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A Preliminary Review of Vestibular Impacts on Upper Extremity Abilities of People with Disabilities

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ABSTRACT

By understanding how the brain receives messages from the eyes and vestibular system, upper extremity deficits that impair coordination in arms and hands can be overcome. This is accomplished when a person with type of disability closes his eyes to perform a specific task. Closing the eyes eliminates the messages the brain is receiving from them. Thus, the brain is only relying on information from the vestibular system. The theory put forth in this paper is: when information from the eyes is eliminated, upper extremity deficits are reduced.

If this notion is true, a person with upper extremity deficits can use this knowledge to have a more independent lifestyle, which will improve his quality of life by increasing educational and career opportunities.

To test this idea, thirteen people were asked to do seven basic tasks using wooden blocks. Each participant did all seven task twice. The first time a task was attempted, their eyes were opened and focused on the blocks. The second time, the participants had their eyes closed relying solely on information from his vestibular system to do the task. The time to complete each task and precision it was done with were measured and analyzed. The participants were also asked key demographic questions including questions about their education and employment histories.

OVERVIEW

People with disabilities like Cerebral Palsy or ALS, which often result in upper extremity deficits, can often improve their tactile accuracy and precision by understanding the mechanics of the vestibular system when performing tasks that are not automatic processes.

The organs of the vestibular system are located in the inner ear and have hair-like cells that send nerve impulses to the cerebellum to determine movement. The cerebellum in turn sends the same impulse to muscles so that they can move accordingly. The eyes also send messages to the brain about where a person is in their environment. If the cerebellum is damaged, gross and fine motor movement will not be well coordinated, which often causes the person's movement to be hampered.

This is particularly true when a person is looking at an object that they are trying to manipulate. Our observations demonstrate that when a person closes his eyes to perform a task, their movements will be less impaired and more precise. Closing the eyes eliminates the messages the brain is receiving from them. Thus, the brain is only relying on information from the vestibular system. Spasticity, tremors or any other type of upper extremity deficit no longer impedes the person's movement.

By eliminating upper extremity deficits, a person will be able to function more freely and independently. His quality of life may improve by receiving a higher education and obtain gainful employment because of this change.

Another explanation for the lack of upper extremity deficits is muscle memory. Muscle memory is the ability to perform movements or tasks identically, programming them into the subconscious mind so they can be recalled automatically from memory. Repetitions and mental focus are needed before a particular movement is committed to memory. Muscle memory is based upon the relationship between muscles, bones, and joints etc.

Athletes and musicians use muscle memory when they practice. A basketball player will practice a foul shot many times until it is perfect. In doing so, they have trained their muscles to shoot an accurate shot. It is now part of their muscle memory. Similarly, a musician will practice their instrument for hours so they can recall notes and chords effortlessly.

Muscle memory can be used to do daily activities as well. For example, when a person locks his door, he usually doesn't pay much attention to this activity. The process happens automatically or without conscious thought.

Muscle memory can also effect the movement of a person with a disability. When a person with a disability does a task repeatedly, they seem to have less deficiency in their movement whether their eyes are opened or closed.

METHODOLOGY

To examine the idea that closing eyes while doing a task eliminates upper extremity deficits, seven individuals who have disabilities that affects their upper body motor skills participated in an experiment. In addition to these participants, another six people who do not have any reported disabilities were tested to serve as a control group.

Each participant did two series of identical desktop tasks that involve manipulating wooden blocks. The first time the participants did the series, their eyes were opened and focused on the blocks. The second time, their eyes were shut.

These tasks are designed to test participants' gross and fine motor movement skills. Gross motor refers to the larger body movements and fine motor are the smaller ones. Some tasks will involve the arms-gross motor and some will use only the wrists and fingers-fine motor.

The hypotheses is that the tasks will be completed faster and with more precision when the participant's eyes are closed eliminating any upper extremity deficits.

Before the participants did the tasks, they answered a questionnaire intended to solicit basic demographic information.

DEMOGRAPHIC QUESTIONS

The following questionnaire was given to each participant.

- How old are you?
- What is your gender?
- What is your race?
- What is your marital status?
- Where do you live?
- What level of education have you completed?
- Do you have a disability? If so, what is your disability?
- How long have you had it?
- What is your main source of income?
- Are you employed?
- If so, what is your occupation?
- How long have you been working?

- Have you ever been employed?
- If so, what type of work?
- Why did it end?
- If you are not employed, what are the main reasons you do not work?
- If you are not employed, would you like to be?

After the participants answered these questions, they did the first series of tasks with the wooden blocks. The participants were given 120 seconds (2 minutes) to complete each task. Each individual task was timed with a stopwatch and scored for precision. These times and scores were recorded on a score sheet for further analysis.

At the beginning of each task, the researcher instructed the participant on what he must do to complete the task. For example, the researcher would say, "put one square block on top of the other." The participant was told that the test started when the researcher said "start". The participant was asked to say "finish" to indicate that he was done. The stopwatch began and ended timing with the words "start" and "finish" respectively. The amount of time it took for a participant to complete a task was then recorded on the score sheet along with a "precision score" which indicated how precisely the task was executed. The researcher determined the individual "precision score" at the completion of each task.

The time to do a task was measured in seconds. For instance, if it took a minute and ten seconds to finish a task, then the time recorded would be 70 seconds.

The "precision score" rated the degree of accuracy with which a task was completed. The possible "precision scores" were 0, 1, 2, or 3.

A "precision score" of "0" meant that the participant was unable to do the task in the 120 seconds he was given. Low precision meaning the participant barely completed the task will get a "1". A task that is done with moderate precision will get a "2" and "3" indicated the task was done with a high degree of accuracy.

The following is a description of the tasks that were performed by each participant.

Test	Purpose	Description
1.	Arm and Wrist Test	The participant will be given an array of 4 long, thin rectangles that have a square shape at the end. The participant will line up the square shape ends.
2.	Wrist and Fingers	The participant will be given 2 rectangles and asked to put one on top of

		the other.
3.	Wrist and Fingers	The participant will be given 1 wide rectangle and 2 squares and then asked to put the 2 squares on top of the rectangle.
4.	Wrist and Fingers	The participant will be given 3 squares and then asked to pile one on top of the other.
5.	Wrist and Fingers	The participant will be given 2 semi-circles and then asked to put them together to form a whole circle.
6.	Wrist and Fingers	The circle from the previous task will remain in front of the participant. The participant will then be given 2 arches and will place the curved side of each arch around the circle forming a square.
7.	Arms, wrists and fingers	There will be an array of 10 different shapes and a box in front of the participant. The participant will be asked to put each shape in the box.

After the participants completed all 7 tasks, they were instructed to do them again. The same rules apply about when the tasks begin and end. The time it took to finish each task and its "precision score" were recorded again.

The major difference between the first time a participant did the series and the second time is that he closed his eyes for the second attempt.

If the hypothesis is correct, a participant will do the tasks on the second attempt quicker than the first and have a higher "precision score". The reason is that the participant’s cerebellum is solely relying on information from the vestibular system and not his eyes. As stated before, when information from the eyes is eliminated, upper extremity deficits are reduced.

DISCUSSION

The typical female participant was white with cerebral palsy who didn't work and collects Supplemental Security Income (SSI) as her primary income source. For men, the typical participant was white and had never been married.

There were 13 participants in all. Nine were women and 4 were men. Five women and 2 men had disabilities that effected movement in their upper body specifically in their arms, hands, wrists and fingers. The average age of this population was 43.9-years-old and the median age was 42-years-old.

Out of the 13 participants, 6 said that they completed college or had some experience with college. Three of them were disabled. Six participants had a high school level education. Half of them had disabilities. The one remaining participant was disabled and had no reported education.

The 2 most common income sources identified were SSI and a salary. All 4 of the participants who used SSI exclusively for income were disabled. Another 4 said a salary was their means of income were all able-bodied. The 5 remaining participants named other sources or a combination of sources as their income.

Testing usually occurred at Liberty Resources, Inc., a Center for Independent Living in Philadelphia.

The duration of the entire test was varied depending on ability. For those having disabilities, the testing lasted approximately 35-45 minutes. Able-bodied participants took about 15-20 minutes to complete the testing.

On the whole, most participants had a positive attitude towards the testing. Many of them were amused at doing tasks with their eyes closed. The participants were given encouragement as they went through the test, especially if they seemed to be getting frustrated. One participant after completing a few tasks said that it was "stupid".

As stated earlier, precision scores were designed to measure the precision or accuracy with which a task was completed. They ranged from 3 to 0. A score of 3 meant a task was done with perfect precision. The precision score decreased as the precision lessened. A 0 score meant that the participant was unable to do the task in the time allotted.

Precision scores can be analyzed in numerous ways using the information generated from the demographics questions.

ANALYSIS BASED ON GENDER