Spatial Generalization in operant learning: Lessons from professional Basketball

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(Hebrew version below)

Recent years seen a growing interest in data acquired from professional sports. Basketball data specifically, were used to study various phenomena, such as decision making in shot selection, the 'hot hand belief' and more. A major advantage of the NBA is the large quantities of carefully collected data that can be used to study players' behavior. Moreover, the human subjects involved are highly trained and motivated (one of the challenges in laboratory experiments is to keep subjects motivated and to make sure they understand the tasks). This kind of high-quality data, retrieved using high speed cameras and processed automatically, could help evaluate current theories and hypotheses regarding computational principles underlying cognitive processes in real life situations.

Humans and animals modify their behavior in response to the consequences of their previous actions (operant learning). However, in real life there are almost no identical situations, an experience is probably never to be repeated. Hence, the ability to generalize is critical ? the organism must understand which past situations are relevant to the current situation and which aren't. On the one hand, a generalization as broad as possible allows faster learning. On the other hand, you would not want to change your behavior incorrectly should your generalization be too broad and the case from which you are inferring be irrelevant.

Sport is a great example ? highly motivated experts are required to take decisions quickly in many different, well-defined situations. This research focuses on the NBA players and their decision to take a shot at the hoop. How do they decide to throw? It is already known that the players do learn and change behavior as a result of experience in the very same game (previously researched by this group). However, every shot is different (current score, clock an location of other players are all variable), so how do they generalize across these situations and still manage to learn? It must be that every shot has a gist while other properties are marginal.
The authors analyzed spatial parameters of almost 760 thousand throws in a single-square-foot resolution. They wanted to understand how an outcome of a throw from a certain location affects the chance of throwing from all other locations. It turns out that it's not the exact spatial location that matters but the distance from the hoop. The data also indicates that the main factor that discriminates areas from which the player is most likely to throw is the potential score of the location — two or three points — and not mere location. Two-point areas can be defined as the areas very near to the hoop and those more distant from the hoop (up to the three-point line). The researchers analyzed and showed that players do not generalize based on the angle of the shooting player in respect to the rim, but on the distance from the rim and the potential score. That is to say, not only low-level features, such as physical distance, affect the decision to throw, but also abstract features, such as the rules of the game, dominate the pattern of generalization that results in behavioral change.

This very interesting work connects complex human behavior in real-life situations with fine-grain analysis using the current theory of unsupervised learning (without guidance) using the carrots and sticks of the environment. Usually, models of learning assume that the learner has full information regarding his state and the relevant choices he is facing (for example, 20% chance to get 10$ or getting 2$ for sure). However, in basketball and in real-life situations, the preliminary step of identifying the current state and the relevant actions is an essential part of learning from failures and successes (operant learning). This research shows how it is done by professional basketball players.

Read the full research paper:

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