Goal

We want to understand how people use/distort probability information in perceptual decision tasks. In a typical random-dot motion task, subjects estimate direction of motion given noisy sensory evidence and receive a reward if correct. Probability of reward therefore depends on probability correct, which can be manipulated by changing the motion coherence level. In standard task, there are only two alternatives for coherent motion direction. This makes probability correct to range from 0.5 to 1 and therefore does not explore the entire range from 0 to 1. This can be solved by expanding the number of alternatives, a design in Laquitaine and Gardner (2017).

Session 1: subjects see a motion stimulus on each trial and give direction estimate. We can measure probability correct under different motion coherence levels. We can fit a smooth function to mapping their relation. Based on this, we can predict under what coherence level the subject would achieve what probability correct.

The interesting question is subject’s sensitivity to changes in probability correct, e.g. whether subjects can tell the difference between 0.2 and 0.25 probability correct, and how sensitivity changes as a function of probability correct. To address these questions, session 2 will be implemented.

Session 2: In a 2-IFC task, subjects on each trial face two sequentially presented random-dot stimuli and have to choose one to perform direction estimation. The idea is, if we present one stimulus carrying 0.2 probability correct and the other carrying 0.25 probability correct, what is the likelihood subjects would choose the 0.25-prob stimulus? If subjects cannot tell the difference, the likelihood of choosing one or the other is 0.5.

Say there are 11 probability levels, from 0 to 1 in steps of 0.1 [0 0.1 0.2 0.3 0.4 0.5 0.6 0.7 0.8 0.9 1]. Then there are 55 possible combinations. But we don’t have to explore all combinations.

11\*5\*20 = 1100 (trials)

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | 0 | 0.1 | 0.2 | 0.3 | 0.4 | 0.5 | 0.6 | 0.7 | 0.8 | 0.9 | 1 |
| 0 | 20 | 20 | 20 | 20 | 20 |  |  |  |  |  |  |
| 0.1 | 20 | 20 | 20 | 20 | 20 |  |  |  |  |  |  |
| 0.2 | 20 | 20 | 20 | 20 | 20 |  |  |  |  |  |  |
| 0.3 |  | 20 | 20 | 20 | 20 | 20 |  |  |  |  |  |
| 0.4 |  |  | 20 | 20 | 20 | 20 | 20 |  |  |  |  |
| 0.5 |  |  |  | 20 | 20 | 20 | 20 | 20 |  |  |  |
| 0.6 |  |  |  |  | 20 | 20 | 20 | 20 | 20 |  |  |
| 0.7 |  |  |  |  |  | 20 | 20 | 20 | 20 | 20 |  |
| 0.8 |  |  |  |  |  |  | 20 | 20 | 20 | 20 | 20 |
| 0.9 |  |  |  |  |  |  | 20 | 20 | 20 | 20 | 20 |
| 1 |  |  |  |  |  |  | 20 | 20 | 20 | 20 | 20 |

Session 3: In a 2-IFC task, subjects on each trial face two random-dot motion stimuli, each carrying a potential reward if subjects make a correct decision on direction judgment. Subjects have to choose the one she prefers and are told that at the end of experiment one of the chosen lotteries will be selected at random and subjects will perform direction estimation on it and receive the reward specified in that lottery if correct or otherwise nothing.

Stimuli

Randomly moving dots. Direction randomly drawn from a probability distribution. Distribution variance is manipulated.

Net-catching task

On each trial, subjects see randomly moving dots. He is told that one of the dots will be selected at random to determine whether he wins a reward. What he needs to do is to place a “net” to catch the randomly drawn dot. The net is always the same size.

Discuss:

Problem with “net catching” design: the task is no longer a direction-estimation task. A dot starting somewhere within the aperture will move in a particular direction. To catch this dot, subjects not only have to consider its direction of motion but also its location. They have to integrate position and direction information. This differs from simply estimating the direction of motion. This can be solved by controlling position, e.g. if all dots start from the center of the aperture. But in this case the stimulus no longer looks like the one used in a typical random-dot motion task.

Problem with realization: at some point after the stimulus onset, subjects are going to place the net. At what point in time do we select from the dots? Dots are not only moving but once they move out of the aperture they don’t come back. Are we selecting from all the dots even those who already move out of the aperture? If we select only the dots within the aperture at the time of selection then the dots sample is only a subset of past samples. This may introduce bias because subjects only need to pay attention to the dots close to the time of selection.

