, 1965. (Dept. Psychol., McGill Univ., Montreal, Canada and Dept. Biol., Massachusetts Inst. Technol., Cambridge, MA)

The theory proposes that the dorsal horn of the spinal cord acts like a gate which modulates the flow of nerve impulses from the peripheral fibers to the central nervous system. The gate is influenced by peripheral fiber activity and by descending influences from the brain. [The *Science Citation Index*[®] (SCI[®]) and the *Social Sciences Citation Index*[®] (SSCI[®]) indicate that this paper has been cited over 975 times since 1965.]

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February 15, 1982

"When we proposed the gate-control theory in 1965, we hardly expected the astonishing increase in research studies and new therapeutic approaches that was stimulated by it. Fortunately, the theory came at a time when the field was ripe for change. A small number of original thinkers had fought hard to replace the old concept of a specific pain pathway by a more dynamic conception in which pain is determined by many factors in addition to injury—by past experiences, culture, attention, and other activities in the nervous system at the time of injury. This small band of courageous people hammered away at the established, traditional theory. But despite occasional lip service to their ingenuity, the field continued unchanged, holding tenaciously on to

Descartes' idea, proposed in 1664, that pain is like a bell-ringing alarm system whose sole purpose is to signal injury to the body.

"In the 1960s, a wave of new facts and ideas that had evolved gradually^{1,3} was beginning to crest, and the gate-control theory rode in on the wave of the times. No one was more astounded at its success than we were. Naturally, acceptance was not immediate or total, but in spite of continuing controversy about details, the concept that injury-signals can be radically modified and even blocked at the earliest stages of transmission in the nervous system is now virtually universally accepted. A fortunate aspect of our publication in 1965 is the use of the phrase 'gate control.' It evokes an image that is readily understood even by those who do not grasp the complex physiological mechanisms on which the theory is based. The fact that the theory had relevance to a wide variety of fields in medicine, psychology, and biology also led to its frequent citation.

"The theory's emphasis on multiple determinants of pain has also provided a conceptual framework for the recent recognition of the complexity of clinical pain. Until the middle of this century, pain was considered primarily to be a symptom of disease or injury. We now know that chronic, severe pain is a problem in its own right that is often more debilitating and intolerable than the disease process which initiated it. The problem of pain has therefore been transformed from a mere symptom to be dealt with by the various medical specialties to a specialty in its own right which is now one of the most exciting, rapidly advancing fields of science and medicine. Happily, the main beneficiary has been the suffering person. The new concept provided the foundation and framework for a host of novel, exciting approaches to the treatment of pain. For a recent survey the reader can refer to J.J. Bonica et al.^{2,4}

1. Melzack R, Stoder W A & Livingston W K. Effects of discrete brainstem lesions in cats on perception of noxious stimulation. *J. Neurophysiology* 21:353-67, 1958.
2. Melzack R & Wall P D. The nature of cutaneous sensory mechanisms. *Brain* 85:331-56, 1962.
3. Wall P D. Presynaptic control of impulses at the first central synapse in the cutaneous pathway. *Prog. Brain Res.* 12:92-118, 1964.
4. Bonica J J, Liebeskind J C & Albe-Fessard D. *Advances in pain research and therapy*. New York: Raven Press, 1979. Vol. 3. 356 p.

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Figure 2) "This Week's Citation Classic" from the June 7, 1982 issue of Current Contents, featuring an abstract and commentary by Melzack and Wall (3) describing the culture of pain at the time, their thoughts on the initial resistance to the gate control theory, its ultimate acceptance and success, and how the theory changed the scientific and clinical communities' conceptualization of pain from that of a symptom of a disease, to a major health problem in need of specialized treatment. Reproduced with permission from Melzack and Wall (3)

spinal gating mechanism and the dynamic role of the brain in processing pain-related information provided a physiological basis for previously inexplicable, 'bizarre' symptoms (eg, phantom limb pain) believed to arise from psychopathology (7). Moreover, anxiety, depression, worry and other psychological factors, which had been considered 'reactions to pain' came to be viewed as integral to the processing of pain-related information (6). The theory also had a profound influence on other approaches to managing pain, including a reduction in irreversible, ablative surgical procedures, and it heralded new therapies, such as transcutaneous electrical nerve stimulation, and other forms of neuromodulation, such as peripheral nerve, spinal cord and deep-brain stimulation.

Fifty years after its publication, the gate control theory has stood the test of time (8); the conceptual components of the gate control theory are as relevant now as they were in 1965 (8,9), and countless patients have benefitted from the clinical innovations spawned by the theory. The historical prominence of Canada's pain research community (10)

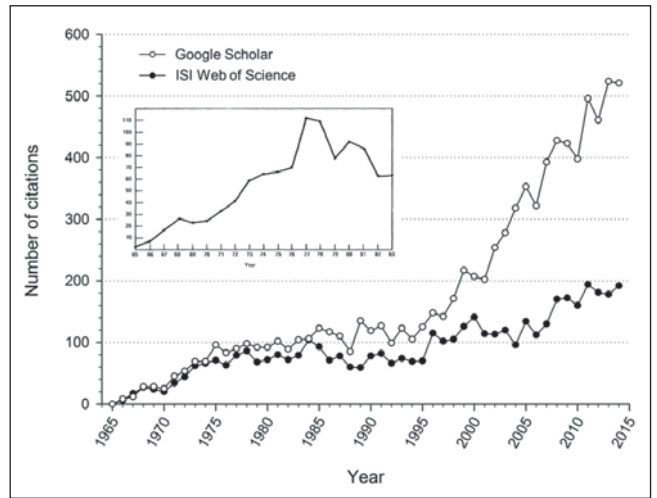


Figure 3) Annual citation count from 1965 to 2014, for the gate control theory paper by Melzack and Wall (1) based on data from the ISI Web of Science (Thomson Reuters, USA) and Google Scholar (Google Inc, USA) (as of September 18, 2015). The increasing trend in the yearly number of citations shown in the inset, and noted by Garfield in 1984 (4), has been maintained in the ensuing 30 years by both citation sources, but even more so by Google Scholar when, beginning in the mid-to-late 1990s, the citation rate increases dramatically – reminiscent of 'windup' (13) (see [14], Figure 2), but on a grand scale! Inset reproduced with permission from Garfield (4)

can be traced to pivotal developments in the field, most notable among them, the gate control theory of pain. *Pain Research and Management*, the official journal of the Canadian Pain Society, is proud to celebrate the 50th anniversary of Melzack and Wall's gate control theory with the international community of pain researchers and clinicians, who work toward the common goal of abolishing the "silent epidemic" (11) of "needless pain" (12).

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