Continuity and discontinuity in learning

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Continuity and discontinuity in learning refer to the problem of whether there are qualitative changes in the fundamental mechanisms that govern learning. This question has been examined in the literature in two separate but related ways. The first approach examines whether qualitative breaks occur with increasing expertise or additional learning, and was conducted mostly prior to the 1980s using animal learning paradigms and human learning of simple verbal materials. The second approach evaluates whether there are developmental changes in learning that are qualitative in nature.

The historical debate was inspired in part by the observation of seemingly contradictory phenomena. On the one hand, much research in learning, including the seminal results from Hermann Ebbinghaus, revealed canonical smooth learning curves, in which performance could be plotted as a negatively accelerating approach to an asymptote. On the other hand, research by Robert Yerkes and Wolfgang Köhler using primates appeared to reveal "insight" in basic problem-solving tasks. Complementing these reports were results from learning in rodents in which learning appeared to hover quite stably around chance levels of accuracy prior to rising rapidly to an asymptote. Even in tasks in which learning appears continuous, theorists such as William Estes and Randy Gallistel have shown that the learning functions for individual subjects may exhibit a more abrupt rise in performance than is comfortably accommodated within a view of learning that is purely continuous.

This dilemma motivated empirical and theoretical demonstrations from notable researchers like Kenneth Spence and Isadore Krechevsky (later David Krech) that continuous and gradual learning processes could underlie the apparently discontinuous learning curves that appeared to imply underlying learning process that were more all-or-none than continuous. Such considerations probably played a large role in the sea-change in American psychology from S-R theories to the mentalistic types of theorizing characterized by the work of Edward Tolman—theories that included previously taboo terms such as "hypothesis generation and testing" and "insight, " and that eventually became known as the cognitive revolution from the 1950s to the 70s.

During that latter period, questions of continuity inspired one of the first widespread applications of basic mathematical models of psychological processes to questions about learning. The burgeoning set of researchers that pioneered the application of Markov processes to cognition, including William Estes, Patrick Suppes, James Greeno, Gordon Bower, found that smooth learning curves could be produced by all-or-none learning functions, and that those all-or-none models accounted well for verbal learning data in humans. Two related empirical data are central to the claim of supremacy for all-or-none models.

First, Estes showed that people tend not to recall items correctly on a second test when they have not correctly recalled them on a previous test. If discontinuous learning actually arose from variable levels of underlying learning, rather than the pure absence of learning, then an above-chance rate of recovery for previously unrecalled items would be expected. Second, there is no increase in memory performance with additional learning

when only those trials prior to the final error for a particular item are examined. This too is consistent with the idea that those items reside in an as-yet unlearned state, rather than a state of gradually increasing learning that is nonetheless insufficient to support accurate performance.

However, the validity of these data and of the all-or-none models were questioned, and other data appeared to contradict the central results. For example, giving subjects an opportunity to guess again when they have made an error leads to a violation of the "stationarity" principle represented by the second finding described above. The lack of a clear resolution can be best understood in light of the insights of Frank Restle, who pointed out that numerous versions of the continuous/discontinuous debate were in play, and that theorists were debating on incompatible terms. A summary of the literature prior to the mid 1960s revealed that, although it is quite clear that much learning is incremental, it is also evident that some learning is more likely of an all-or-none flavor.

Given the many ways in which discontinuous processes can mimic continuous ones, and vice-versa, it is not evident that a deep theoretical resolution to this issue is forthcoming. However, from an educational perspective, it is worth remembering that the progression of learning may have as much to do with the nature of the task as with the nature of the learning process: Tasks in which information can be acquired incrementally are more likely to yield continuous learning functions than are tasks for which mastery hinges on the acquisition of a single principle or rule.

A related issue of continuity has been evaluated within developmental or lifespan approaches to understanding cognition: Does maturity induce qualitative changes in the mechanisms of learning? Indeed, much of the work in cognitive development and geriatric cognition can be characterized as a debate over which learning processes develop when, and which ones selectively decline with age. What is not in dispute is that there are qualitative changes in the patterns of results seen on tests of learning and memory. The elderly exhibit, for example, a much greater deficit relative to young learners on tests of recall than tests of recognition. Fergus Craik has proposed that elderly learners will show, in general, deficient performance on tests that require them to self-initiate processing and relatively intact performance on tests that place little demand on such self-initiation. Tests of recall, which require the subject to develop and execute a systematic plan for addressing memory, retrieving relevant information, and outputting it successfully, play to the weaknesses of the elderly. Tests of recognition, which elicit only small deficits, do not place a premium on self-directed processes but rather emphasize simple, presumably automatic, mechanisms.

Despite these results, it is not clear whether the underlying learning mechanisms actually differ between people of different ages, or if the apparent discontinuities arise epiphenomenally. Older learners may suffer more from proactive interference than younger learners, not because fundamental mechanisms differ, but rather because they have many more years of experience to interfere with learning and memory. If a constant amount of proactive interference affects different tests or tests for different types of information differentially, then empirical test dissociations can appear between age groups without a change in the underlying cognitive processes.