Barany Chair

Rotating Chair : Activities
Courtesy of NSBRI

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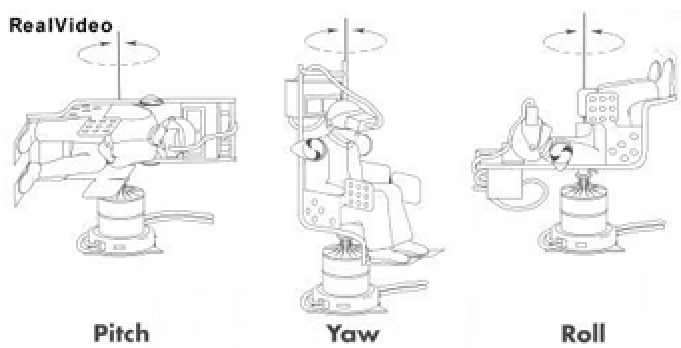
The Rotating Chair Experiment

Figure 11. An Earth-bound version of the rotating chair. It is capable of rotating a subject in three axes: pitch, yaw, and roll.



Background

In order to study how rotational effects might be perceived differently during space flight, a simple piece of equipment was designed to provide a rotational stimulus as well as a means for measuring important vestibular parameters in humans during rotation. It is called the **rotating chair**, which is exactly what it is! The chair, together with all of its computerized components and detection devices, is essentially an **angular accelerometer**, an instrument that measures acceleration or detects and measures vibrations. With the use of the chair and all of its supporting equipment, one can:

- initiate and maintain a controlled rotational stimulus;
- quantify (measure in numbers and units) the rate of rotation;

- measure various physiological variables during rotation.

Dr. Young's science team utilized this equipment on two different space missions to examine how gravity influences the interaction between the visual and semicircular canal pathways to the brain. **Recall that it is our semicircular canals that are responsible for informing our brain about our rotational movements and, remember most of all, that they are mostly unaffected by gravity.**

For this Student Investigation, you are going to repeat the exact **protocol**, or technique, that was used in space, but you will observe and measure your own **per** (during) and **post** (after) **rotatory perceptions** (perception = a conscious feeling or sensation) during and After being spun in a rotating chair. You will compare your perceptions with and without other sensory cues. Before we begin, let's discuss the operation and significance of the rotating chair.

Here on Earth, when using the chair to carry out preflight and postflight measurements, the chair sits on a very sophisticated, motor-driven rotation device that can spin the chair in three axes; pitch, yaw, and roll (Figure 11). In space, however, the chair can be used without the motor-driven rotator and may be spun by hand. The chair even has a different name in space! It is known as the **Body Restraint System (BRS)**. It seems that everything in space is called something different from its counterpart on Earth. For instance, the "Waste Management System" in space is called the bathroom here on Earth! Let's get back to the subject of rotation and the description of the BRS.

In order to accurately measure the angular acceleration of the human **subject** being spun on the BRS, the subject must wear a head-mounted accelerometer recording unit that is attached to a belt-mounted digital tape recorder. In order to measure per- and post-rotatory perceptions in space, the astronauts were spun in the chair for one minute with their eyes closed. Using a pocket voice recorder, they were asked to verbally respond when their **sensation** of spinning was over. There were two main objectives to this study:

- to determine the **perceived** spinning time which is usually much less than the one minute of actual spinning time;
- to determine whether the subject perceives themselves spinning after the chair stops, and in what direction.

Does your perception change when you open or close your eyes during rotation? What is the explanation for your response? Does gravity change the way you perceive this on Earth? We will be considering some of these questions and others as we examine our own responses to the rotating chair.

Dr. Young's science team also measured eye movements during and after rotation. After a person is rotated and then stopped abruptly, the person's eyes respond in the opposite direction to the original spin direction for a period of time. This phenomena is known as **nystagmus**, and it represents the eyes attempt to help stabilize our visual field of view After movement. The word "nystagmus" comes from the latin word for "nodding," and it refers to a sawtooth like motion: slow in one direction (**slow phase**) and quick in the other (**fast phase**). As an example of this sawtooth motion, think about when you see students who are dozing off to sleep in class and their head falls to one shoulder in slow stages, and then quickly is brought back erect! This funny display can be considered "head nystagmus." Ocular nystagmus occurs when the eye is driven in one direction and then quickly jumps back in the other direction.

The eye movements can be left-right (**horizontals nystagmus**), up-down (**vertical nystagmus**), or torsional nystagmus. Nystagmus is also classified by the stimulus that produces it. When we look out the window of a moving car, or watch a moving stripe displayed on a computer screen, our eyes naturally tend to follow the objects we see, and the resulting eye movement is called **optokinetic nystagmus** (opto = refers to the eye, kinetic = refers to movement). For the rotating chair experiment, the eye movements that occur are typically those of horizontal nystagmus.

The comparison of eye response to motion on Earth and in space can give the researcher some valuable information about how gravity influences our perceptions of motion. We will be examining the interaction between vestibular and visual signals and gravity in the next Student Investigation. This investigation examines our rotational perceptions.

It is important as we proceed on to our activities, to make sure that you READ ALL OF THE DIRECTIONS BEFORE BEGINNING this Student Investigation. Also, you can probably use a swiveling desk chair, or a piano stool that rotates to carry out this exercise. Your teacher will give you instructions and help direct your activities, but it is up to each group of students to develop their own hypothesis about what they expect to happen, to carry out the experiment, and to explain their results. Let's get started.

