To compute the VOP we solve the MDP by dynamic programming.

**Optimal brain points**
- Brain points reward effort and persistence rather than performance.
- The optimal brain points of learning activity communicate the value of the expected improvement in the value of the learner’s skills:

\[
\Delta V(s_t, a) = \gamma \cdot E[V^{*}(s_{t+1}) | s_t, a] - V(s_t)
\]

\[VOP(s_t, a) = \Delta V(s_t, a) + r(s_t, a)\]

**Experimental design:**
- Optimal Brain Points
- No Brain Points

**To learn or not to learn?**
- **a)** Exploit Skill 1: Navigate using the arrow keys (known but inefficient)
- **b)** Learn Skill 2: Discover which of the 26 letter keys teleports the spaceship to its destination (unknown but efficient)

**The Spaceship Adventure Paradigm**
- **Goal:** Move spaceship (X) to its destination (O)
- **Step 4:** Round 1
- **Your score:** 0
- **Your total step:** 4
- There is a 6 percent probability that your spaceship will crash in the next step!

**Experimental results:**
- **Skill acquisition:**
  - A: one action for each skill
  - S: set of attainable skill levels
  - D: N2: work required to complete current task
  - y: probability that the skill will still be useful in the next step

**To compute the VOP we solve the MDP by dynamic programming.**

**Introduction**
- Only 15% of the students enrolled in a MOOC actually finish it.
- Game elements are used to overcome motivational obstacles but are often ineffective or even harmful.
- Recent research suggests that optimal gamification can help people make better decisions.
- Can optimal gamification help people overcome the motivational obstacles to life-long learning?

**Optimal incentives for self-directed learning**
- **Problem:** When should people complete a task using the already acquired skills vs. try to learn a better way to accomplish their goals?
- **Approach:**
  - 1. Model skill acquisition
  - 2. Calculate optimal brain points
  - 3. Integrate the optimal brain points into the learning environment.
- **Question:** Can optimal brain points improve people’s study choices, persistence, and learning outcomes?

**Optimal brain points**
- Brain points reward effort and persistence rather than performance.
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\]

**Expected value of the new skill level**
- Value of current skill level
- Reward for getting it right

**Effects of optimal brain points**
- **1. Practice:** Brain points increased the proportion of people who attempted to learn skill 2 by 14% (\(\chi^2(1) = 5.74, p=0.0165\)) and doubled their additional learning attempts (\(\chi^2(1) = 1.36, p=0.0032\)).
- **2. Mastery:** With brain points 24% of participants mastered skill 2 – compared to 15% in the control condition (\(\chi^2(1) = 3.77, p=0.0523\)).
- **3. Performance:** Brain points doubled the number of points participants earned (\(\chi^2(1) = 1.74, p=0.0414\)).

**Conclusion and future directions**
- 1. Optimal brain points can effectively motivate people to learn valuable new skills.
- 2. Optimal brain points help learners persist in the face of setbacks.
- 3. Optimal gamification can be applied to many different learning environments.

**References**

http://re.is.mpg.de