Lab 4.1 Name: ___________________________

Modes of Control

Purpose
To illustrate the combined use of closed-loop and open-loop control in executing movements.

Background
Chapter 3 of your textbook introduces the concept of closed-loop control for executing movements. The authors point out that closed-loop control is used for relatively long-duration continuous activities that provide the opportunity to make *online* corrections based on feedback received *during* the movement. In closed-loop control, the information that is used to make corrections travels through the stages of information processing. This means that corrections will occur about 300 ms after the error is detected. Any action that lasts less than 300 ms cannot be corrected using closed-loop control. Even though a voluntary reaction-time response takes only 120 to 180 ms (see table 3.1), multiple online corrections cannot occur this quickly because it also takes time to make the correction and then monitor ongoing performance before the performer can determine whether another adjustment is needed. Thus, only about three corrections per second can be made.

Closed-loop control cannot be used for rapid, discrete actions that do not last long enough for feedback to be used during the movement. For these types of tasks, the control mode is called *open loop*. Chapter 4 describes open-loop control in detail. To use open-loop control, the performer needs to preplan the movement. This *plan* is called a *motor program*. A good example of open-loop control can be seen when you sign your name. Most of the time, this action is executed rapidly without modification during the movement.

When asked to sign your name in a small box (e.g., those commonly found on applications for a loan or a driver's license), it is likely that portions of the signature will fall outside the space provided. In preparing to sign your name, you evaluate the space available and then prepare to execute a movement that will result in an acceptable fit. If the box is smaller than the space you normally use to sign your name, you will attempt to adjust the *parameter settings* of the motor program for signing your name so that you produce a smaller signature. There is still a good chance, though, that portions of your signature will fall outside the box.

Because you execute the entire signature without regard to feedback, you do not make any attempt to adjust your signature even as your pen approaches and crosses a line of the box. Of course, there are often no consequences for this sort of mistake as long as your signature is legible. If you wanted to sign entirely inside the box, your first attempt would indicate that you need to adjust the parameter settings of the motor program to produce an even smaller signature. Using feedback in this manner does not mean the action is controlled in a closed-loop fashion because the information is not used to make adjustments during the movement. Instead, it is used to adjust your *next* attempt. Open-loop control of movements is very common. Examples include pressing an elevator button, heading a ball in soccer, flipping a light switch, and catching a line drive in baseball.

Sometimes it appears that performers do actually make corrections during the performance of rapid actions. In some cases, rapid movements might be modified through reflexive modulations, three of which occur faster than a voluntary reaction-time response. The M1 response takes about 30 to 50 ms and plays a role in stabilizing a joint in response to an unexpected load. The M2 response takes about 50 to 80 ms and allows a performer to voluntarily influence the position in which a joint is stabilized to meet performance goals. For example, when you hit a small bump with your front wheel while riding a mountain bike, the M1 response will act to prevent flexion at the elbow to stabilize your hand position. If you are traveling downhill, the M2 response might act to cause elbow extension to shift weight toward the rear tire. The M2 response was influenced by your intentional desire to not fly over the handlebars. The triggered reaction takes about 80 to 120 ms and can be used to execute more complex responses than the M1 or M2 responses. In the mountain biking example, a triggered reaction to a bump might involve moving your weight behind the seat (an action that involves more than just elbow extension).

Sometimes we modify rapid actions by quickly initiating a second motor program before the execution of the first action is completed. In chapter 3, you read about the Slater-Hammel (1960) experiment, which indicates that a person needs about 200 ms to inhibit a preplanned response. However, if a second decision is made within that 200 ms window of time, it might be possible to modify the initial response even though you cannot prevent it. A good example is a checked swing in baseball. Assume the batter’s first decision is to swing at the pitch. If a second decision to *not swing* is made early enough (e.g., earlier than 200 ms before the response), the batter can prevent the swing. If the second decision is not made in time to prevent the swing, it might still be possible to check the swing. If the second decision is made very late in the process of swinging, the batter will execute the first action but might have the sense of “knowing” it was not right even though nothing could be done to stop it. You might be familiar with this last phenomenon if you have ever realized too late that you just slammed your car door shut with the keys locked inside.

Many activities incorporate both open-loop and closed-loop control. For example, in starting a car, you probably use open-loop control to turn the key, but you use closed-loop control to determine how long to hold the key until the engine starts. To understand how a person executes a task, it is sometimes helpful to think about which portions of the task are controlled in an open-loop fashion and which are controlled in a closed-loop fashion. To do this, think about the amount of time that it takes to execute the action in question. If it is very rapid, then it will be controlled in an open-loop fashion.

Lab 4.1 Name: ____________________________

Equipment
30 cards for stacking
1 short length of rope (60 cm)
1 coin for spinning

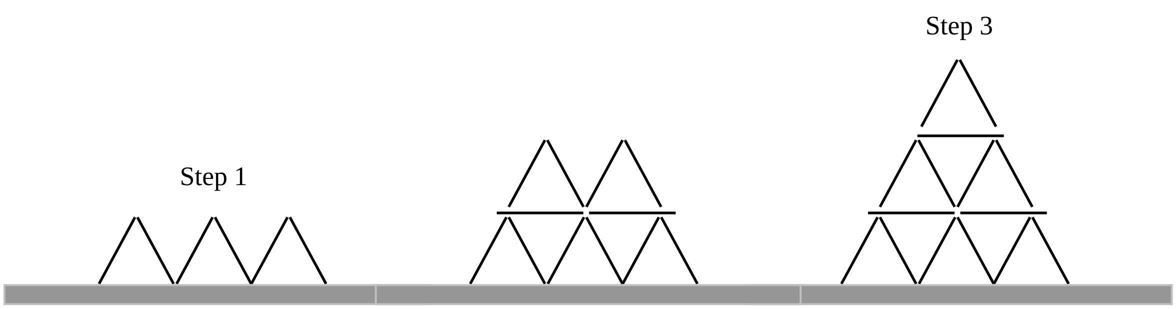
Lab 4.1 Name: ___________________________

Instructions

Students will take turns in the roles of experimenter and participant. The participant will complete five trials of each of the four activities described as follows. Collect all the data for one participant before switching roles.

Task 1—Card Stacking

Build a pyramid structure composed of inverted-V shapes. The following diagram gives an example of this technique. You can practice the technique a few times before beginning your trials. Use as many cards as possible before the structure falls. For each trial, the experimenter will record the total number of cards used and the number of levels created. A trial ends when the cards fall or when all available cards have been used. If table or desk surfaces are very smooth, try working on a piece of paper taped to the desk.



Task 2—Coin Spin and Trap

Hold a coin by its edges between your index finger and thumb. Place the edge of the coin on a tabletop so that your finger and thumb are pointing down. Start the coin spinning by quickly rotating your hand so that your thumb moves in one direction and your index finger moves in the other. Trap the coin by placing your index finger on the top of the edge so that it stops on edge between the table and your finger. For each trial, make five attempts. Record the number of successful spins and traps.

Lab 4.1 Name: ___________________________

<u>Task 3—Knot Tying</u>

Tie a *sheep-shank* knot as indicated in the following pictures and directions.

Step 1: Make three loops. Moving left to right, the right tail (end) of the rope should be *over* the first loop, *under* the second, and *under* the third. When complete, the tails of the rope both run *under* the two outside loops.

Step 2: Pull the center loop through the side loops. When pulling the center loop through, make sure it is *under* the outside loops and comes up through them.

Step 3: Pull the "*tails and ears.*" Pull the portions of the center loop that are protruding through the outside loops (the ears) and the tail of the rope on the same side. Grab an ear and the tail on the same side in one hand and the other ear and its corresponding tail in the other hand.

Step 4: Tighten the knot. Hold both *ears* in one hand (put your fingers in the loops) and both *tails* in the other. Pull the knot tight.

For each trial, the experimenter will record the last step completed correctly and, if you finished, the quality of the knot (i.e., good, fair, poor—the knot pictured in step 4 would be classified as good). The experimenter will also record any problems with the knot (i.e., uneven loops, not centered, or loose knot—the knot pictured in step 4 shows different-length tails so it is not centered on the rope).

Lab 4.1 Name: ____________________________

Data Sheet

Participant: _______________________ Experimenter: ________________________

Task 1—Card Stacking

5 to 10 Seconds Between Trials

Trial	Cards used	Levels
1	______	______
2	______	______
3	______	______
4	______	______
5	______	______
6	______	______
7	______	______
8	______	______
9	______	______
10	______	______

1-Minute Break

Task 2—Coin Spin and Trap

Trial	Spins	Traps
1	______	______
2	______	______
3	______	______
4	______	______
5	______	______
6	______	______
7	______	______
8	______	______
9	______	______
10	______	______

1-Minute Break

Lab 4.1 Name: ______________________________

Data Sheet (p. 2)

Participant: _________________________ Experimenter: __________________________

Task 3—Knot Tying

Trial	Step	Quality or problems
1	_______	____
2	_______	____
3	_______	____
4	_______	____
5	_______	____
6	_______	____
7	_______	____
8	_______	____
9	_______	____
10	_______	____

Quality—Good, fair, or poor:
Problems—Uneven loops, not centered, or loose:

Lab 4.1 Name: ___________________________

Discussion

For each activity, describe which aspects were controlled in an open-loop fashion and which were controlled in a closed-loop fashion. Which part of each activity did you find the most challenging? Discuss how your results illustrated closed- and open-loop control modes as discussed in chapters 3 and 4 of your textbook. For each of the tasks that you were able to perform fairly well, indicate whether the mode of control that you used for a given aspect changed as you gained more experience.