Materials

Each group will need:

- A rotating chair
- Two stopwatches
- A blindfold

Procedure

Remember to read all of the steps before beginning.

Step 1

Break into small groups of at least four people. Select one person to serve as the **subject**, another to serve as the **chair operator**, and two people to serve as **timers**. Every person in your group will have an opportunity to serve as a subject.

Step 2

The chair operator and the timers must practice rotating the chair at a particular frequency so that they can become familiar with the approximate speed for each revolution, **which they must maintain** while the subject is seated. Just as in the actual space Right experiment, the operator should rotate the chair at 120° per second. Since an entire circle is 360°, the students can calculate how long one revolution should last and this should be practiced before a subject sits down. The operator should also practice how to maintain a constant velocity for one minute and how to bring the chair to a quick and smooth stop. It is important to note that this experiment can produce symptoms of motion sickness in some people. If any subject finds the test makes them nauseous, they should stop and change subjects.

Step 3

Have the subject sit down on the chair. The subject's feet should not touch the floor. Also, the subject should hold their hands on their lap, if possible. The subject should be spun smoothly at a rate of 120° per second for one full minute and it is very important that the chair operator bring the chair to a **quick, smooth stop**. You will be spinning each subject under each of the three differing conditions. These conditions are:

- with eyes open during rotation;
- with eyes closed during rotation;
- with eyes closed during rotation, followed by voluntarily pitching the head forward immediately after the chair has stopped rotating, with the eyes still closed.

These conditions will be explained more fully in the steps that follow. However, before you spin anyone, your group should develop an hypothesis to predict the results of two responses for each condition. The two responses that you will be measuring are:

- the subject's **perceived spin time during rotation;**
- the subject's **perceived spin time after stopping.**

Step 4

Before each spin, the subject will be reminded to respond verbally when they perceive the spinning to have started and to have stopped. This applies for the period of time during the spin and after the chair has stopped. The subject may begin to feel an oscillating, back-and-forth motion during the spin but should try very hard to distinguish this from the rotational sensation. The subject should only report on the beginning and end of the sensation of spinning, both during and after the spin.

The two timers have different, but important roles.

- The first timer will be responsible for timing the one minute rotation.
- The second timer will be responsible for timing the subject's perception of rotation during the spin, and then again After resetting the timer, immediately After spinning has stopped.

At any point during or after the one minute rotation, the subject will let everyone know when their perception of rotation has started (at which time the second timer starts the stopwatch) and when their perception has stopped (at which time the second timer stops the stopwatch).

This will occur for each of the three conditions stated above and as indicated in Step 5.

Step 5

The spinning protocol is performed first when the subject's eyes are open. It is performed again with the subject blindfolded. It is performed a third time with the subject, again blindfolded, being asked to bend at the waist while pitching the head forward and down 90°, abruptly and immediately **after the operator stops the chair**. The subject should stay nose down for about 30 seconds after bending. The operator should wait about two minutes between the three rotations per subject.

Step 6

The data that is collected by the second timer should be recorded carefully. There will be three sets of data for each subject, one set each for the conditions of: eyes open, eyes closed or blindfolded, and eyes blindfolded along with pitching the head forward After the rotation has ended. **Each set of data** will include:

- the conditions of rotation (eyes open, eyes closed, or eyes closed and pitch forward),
- the actual spin time (approximately 1 minute),

- the perceived spin time during the actual spin,
- any difference (+ or -) between actual and perceived spin times;
- the perceived spin time After the spinning has been stopped.

You should use a copy of the data sheet, shown in Table 1, that your teacher will provide for you. **Do not write in the book.**

step 7

The data for each subject can be grouped and averaged for the whole class or just for each group to determine the average perceived spin time during the rotation and After the rotation for each of the three conditions. These differences can be compared and used to answer the questions. Read the questions before you begin so that you will know what to expect.

Table 1. A comparison of actual and perceived spin times during and after various conditions of ratation.

	During Rotation			**After Rotation**	
Conditions of Rotation	Actual Spin Time (seconds)	Perceived Spin Time (seconds)	Actual-Perceived Spin Time (seconds, + or -)	Perceived Spin Time (seconds)	Comments and Observations
Eyes Open					
Eyes Closed					
Eyes Closed and Head Pitched Forward					
other conditions					
other conditions					

Questions

1. Is the visual cue an important contributor to your perception of rotation?

2. Do you think that hearing or touch cues are important contributors to your perception of rotation? Explain.

3. How did being blindfolded affect your perception of rotation, both during the spin and right after spinning? Did the perceived direction of rotation reverse after the chair was stopped? Would the effect be the same in space as on Earth? Explain.

4. How did pitching the head forward immediately after spinning affect your perception of rotation? Would the effect of pitching your head forward be the same in space as on Earth? Hint: The semicircular canals are your angular detection receptors (which are mostly unaffected by gravity) and your otolith organs are your linear detection receptors (which are fully affected by gravity). Explain.

5. Were your hypotheses supported or refuted from the results of your data analysis? Did you obtain similar results for most of your subjects or were the data hard to interpret?