**Dot-catching task**

On each trial, dots will move for a period of time (e.g. 3 sec). After that, all dots disappear and subjects have to place a basket somewhere along the edge of the aperture to catch a single new dot. Once he confirms the basket placement, a new dot will be shown on the screen and start moving. If the dot passes through the basket, the subjects will receive a reward. Note that this task is different from the standard motion-direction judgment subjects have to make in the motion discrimination task.

How do we determine where the dots will go? Each dot will be sampled from a von Mises distribution  on “pass-through” location, , defined as the location dots would pass through the edge of the aperture. On each trial, we will randomly select . We will manipulate , the variance of the distribution, so that there will be 5~7 levels of . Perceptually, this still will look like a random-dot-motion task where dots are moving in random direction. But it will not create a percept that some dots are moving coherently in one direction while other dots move in random directions. Rather, people will see that some dots move to the same “pass-through” location while others move randomly to different locations. This design – distribution on pass-through location – simplifies the calculation of probability of reward, which depends on the probability that any dot would be caught by the basket. This is simply the integral  where  and  represent the left and right boundary of the basket location respectively. By contrast, one has to perform a much more complicated integration to calculate the probability of reward if *x* represents motion direction. Further, manipulating effectively manipulates probability of reward if *x* represents pass-through location, while this is not the case if *x* represents motion direction. These are the main reasons why we design our motion stimuli this way.

**Experiment 1:**

Session 1: “dot-catching” task

Subjects place a basket in order to catch a dot that would bring reward. There will be 5 to 7 different levels of distribution variance implemented. We will use this to estimate how actual frequency of reward based on subjects’ behavior changes as a function of distribution variance (performance curve).

Session 2: lottery decision tasks

Subjects will perform two tasks, an economic lottery decision task and a perceptual lottery decision task. These two tasks are designed such that they are mathematically equivalent.

Economic lottery decision task. On each trial, subjects choose between two lotteries where potential outcomes and their probabilities of occurrence are revealed such that subjects do not have to estimate probability of reward.

Perceptual lottery decision task. The main difference between this task and the economic task is that subjects need to estimate probability of reward based on noisy sensory evidence. On each trial, subjects choose between two patches of randomly moving dots that differ in the magnitude of reward and its probability of occurrence –incurred by the variance of the distribution these dots are sampled from – to perform the dot-catching task. For a given lottery , we will use the performance curve obtained from Session 1 to determine the variance of the distribution such that it is equivalent to having probability *p* of winning $*x*. To simplify the task, parameter  of both dot patches will be the same on each trial, but will randomly vary from trial to trial.

How can we design the economic task such that they look the same as the perceptual lottery task with the only difference being that they don’t have to estimate probability of reward?

Lottery (ping pong ball) machine: Tell subjects that there are 100 ping pong balls each assigned to a unique number from 1 to 100. The ping pong balls will move – just like the randomly moving dots – and one ball will be randomly selected. If the number is smaller than or equal to p, then subjects win $x. Otherwise, she or he wins $0. This is equivalent to a lottery (p/100,$x). To accommodate for this design, the storyline for both the perceptual and economic tasks will be the same, like the following:

“On each trial, 100 ping pong balls, each assigned a unique number from 1 to 100, will be placed into a lottery machine. Once in the machine, these balls will move randomly until they hit the wall. When they do, each ball will be placed at a random location again and will be assigned a new direction of motion at random.

Perceptual task: Your task is to put a basket somewhere along the aperture. Once you do so, a ball will be selected randomly and move at random direction. If the basket catches the ball you will win $x. Otherwise, you win $0. In other words, you have to assess where most dots are moving and put the basket at the location where you think has the best chance of catching the randomly selected dot.

Economic task: Your task is to put a basket somewhere along the aperture. Once you do so, a ball will be selected randomly and it will move towards where you put the basket. Once the ball is in the basket, it will reveal its number. If the number is smaller than or equal to p, you will win $x. Otherwise, you win $0. In other words, where you put the basket has no impact on whether you win the reward or not.

========= For the future =============

Note: In this experiment, the basket will always have the same size, although it could be interesting to manipulate basket size in addition to manipulating the variance of the distribution that determines where the dots move. Imagine the following task, subjects see two stimuli on each trial. Each stimulus has a unique combination of basket size and distribution variance. After seeing both stimuli, subjects have to pick one of them to perform the dot-catching task. To do the task well, subjects have to consider which stimulus will yield a larger probability of catching the dot and hence a reward by combining two perceptual attributes – basket size and dot-distribution variance. This is interesting because we can study transitivity similar to what Tversky (1968) did.

Experiment 2: